ERIA Research Project Report 2009, No. 7-4

FOSTERING PRODUCTION AND SCIENCE & TECHNOLOGY LINKAGES TO STIMULATE INNOVATION IN ASEAN

EDITED BY
PATARAPONG INTARAKUMNERD

March 2010

CONTENTS

MEMBERS

Project Leader

Patarapong Intarakumnerd	College of Innovation, Thammasat University, Thailand

Project Member

Sunil Mani	Centre for Development Studies, India
Haryo Aswicahyono	Centre for Strategic and International Studies, Indonesia
Tomohiro Machikita	Institute of Developing Economies (IDE/JETRO), Japan
Masatsugu Tsuji	Graduate School of Applied Informatics, University of Hyogo, Japan
Avvari V. Mohan	Nottingham University Business School Malaysia Campus, Malaysia
Mari-Len Macasaquit	Formerly affiliated with Philippine Institute for Development Studies, Philippines
Somrote Komolavanij	Sirindhorn International Institute of Technology, Thammasat University, Thailand
Truong Chi Binh	Institute for Industry Policy and Strategy, Vietnam

Coordinator

Yasushi Ueki	Bangkok Research Center, IDE/JETRO, Thailand

Executive Summary

Patarapong Intarakumnerd

1. RATIONALE OF THE PROJECT

There is a possibility that the distribution of industrial location and population could be changed as agglomerations in East Asia are integrated. The deepening industrial integration can stimulate diversification of industry and concentration of population in production and logistics hubs.

Said integration can also bring about and promote innovations through four ways.

The first way is through efforts driven by *ex-ante* productive firms. Such firms can extend the reach of their business toward the integrated market where they can supply goods. This increased access to the bigger integrated market with more business opportunities is expected to facilitate the firms' attainment of economies of scale, thereby allowing them to cut and economize on certain expenses and have more capital for innovation. With more capital on hand, firms will therefore be more encouraged to pursue innovations.

The second innovation-promoting effect of industrial integration is through the intensified competition that said integration is expected to bring about. The integration of the markets in ASEAN and East Asia into a single market along the pan-East Asian industrial corridor will intensify competition. In order to avoid cutthroat price competitions, individual firms will thereupon undertake more efforts to innovate to create new products and new markets. Firms can also focus on process innovations to improve productivity, decrease marginal costs and increase profit margins.

The industrial corridor will also provide firms with more alternatives of intermediate and capital goods and technologies that are available lower prices. This increased selection of varieties of accessible intermediate goods enables the formulation of new combinations of inputs, thus promoting product innovations, The improved availability of capital goods, meanwhile, will also facilitate diffusion of new processing technologies and process innovations. This is the third innovation-promoting effect of integration.

In the meantime, there are firms located in places where no distinct geographical advantages may exist. Under ordinary circumstances, these firms may be excluded or “hollowed out” from industrialization developments. However, with the creation of an integrated industrial corridor in East Asia, even these firms located in such disadvantaged areas will be able to benefit from and use the upgraded transportation infrastructure built and developed precisely to extend the geographical reach to various product/consumer and intermediate markets in the industrial corridor. Efficient infrastructures enable firms to renovate their production linkages and create higher value added in a supply chain. This is the fourth way by which integration promotes innovation, and this time, the outcome is driven by *ex-ante* non-productive firms.

As seen from the above effects, in designing policies to promote an Asia-wide industrial upgrading through the creation of a pan-East Asia industrial corridor, policy framers should carefully consider the potential impacts of market integration and market expansion on industrial upgrading and innovation.

And since said industrial corridor can affect the regional level of innovation via four ways as explained above, the policy instruments to be developed and instituted to encourage and promote innovations will have to suit and be appropriate to the ways described. It is therefore very important to identify pathways to innovation and to determine the possible impacts each pathway has. This will be useful in the formulation of each country’s policy that will supplement the creation of an industrial corridor.

In this regard, the empirical studies on the determinants of upgrading/innovation and production linkages which the working group of this project plans to conduct will provide policy implications for stimulating innovation in ASEAN via the East Asian economic integration with the use of the following guidelines: (1) improvement not only of individual town’s reputation in the world market but also the corridor’s collective reputation; (2) upgrading of specialized fields, with common certification standards for engineers and lawyers to secure innovation incentive for local firms in ASEAN and to decrease costs of alternative dispute resolution on counterfeiters and of access to world technology; (3) combination of global scientific knowledge and shared local business knowledge in the integrated economy to achieve local market-driven innovation.

2. OBJECTIVE OF THE PROJECT

The findings from the previous firm-level survey in the earlier phase of the project indicate that it is the kind of management practices which take advantage of accessible production/intellectual linkages, institutions and other business environments that may determine the topology of production and intellectual linkages and achievements of upgrading and innovation. This is because the respondent firms were sampled from a specific region and acting in a similar business environment. There were however differences in the probability of achieving innovations among these firms and management practices were thus the deciding factor that would spell the difference. Another related finding suggests that organizational and intangible assets affect a firm's level of absorptive capacity.

The linkages can also be classified into on-market and off-market linkages. The former indicates a network based on daily transactions of material, parts, final products and services in the market through which firms can obtain information necessary for upgrading and innovation. The latter, on the other hand, includes cooperation and collaboration organized outside of the market mechanism. More macro- level institutions affect both the linkages and the resulting upgrading and innovation. For example, trade policy and related institutions may increase trade volumes, diffuse more information, technologies and knowledge and facilitate innovations. This pathway to innovation can be called "market-driven innovation." Another example would be science and technology (S&T) policies that emphasize new technology developments and new scientific discoveries to promote "S&T-driven innovation." It can be said that the quality of the institutions as well as the linkages, absorptive capacity, and function of management of firms located in a specific region affect the regional capability of innovation in the long run.

This phase of the research project is going to investigate the capacity/linkages in the building of innovation and shed light on the relationship between innovation outcome and innovation management. The research focuses on three factors: (1) knowledge transfer through production linkages, foreign direct investment (FDI) and trade (mutually beneficial relation between motivations, importation of intermediate and capital goods, and learning from exporting); (2) absorptive capacity and the current state of sourcing inputs for innovation inside firms (human resources, foreign capital introduction, licensing arrangements, fund-raising and new technologies); and (3) agglomeration economies, including pro-competitive effects. The effects of these three factors on innovation outcome could predict the degree of success of innovation management.

The research project puts emphasis on institutional and policy designs that facilitate firms' innovation managements to upgrade the quality of products and to provide differentiated products. The research also hopes to determine the degree of complementarities between the policies of building capacity and of fostering linkages in the stimulation of innovation in ASEAN. If the empirical evidences show a strong complementary relationship between firm-level capacity and linkages to stimulate innovation, policymakers should then simultaneously allocate policy resources to strengthen both the building of firm capacity and the fostering of linkages.

Two procedural steps were followed and implemented. First, much attention was paid to the relationship between linkages and capacity: how production and intellectual linkages could be formulated by using internal resources of firm. Second, the research took into account the role of innovation management in achieving a higher or more differentiated innovation outcome by estimating the relationship among innovation outcome, absorptive capacity, and production and intellectual linkages.

And while the earlier phase of the project focused on matters related to the integration policy in the face of production and science and technology linkages and the relationship between economic integration and clustering effects, this phase will pay additional attention to institutions and policy instruments for economic integration to build innovation capacity.

3. RESEARCH METHODOLOGIES

The research used Schumpeter's definition of innovation such as: (1) product innovation; (2) application of new technology; (3) organizational change; (4) securing of new suppliers; and (5) securing of new markets.

Both questionnaire surveys and in-depth interviews were conducted.

The questionnaire survey covers an agglomeration of manufacturing firms (and other actors) in four geographical areas in four ASEAN countries, namely, Greater Jakarta Area (JABODETABEK) in Indonesia, CALABARZON Area in the Philippines, Greater Bangkok Area in Thailand, and Hanoi and Ho Chi Minh Area in Vietnam. Firms were asked about their business profile, innovation and upgrading activities in the last three years, sources of new technologies and information for upgrading and innovation in the last 3 years, business linkages with main customers and suppliers, capabilities and strategies for technological upgrading and innovation, and geographical distribution of production and distribution networks.

To have better insights, in-depth interviews of ten firms in each geographical cluster were also conducted. The interviewed firms include subsidiaries of multinational corporations (MNCs), locally owned firms, and joint ventures. They were asked about the type (new products, new processes, new markets, new sources of raw materials, and new forms of organization) and degree (incremental vs. radical) of their innovations, and the importance of linkages within and across agglomerations for innovation. The interviews cover automotive firms in the Greater Jakarta Area (JABODETABEK), electronics firms in the CALABARZON Area, electronics firms in Penang, automotive firms in the Greater Bangkok Area, and motorcycle part makers in Hanoi and plastic firms in Ho Chi Minh. In addition, aerospace firms in Bangalore, India were included for comparative purpose.

4. KEY FINDINGS FROM THE QUESTIONNAIRE SURVEYS

A total of 864 firms participated in the survey: (1) 183 firms in Indonesia; (2) 203 firms in the Philippines; (3) 178 firms in Thailand; and (4) 300 firms in Vietnam. The analysis can be divided into two parts: descriptive statistics and inferential statistics.

Key Findings from Descriptive Statistical Analysis

- The average age of a firm is 16.8 years, with a standard deviation of 13.9 years.
- Average size is 340 employees, with a standard deviation of 499.
- Approximately 67.5 percent are local firms; 14.5 percent, joint venture firms; and 17 percent, MNCs.

- Seventeen (17) percent of the firms produce raw materials, 42 percent process raw materials, 36 percent produce components and parts, and 63 percent produce final goods.
- For the characteristics of top management, 28.4 percent hold master's degrees or higher. Almost 57.8 percent have experiences as engineers during their careers while 45.9 percent have had work experience in multinational companies (MNCs) or joint venture companies.
- Fifty-eight (58.1) percent of blue-collar workers finished high school while 50.4 percent of engineers have technical college degrees.
- Regarding product innovation, 64 percent were able to change the design of existing products. More than 80 percent of firms improved their own existing products. Almost 70 percent of firms developed new products based on *existing* technologies while only 57 percent developed new products based on *new* technologies. This suggests that it is more difficult to achieve *product innovation* combined with *new technologies*. Eighty-five (85) percent of firms succeeded to sell new products to *existing markets* while only 71 percent of firms were able to sell new products to *new markets*. This also implies that the creation of new markets is more difficult and costly.
- Regarding process innovation, more than 83 percent of the firms were able to buy *new machines*, 70 percent could *improve existing machines* while 71 percent introduced *new know-how* on production method. Firms in the sample tended to change production processes more than shipping processes. Changes in accounting systems and human resource management practices (HRMP) within firms were more popular than meeting regulations and global standardization. Other important reasons for upgrading production processes were related to: improvement in quality (84%), meeting of regulations (82%), decrease in defections (72%), reduction of pollution (61%), increase in domestic market (60%), decrease in inventories (58%), decrease in materials (50%), and reduction in lead time (50%).
- As for sources of innovation, internal sources (within the same companies) are quite important in all countries. Regarding the role of local firms, they were

regarded as very important by surveyed firms in Vietnam (almost 80%), moderately important (around 50%) in Thailand and Indonesia, and not so important in the Philippines. Interestingly, local firms located in the *same geographical area* in Vietnam are considered as very important in comparison with other countries. MNCs are relatively less significant, except in the case of the Vietnam where MNCs that are located far-away places like East Asia, the United States and Europe are more important than those in the same geographical area and within the country. Government agencies, universities, and research institutes are significantly less important in all countries. In relative terms, meanwhile, firms in Thailand had a more positive view of domestic agencies than those in other countries.

- Recruiting mid-career engineers is considered important for innovation in all countries. Most of these engineers came from local areas and within the countries. Vietnam, in particular, significantly sourced engineers from the same geographical area.
- Foreign-made equipment and licensing of technologies from other firms are not considered very important for innovation.
- As for the distance of most important customers and suppliers, they are mostly in the range of 100 kilometers. This signifies that they are within the same geographical area. Thus, agglomeration is seen to be important for innovation.

Key Findings from Inferential Statistical Analysis

After the robustness test, the following variables are considered to be statistically significant for innovation: firm size (measured by the number of full-time employees), cooperation with MNCs, technical assistance financed or provided by government-owned financial institutes, licensing technologies from other firms, and number of linkages with partners or sources of knowledge. However, information from academic publications is not seen to be important for innovation.

The results of the statistical analysis also confirm that the impact of face-to-face knowledge exchanges on product innovations is significant. Effective technology transfer needs face-to-face and two-way flows of knowledge. Managerial experiences with foreign firms are considered important for innovation and upgrading.

Key Findings from Case Studies

There are interesting key findings in terms of similarities and differences, especially when industrial agglomerations in more or less the same sectors but in different countries are compared.

Hanoi, Greater Bangkok and Greater Jakarta Automotive Clusters

These three automotive agglomerations are facing similar circumstances. The benefits of becoming a part of global production networks of MNCs are quite clear and they are therefore struggling to access, stay on and gain most from the networks. For second-tier suppliers, being in such networks helped them standardize their manufacturing process and become much closer to demanding customers. However, only a few second-tier suppliers could manage to upgrade themselves to become first-tier suppliers. Many in the second tier are still struggling with low profit margin, and knowledge transfer from MNCs is limited only to quality control and production management system (e.g., the 5 Ss). Many others even left the industry. A few second-tier suppliers used capabilities gained in the automotive industry to diversify to other sectors like electronics, home appliance and others. In essence, being part of MNCs' production network is like a 'training school' for them. Benefits of being first-tier suppliers are much greater in terms of level and intensity of knowledge transfer such as receiving and dispatching engineers, high-level training and direct discussion, co-design and development.

'In-house' technology capabilities like R&D and design are important in being qualified to be first-tier suppliers (e.g., Summit Auto Seat in Thailand). Without in-house 'absorptive capacity', knowledge transfer or collaboration in terms of design and development of new parts as well as advanced manufacturing technologies will not be achieved. Educational qualifications and professional skills of engineers, technicians and laborers are critical in upgrading. Furthermore, a firm's culture, especially in terms of awareness of the importance of innovation and upgrading at all levels from top management to the laborers, is indispensable. The role of an intermediary such as the Thai Automotive Institute has been highlighted as important in facilitating networking and knowledge transfer between MNCs and local firms.

Penang and CALABARZON Electronics Clusters

Innovations in these clusters are mostly incremental and new to the firms. Penang is relatively more advanced as firms conducted relatively more design and development activities whereas most firms in the CALABARZON area are only doing largely assembly activities. Radical innovations were also found in a few cases in Penang. Customers are the major source of knowledge and information in both cases. In-house R&D is a very important source of innovation.

The role of MNCs as lead firms is absolutely critical for innovation of local firms. MNC and local firm collaborations both ‘within’ and ‘across’ agglomerations are very important. Proximity does matter for effective linkages and innovation. Nonetheless, linkages in global production networks (across agglomerations) are equally significant.

Within Penang, some firms are more ‘active’ learners. They learned not only from customers/suppliers but also from competitors and publications. Universities and public research institutes are considered to be much less significant. However, this belief may have begun to change in Penang in recent years as firms have advanced enough as to have R&D collaborations with universities.

The big differences between Penang and CALABARZON are the roles of local governments and local agencies. These local agencies are much more pro-active in upgrading capabilities of local firms in the former. The Penang Skill Development Center (PSDC), in particular, acts as a trainer of local firms and an intermediary that connects MNCs with local firms, leading to business partners and knowledge sharing. In both cases, the dispatch of engineers between local firms and MNCs facilitated knowledge exchanges.

Ho Chi Minh City Plastic Cluster

There are three groups of firms in this cluster: a) low value-added packaging for export, b) highly competitive but low value-added products for domestic construction industry, and c) high value-added and high-skilled suppliers for manufacturing industries. In general, the demands of MNCs may help to upgrade local firms, but the latter are not aware of such nor are they active. They are not really competitive players in the global production network or global value chain. Links with domestic finished goods manufacturers (forward industrial linkages) are weak, which is a typical phenomenon in developing countries. Low government attention both at the national and local levels has been paid to developing this sector.

Bangalore Aerospace Cluster

This is a cluster by nature since it requires proximity of manufacturers, specialized research institutes, and specialized education institutes. There are two sub-sectors: aeronautic and astronautic. For the aeronautic sub-sector, links with global players such as customers and strategic partners like Boeing and Airbus are critically important.

For the astronautic sub-sector, the main linkages are with domestic players, both governmental, especially in terms of defense and private actors.

The problems facing this cluster are different from other developing countries. While many developing countries need to develop technological capabilities from the very beginning, some capabilities in this sector in India have already been developed in the defense sector. The question is more of transferring these existing capabilities from the defense to the civilian sector.

Local (state) governments have significant roles in providing legal, tax, and physical infrastructure necessary for building agglomerations (e.g., special economic zones).

National/ local education institutes (Indian Institute of Science) play crucial roles in supplying specialized researchers and engineers. There are also mutual spillover impacts to other sectors like the automotive sector as firms in the sector started to produce automotive parts using existing high-precision production and engineering capabilities. Through transfer of skills and business diversification, the existence of the aerospace industry in India will help to upgrade other sectors in the future as well.

5. SUMMARY AND POLICY RECOMMENDATIONS

Key findings from the questionnaire surveys and case studies illustrate that firms in ASEAN are struggling to survive and prosper in the global value chains. For them to succeed in doing this, there are two alternatives or roads. On one hand, the ‘low road’ is a trajectory in which producers face intense competition and are engaged in a “race to the bottom”, On the other hand, the ‘high road’ is a trajectory in which producers increase and improve participation in the global economy and, hence, realize sustained income growth. ‘Upgrading’ is a necessary condition for a ‘high road’ path to competitiveness in the context of globalization. The key question therefore is how these firms can upgrade. The findings from this study point out that innovation to create new values or increase value added is a key factor for upgrading.

On closer examination, the ASEAN firms in the study can be divided into two groups.

The first group consists of firms that are still in the low road. They are struggling to penetrate the global value chains of MNCs. They are mainly competing on the basis of low labor cost. But to be able to be parts of global value chains, they have to strengthen their production capability, especially their production management system and quality control, to meet international standards. The cases of the Vietnamese auto parts and plastic packaging firms and the Thai second-tier auto part suppliers are examples.

The second group includes those which have, to a certain extent, succeeded in technological upgrading. Nonetheless, most of the innovations which the study found from this group are not breakthroughs for a product or a process that are new to the world. Rather, they are more of marginal, evolutionary improvements of products and processes that are new to the firm and allow it to keep up with international (moving) standards. Further, firms in this group pursued four different upgrading strategies, as follows:

1. *Process upgrading.* Firms upgraded processes – transforming inputs into outputs more efficiently by re-organizing the production system or introducing superior technology. These are the cases of the first-tier Bangkok auto parts suppliers, and the Penang and CALABARZON electronics part makers.
2. *Product upgrading.* Firms upgraded by moving into more sophisticated product lines (which can be defined in terms of increased unit values). These are the cases of Penang part makers and Bangalore aerospace firms.
3. *Functional upgrading.* Firms acquired new functions (or abandon existing function) so that they could increase the overall skills content of their activities. They might complement production with design or marketing, or move out of

low-value production activities. These are the cases of the Penang and, to a lesser extent, CALABARZON electronics part makers which upgraded from being Original Equipment Manufacturers (OEMs) to Own Design Manufacturers (ODMs), and some Bangalore aerospace firms which finally transformed to become Own Brand Manufacturers (OBMs).[1]

4. *Inter-sectoral upgrading*. Firms may apply the competence acquired in a particular sector to move into a new one. These are the cases of the Indian auto part makers which moved to aerospace and the Hanoi auto part makers which moved to home appliances and electronics (see Figure 1 for graphical illustration).

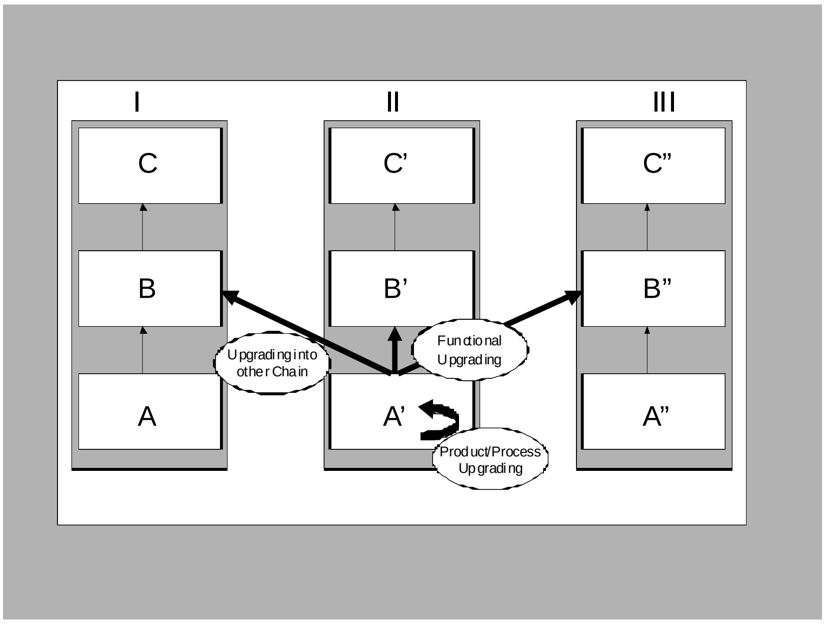


Figure 1: Different Strategies of Upgrading in Global Value Chains

The study also elucidated that agglomeration does matter for production linkages and technological upgrading, especially for less capable firms. However, in some cases, it is less important than linkages outside of an agglomeration. In these cases, production and knowledge linkages with capable and better managed MNCs located in other places

[1] OEM and ODM are specific forms of subcontracting. Under Original Equipment Manufacture, a firm produces a finished product in accordance with the precise specification of a foreign transnational corporation, which will market under a brand name via its own distribution channels. Under Own-Design Manufacturer (ODM), a firm carries out most or all of the product design. In the case of Own-Brand Manufacturer (OBM), a firm carries out product design and markets its products under its own brand.

are more important for the upgrading of local firms. A certain level of ‘absorptive capacity’ accumulated through in-house activities of local firms like R&D is necessary for both within- and across-agglomeration linkages leading to upgrading and innovation. The study also found that linkages with universities and public laboratories are less important. However, such linkages are more important for higher-capability firms like, for example, those having R&D capabilities since the interests and activities done in said firms and universities are more similar at that level.

The study draws up certain policy recommendations on the basis of the key findings both at the levels of national governments (ASEAN members) and of the ASEAN Plus Six.

Policy Recommendations for National Governments (ASEAN Members)

First, strengthening the ‘absorptive capacity’ of local firms is a key success factor in gaining benefits both from within- and across-agglomeration linkages. The study points out that one major obstacle that prevents firms from doing innovations and building up absorptive capacity is their perception of the costs and risks being too high. Government can help firms mitigate this obstacle through several policy options, ranging from tax incentives to financial incentives in the form of grants or soft loan to the provision of technical infrastructure. Government can choose to implement one or several of these options based on its preference and bureaucratic capacity in devising, implementing, monitoring and evaluating these policy options.

a) Tax incentives can be provided not only for firms doing R&D for innovation, but also for firms doing R&D for absorbing and upgrading external knowledge. They might also cover other non-R&D activities like design and engineering, which are very important for product and process upgrading where many ASEAN firms, as illustrated by the study, are quite weak.
b) Government financial incentives in terms of matching grants and/or soft loans targeting upgrading activities may be provided. The incentives can be given to both high-potential individual firms, and consortium of several firms (and, in some cases, with participation from universities and government research institutes). Providing incentives to the latter can help to create and reinforce

inter-firm production linkages and knowledge linkages with universities and public research institutes, as in the cases of Taiwan Province of China in the past. The choice of universities and public research institutes should be done through a careful and transparent selection process (for example, by neutral committees consisting of the relevant stakeholders) and through a vigorous evaluation of the results (for example, application of performance-based criteria where firms receiving incentives must be able to export within a limited period after receipt of such incentives, must be ensured).

c) Government financial assistance should be extended for the hiring of external experts to help local firms upgrade. Both the surveys and the case studies show that experts in both the technological and managerial areas are very useful in stimulating the process of upgrading of local firms. Government can help by *partially* funding the salary of these experts for a limited period at the beginning.

d) Government procurement is a measure that can promote business opportunities. Local firms do not only need financial incentives but also business opportunities for their incrementally innovative products. Government procurement can give them such business opportunities before they are further developed and accepted in private markets.

e) One of the obstacles for innovation, as gleaned from the surveys, is the lack of technological facilities like testing, quality assurance, and calibration centers. These facilities require a lot of investment and market mechanism alone may not provide them sufficiently. Government can step in by creating such facilities for the common uses of firms in the industry.

Second, enhancing linkages within agglomerations is essential for upgrading, as shown by the study. The following policy options can help to achieve this goal.

a) Developing and strengthening intermediaries like the PSDC in Penang's electronic agglomeration which link local firms with MNCs both in terms of production and knowledge flow must be encouraged.

b) Empowering regional/local actors like local governments, business/industrial associations, universities, research institutes and financial institutions will be helpful since there is too much centralization in several countries in the region.

Effective upgrading within agglomerations requires more active roles for local governments and agencies since they are both geographically and politically closer to the needs of local firms.

c) Designing and implementing programs using engineers from MNCs within agglomerations to train engineers and technicians of local firms in knowledge and skills is critical for upgrading. This is an effective way for upgrading, as clearly illustrated in the case of the Penang electronic agglomeration.

Third, as illustrated by the study, enhancing linkages outside agglomerations (between MNCs located elsewhere and local firms) is also very crucial for the upgrading of local firms. A few policy options for meeting this objective are provided here.

a) Government financial incentives in the form of partial funding for dispatching engineers from local firms for on-the-job training or working at the Headquarters of MNCs for a certain period must be encouraged.
b) Business matching programs between MNCs looking for future investment and potential local partners, as elaborated in the case of the PSDC, are valuable activities. This can be implemented by both the national and local governments.

Policy Recommendations for ASEAN Plus Six

At the level of the ASEAN Plus Six, several joint activities can be carried out, especially in terms of creating common institutional arrangements and policy platforms. Some of these include:

a) A database of experts, especially retired ones, in ASEAN Plus Six, classified by types of knowledge and skills in specific industrial sectors, should be created and updated annually. This requires additional work to identify critical knowledge and skills which should be promoted and which are necessary for upgrading and future international competition.
b) Region-wide experts exchange programs should be initiated afterwards To facilitate the programs, an ‘ASEAN plus Six Special Fund for Experts Exchange’ might be set up. Monitoring and evaluation of these programs are essential.

c) Streamlining of different national immigration procedures for professional experts must also be done.
d) Regional certification and accreditation of specific skills, knowledge and professional standards should be carried out. This will be a very useful basis for experts exchange programs.
e) A joint policy research on good practices relating to the strengthening of linkages within and across agglomerations in the ASEAN Plus Six should be carried out. Policy measures themselves should be subjects of serious studies both in terms of content and deployment procedures and mechanisms.
f) A joint policy research on good practices relating to promoting technology-based entrepreneurship in ASEAN Plus Six should also be carried out. Several governments in the region are trying hard to promote such entrepreneurship. It is the right time to have comparative studies to examine successes and failures of such policies.
g) Annual policy fora between high-ranking policymakers and policy researchers/experts in ASEAN plus Six should be encouraged. The fora should discuss key success and failure factors in devising and implementing policies as well as provide a venue for learning and sharing experiences from and with each other.

1
The Flight from Defence to Civilian Space: Evolution of the Bangalore Aerospace Cluster

Sunil Mani

Abstract

The paper maps out the contours of the aerospace cluster in Bangalore, India and tracks its evolution from one dominated by defence contracts to one that is having civilian aircraft ambitions. All the leading constituents of the sector are identified and the knowledge flows between the various agents charted out. The study concluded with a comparison of the performance of the cluster in terms of exports and competitiveness and also delves on the policy instruments that are required for placing the industry on a sure flight path.

1. INTRODUCTION

India is one among the few developing countries which have attempted to create a domestic sectoral system of innovation in a truly high tech sector such as the aerospace industry. The country is currently having one of the fastest growing aerospace sectors in the world: exports of aerospace products from India have grown at a rate of 82 percent per annum during the period 1988 through 2008. Although the sectoral system of innovation of the industry is almost five decades old, for much of that period both manufacturing and innovative efforts of the sector was geared solely towards the defence sector, but this orientation of almost entire defence and governmental hold of the sector started diminishing with the opening up of the sector to private sector actors in 2001. So the evolution of the SSI neatly falls itself into two phases: phase 1 is period, 1959-2001 when both the research and manufacturing were entirely geared towards the defence sector and phase 2 is period since 2001 when the government opened up the sector to private sector participation. In fact this radical shift in policy appears to have made the sector very dynamic in the sense that it has considerably enhanced the breadth and depth of its activities in both research and manufacturing in both the aeronautical and astronautical components of the aerospace industry. Historically speaking Indian public policy has been disproportionately directed towards the astronautical part than the aeronautical so much say that in terms of public expenditure intensity on space related activities (defined as expenditure on space as per cent of GDP), India is second only to the USA, but ahead of many other OCED and BRIC countries. See Figure 1.

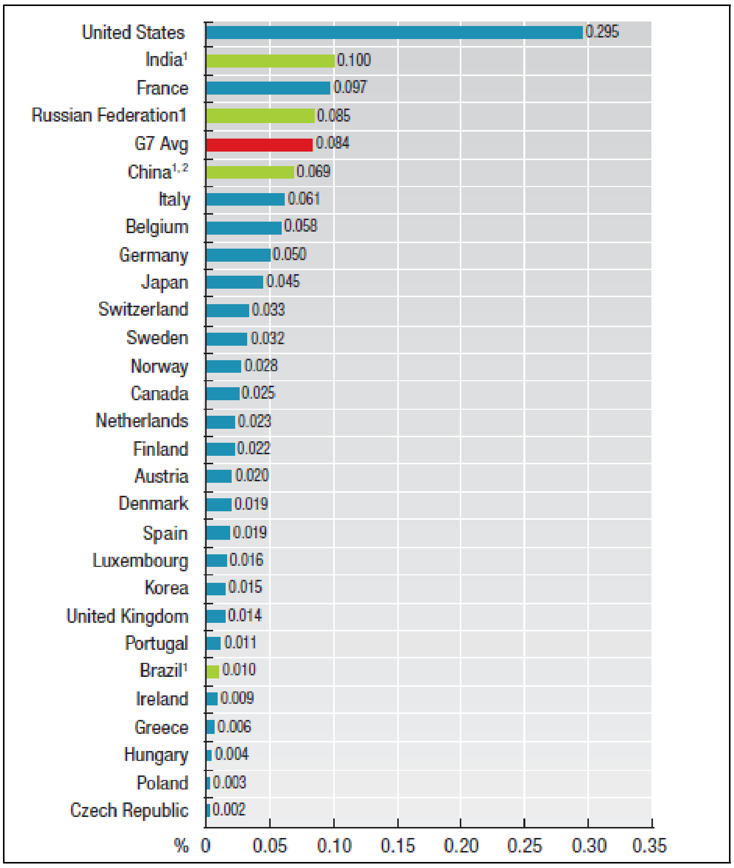


Figure 1 Public Space Budgets for OECD and BRIC Countries as a Per Cent of their GDP, 2005

Notes 1: BRIC countries are Brazil. Russia, India and China.
2: Chinese data based on unofficial estimates.
Source: OECD (2007), p.35.

According to Malerba (2004), a sectoral system of innovation has essentially three building blocks, namely, the actors, technology or knowledge domain and the demand or the market. Significant changes have taken place in all the three building blocks. For instance, during phase 1 the knowledge and technology domain depended to a great extent or almost in its entirety on domestic sources, the actors and institutions were lead by one public laboratory, one public sector research organization which did both research and manufacturing and one leading public sector enterprise in the manufacturing sector and demand was almost entirely and driven by public technology procurement. But during phase 2 there has been a dramatic change in all the three building blocks with the knowledge domain now composed of both domestic and foreign sources, there has been considerable increase in the number and types of actors and institutions and the demand has shifted from domestic public sector to foreign private and public sector enterprises.

Aerospace industry across the world is structured in the form of clusters. This is because at the centre of the cluster is a large aircraft manufacturer with a whole host of component manufacturers. In India, the southern city of Bangalore has emerged as one of the leading aerospace clusters in the country. This is essentially due to the existence of four major actors in the SSI of the sector, namely Hindusthan Aeronautics Ltd (leading manufacturer of aerospace products). The National Aerospace Laboratory (leading research facility on aerospace domain under the CSIR network of laboratories across the country), the Indian Space Research Organization (leading researcher and consumer of especially astronautics products from the country, and the Indian Institute of Science (leading centre for training of aerospace engineers). The cluster development policy has received a fillip with the state governments of Andhra Pradesh, Karnataka and Gujarat establishing special economic zones (SEZs) for the aerospace industry. These include:

- The Rs 3,000-crore Aerospace and Precision Engineering Special Economic Zone to be set up at Adibatla, Ranga Reddy district in Andhra Pradesh
- The specialised aerospace park of around 1,000 acres, proposed near the Bangalore International Airport;
- The 2,500-acre SEZ for the aerospace and avionics industry, proposed to be established in south Gujarat, close to the Delhi-Mumbai industrial corridor. This is likely to have a number of MRO (Maintenance, Repair and Overhauling) facilities.

In the case of the Indian aerospace industry, its sectoral system of innovation overlaps very well with the Bangalore Aerospace cluster as the major components of SSI are located within the Bangalore cluster. So in our study we use the term, sectoral system of innovation of India's aerospace industry and the Bangalore aerospace cluster interchangeably.

Systematic academic literature on India's aerospace industry is scanty and focuses almost exclusively on the astronautical part. Three sets of issues have come up for inquiry and analysis in this literature. The first one deals with overall assessment of past and future public policies on space programmes (Rajan (1988), Kasturirangan (2004), Murthi, Bhaskaranarayana and Madhusudan (2009)). The second one is a more detailed study on the evolution of the space sector from one being more science oriented to one that is more commercial oriented. The studies in this set also deals with the way India has acquired technological capability in this area (Baskaran (2005) and Sankar (2006). The last one deals with one particular kind of space technology namely remote sensing in which India has managed to have considerable technological capability. The only study in this set (Satheesh (2009) deals with the extent of diffusion of this technology and the factors that have contributed to its diffusion. To the best of our knowledge no studies exist on the aeronautical part of the sector. The present study seeks to fill in this gap by focusing on both the sectors and especially on the aeronautical part of the industry.

The basic objective of our study is to understand and map out the Bangalore aerospace cluster and its performance over time. In very specific terms we are interested in identifying and analyzing the major actors in this cluster, research and manufacturing as well and identifying the linkages that these actors have which each other especially in the generation of new technologies. In keeping with these objectives the study is structured into three sections. The first section maps out in detail the Bangalore Aerospace Cluster, identifies and discusses the key players or actors from the knowledge generation point of view. The second section measures the performance of the cluster and the last section distils out the policy implications of the study.

2. THE BANGALORE AEROSPACE CLUSTER

The city of Bangalore, capital of the southern state of Karnataka, has shot into international fame as the centre for India's information technology industry and also as an innovation hub. Besides it has a very high density of national level research institutes focusing on a range of technology disciplines, same basic and some applied as well. It has also a very density of undergraduate and graduate institutions in science and engineering and some of it like the Indian Institute of Science is of international repute. Further it has a very large number of new technology based firms especially in electronics hardware, computer software and in biotechnology industries. India's aerospace industry has its origin in Bangalore with the establishment of three major institutions in that city, namely the National Aerospace Laboratory, the Hindusthan Aeronauticals and the Indian Space Research Organization. No other place in India has such a large density of aerospace related institutions as Bangalore has. Although the Bangalore aerospace cluster is now more than 50 years old, over the last ten years or so it has evolved into a fairly sophisticated and clearly identifiable cluster. Three factors appear to have contributed to this change. First is the increasing market for aircrafts within the country thanks to the phenomenal growth in domestic air travel and the increasing success of India's space programme which has also increased with India emerging to have capability in designing and launching satellites using her own indigenously designed satellite launch vehicles. Second, is the launching of research and development of India's first civilian aircraft, the HANSA and SARAS in 1991 and the establishment of the Antrix Corporation in 1992 for the promotion and commercial exploration of products and services from the Indian space programme. Third is the growth of R&D outsourcing by foreign aerospace companies and one does hear, with increasing frequency, of an increasing number of such outsourcing outfits being located in the country and most of them again happen to be in Bangalore. An indication of the growing importance of Bangalore's aerospace potential can be gauged from the fact that during a recently concluded Aero India 2009 air show – billed as the largest in South Asia – deals worth more than $1.2 billion were signed between Indian and foreign aerospace firms. For all these reasons, we restrict our study to the Bangalore Aerospace cluster. However given the importance of Bangalore in India's aerospace industry, this is tantamount to analyzing India's aerospace industry itself.

Regarding the Bangalore cluster, we first map out the contours of this cluster in terms of the institutions that constitute this cluster. This is followed by a detailed analysis of some of the leading constituents of this cluster. Finally we end with a discussion of the performance of the cluster in terms of some standard indicators such as exports and R&D.

2.1. Mapping the Bangalore Aerospace Cluster

Based on my field visits and on the basis of secondary source material, I have been able to map out the Bangalore aerospace cluster. See Figure 2. At the core of the cluster are two different sets of aerospace organizations: one set representing the research system and the other representing leading aerospace manufacturers. Around the core are ten different types of parts and machinery manufacturers and two different types of business support, marketing and technology transfer firms.

At the core of the cluster are three major aerospace research organizations. These are the National Aerospace Laboratory (NAL) of the Council for Scientific and Industrial Research

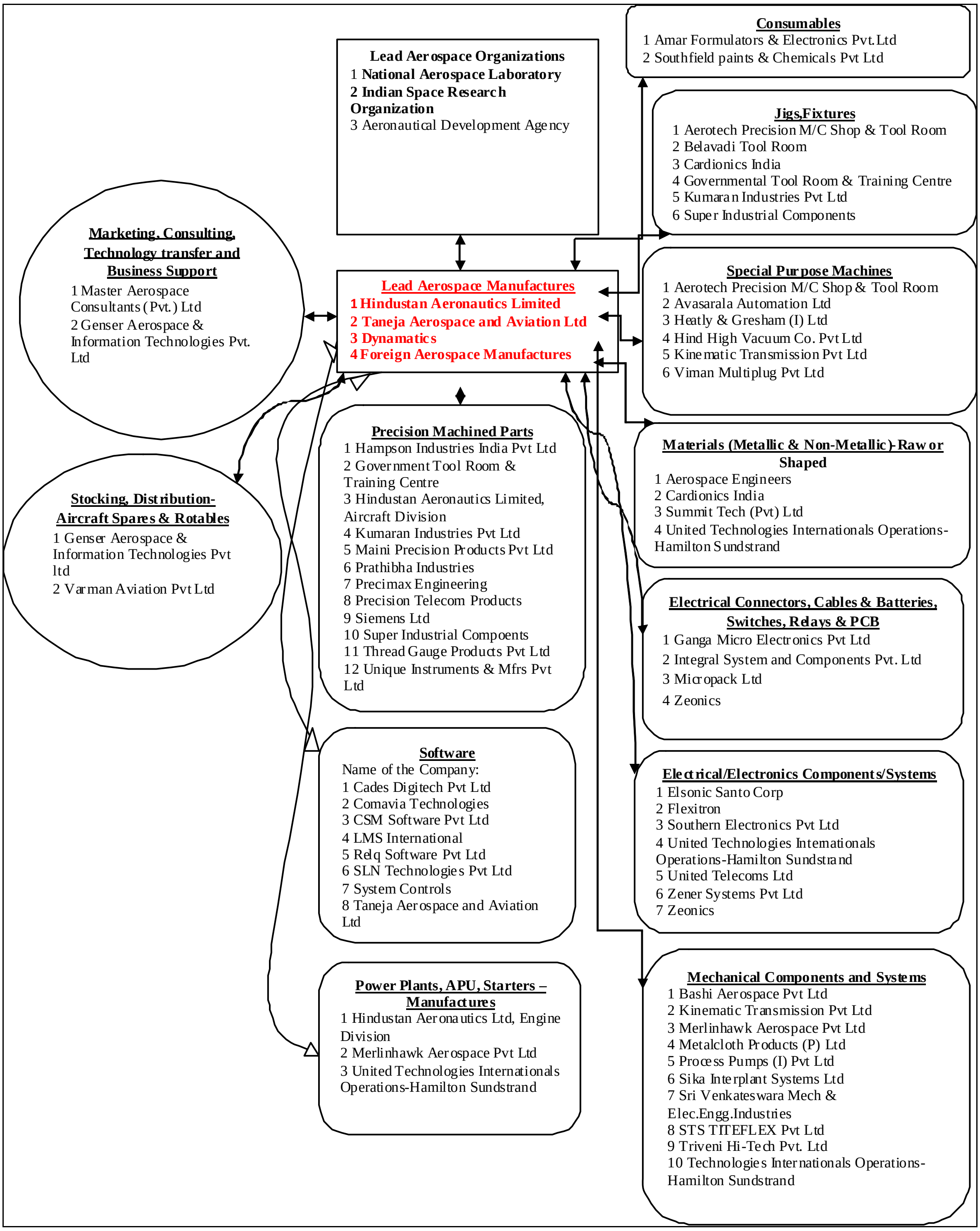


Figure 2 The Bangalore Aerospace Cluster (c2010)

Source: Own compilation.

2.2. Lead Actors in the Bangalore Aerospace Cluster: Based Aerospace Players

In this section, we discuss some of the leading actors within the aerospace cluster in

Bangalore. The focus is on the activities of these actors and the S&T linkages that these actors have with other actors both in the cluster, elsewhere in India and even abroad. We first start with the research or knowledge base of the cluster followed by the manufacturing base although this division is by no means fool proof as some of the manufacturers themselves have their own in house knowledge production centres. The research base in aeronautics is led by the NAL (although the Indian Institute of Science, Bangalore has also a strong contribution to the research base with a stead supply of high quality human resource) and the Indian Space Research Organization in the case of astronautics. This is followed by a discussion of four of the leading manufacturing enterprises. Through this discussion we hope to track the knowledge flows that are taking place within this cluster.

Research and Development entities

(i) National Aerospace Laboratory

National Aerospace Laboratories (NAL), Bangalore is a constituent laboratory under the Council of Scientific and Industrial Research of India. NAL is a high technology oriented institution concentrating on advanced topics in the aerospace and related disciplines. Originally started as National Aeronautical Laboratory, it was renamed National Aerospace Laboratories to reflect its major involvement in the Indian space programme, its multidisciplinary activities and global positioning. It is India's only civilian aerospace R&D organization in the public sector as the other.

NAL is well equipped with modern and sophisticated facilities that include:

- Nilakantan National Trisonic Aerodynamic Facilities (NTAF) with three wind tunnels is one of the finest of its kind in the world and is used for testing of aircraft, missiles and launch vehicles.
- Full-scale Fatigue Testing Facility for fighter aircraft life extension programmes. Many versions of the MiG aircraft have been evaluated at NAL's fatigue testing facility.

- Acoustic Test Facility for acoustic qualification of satellites and launch vehicles. Over 2000 tests, involving every Indian satellite and launch vehicle, have been carried out at this facility. The reverberation chamber has a volume of 1100 cu m; the design of the chamber's massive door ensures that 99.9% of the acoustic noise is successfully reflected internally.
- Composite Structures Laboratory for design and fabrication of composite fins, rudders, fuselage, etc. for fighter aircraft. There is probably no fighter aircraft being built anywhere in the world with as many composite components as India's Tejas – and a large fraction of Tejas's composite structures have been designed and developed at NAL.
- Black box readout facility. NAL has developed readout systems for the digital flight data recorder (DFDR) and the cockpit voice recorder (CVR) – commonly referred to as the `black boxes' – compatible with all aircraft flying on Air India and Indian Airlines fleets. Readout services have been offered for practically every major flying incident in the Indian skies since 1990. An integrated flight data readout system, developed by NAL, is now operational both at Indian Airlines and Air India. A new Windows-based software, NALOQA, for flight operations quality assurance, was unveiled at the Singapore air show in February 2004.

NAL has also developed significant technologies related to the field and is an acknowledged centre of excellence in many fields including composite structures, high speed wind tunnel testing, aircraft fatigue and aerospace acoustics, failure analysis and accident investigation.

Although NAL was established in 1959, it was only in 1993 that it set up a commercial wing, NAL Tech, to commercialise the internally generated technologies and to interact with other actors in the cluster. NAL tech has technological capability in the following 7 areas:

- Surface Engineering
- Composites Technology
- Resin and Fibre Technology
- Failure analysis and accident investigation
- Non-destructive and destructive testing and evaluation

- Materials charecterisations
- HANSA 3 trainer aircraft

Two of the major R&D projects in the civilian aircraft space that the NAL has worked on in recent times are the development of two different types of aircraft; first a two-seater trainer aircraft called HANSA and the second a multi role light transport aircraft called SARAS. The development of these two aircraft has added to the technological dynamism of this evolving cluster. Of the two, HANSA trainer aircraft has been developed and is currently in use in India and abroad.[1] The Hansa programme got under way in the early 1990s, with the first prototypes flying in 1993 and 1996. In February 2000, Hansa received its type-certification from the Directorate General of Civil Aviation (DGCA) and was cleared for day and night operations. Though NAL had initially manufactured the Hansa on its own and are again doing so, in the interregnum they had had one produced by the only private sector Aerospace company, Taneja Aerospace and Aviation Limited (TAAL).[2]

The second and more complex one, SARAS is essentially a twin turboprop[3] multi-role aircraft with air taxi and commuter services as its primary roles. It has a maximum take-off weight of about 6100 kg and a seating capacity of up to 18 passengers in the high density version. With a pressurised cabin, the aircraft will have a level of comfort comparable to regional aircraft such as the Embraer or ATR aircarft. The aircraft is well-

[1] The main competition for the Hansa comes from the Cessna 152 and the Cessna 172. The Hansa 3 is priced around Rs. 6 million (approximately 0.13 million dollars)

[2] NAL had entered into an equal cost and work sharing collaboration with Mahindra Plexion to develop a four-five-seater general-purpose aircraft. The aircraft is being designed and developed to perform a variety of missions, including 4 to 5 passenger transport, cargo operations, air taxi, etc. A combination of state-of-the-art composite technology as well as advanced sheet metal fabrication techniques are proposed to be used. It will be contemporary in design with advanced cockpit and comprehensive safety features which include energy absorbing seats and lightening protection. Yet another unique feature is the integration of a number of indigenous components and proven systems and technologies. During the design and development phase, a combined technical team from both the organizations would be jointly involved followed by design validation and testing using the extensive facilities of NAL.

[3] Saras is one of the few aircraft to make use of a pusher propeller configuration. The basic configuration resembles very closely the platform of the Embraer/FMA CBA 123 Vector which never went into production.

suited to fulfill a variety of other roles such as executive transport, light package carrier, remote sensing and aerial research services, coast guard, border patrol, air ambulance and other community services. The project started in 1991, had some interruptions in 1998 due to the sanctions imposed on India by the international community[4]. The first prototype was field tested in 2003-4 and the second one in 2007. But the technology is yet to be commercialised as it still has to solve some technical issues with regard to the weight of the aircraft. Although the project is of indigenous in terms of its conception and design, NAL has actually collaborated only with a limited number of international agencies. For instance, (a) a contract has been signed with Honeywell Technologies, Bangalore for the joint development of digital autopilot for the SARAS aircraft; (b) three engines (PT6A-67A) with a power rating of 1200 SHP at 1700 RPM have been procured from Pratt and Whitney, Canada; (c) pusher propellers developed in collaboration with MT Propeller, Germany; and (d) NAL has worked out flow computational programme for a transport aircraft in flight in collaboration with the University of Cambridge.

A more detailed analysis of the HANSA and SARAS cases are attempted in the second section analyzing the performance of the cluster.

NAL is at the moment initiated a new project to design a 70-90 seat Regional Transport Aircarft (RTA) in a public-private partnership mode. Our inquiries reveal that currently it is the drawing board stage. It will be an aircraft which could land in an all weather condition even in airfields which do not have adequate ground infrastructure facilities like Instrument Landing System (ILS). The first test flight is to be done in 2015 and expects to commercialise the new technology by 2016. Once again NAL is working in close collaboration with a number of other actors in the cluster like academic

[4] According to NAL sources, technological and procurement problems - arising out of US sanctions - have adversely affected the development of Saras and raised the cost of its development by Rs 15 crores although this view was contested by the CAG(2008) in its auditing of NAL’s R&D projects.

institutions and manufacturing enterprises.

(ii) Indian Space Research Organisation (ISRO)

Government of India established the Department of Space in 1972 to promote development and application of space science and technology in the country for the socio-economic benefits. Indian Space Research organization (ISRO) is the primary agency under the Department of Space for executing space programmes. During the early seventies, India undertook demonstration of space applications for communication, television broadcasting and remote sensing building experimental satellites namely, APPLE, Bhaskara – and experimental satellite launch vehicles, SLV-3 and ASLV.

At present, India has an impressive array of achievements with the largest constellation of domestic communication satellites called Indian National Satellite System (INSAT) in the Asia pacific region with about 210 transponders in orbit. And, India has plans to augment the capacity with the launching of INSAT satellites and increase it to about 500 in 4-5 years to meet its growing needs. Bangalore occupies an important place in India's space programme. See Figure 3.

Figure 3 Importance of Bangalore in Astronautical Sector in India

Source: Indian Space Research Organization.

India also has the largest constellation of earth observation satellites called Indian Remote Sensing (IRS) satellites with better than one meter resolution. IRS data is being used for a variety of applications such as crop yield estimation, drinking water missions, waste land development, forest cover mapping and a host of other applications benefiting the common man. Using INSATs, besides TV Broadcasting, telecommunications and meteorological applications societal applications such as tele-education, telemedicine applications have been operationalised. Village Resource Centers (VRCs) combining the services of IRS and INSAT satellites for providing an array of services have been established. India, today is considered as a leader in the application of space technology. INSAT and IRS satellites are also providing invaluable services in disaster management.

To put the IRS and INSAT satellites into orbit, India has developed two work horse launch vehicles namely the Polar Satellite Launch Vehicle (PSLV) and Geo-synchronous Satellite Launch Vehicle (GSLV). PSLV weighing about 300 tons at lift off has the capability to put 1500 kg satellite in polar sun-synchronous orbit. PSLV with eleven consecutively successful launches has demonstrated its high reliability. PSLV has launched eight satellites for various customers from abroad. GSLV with four successful flights is capable of launching 2200 kg satellites into geo-stationary Transfer Orbit. India has also created world class facilities at its space port in Sriharikota near Chennai with launch pads besides a host of test facilities for testing satellites and launch vehicle systems.

ISRO has established linkages with more than 500 firms in small, medium and large scale sectors, either through procurement contracts, know how transfers or provision of technical consultancy. The association with the space programme has enabled these firms to adopt advanced technologies and handle complex manufacturing jobs. With Antrix Corporation, the commercial front of DOS, having established itself in the global market, Indian firms have begun participating in the fabrication of space hardware to meet the requirement of international customers also.

Hitherto, 289 technologies have been transferred industries for commercialisation and 270 technical consultancies have been provided in different disciplines of space technology. Technology transfer activities have made further progress during the year (2008-09). Four new technology transfer agreements were concluded during 2008-09. The technologies licensed to industries for commercialisation include PF 108 Resin, Umbilical Pads, Ammonium Dinitrimide (AND) and ASIC Based Demodulator. A number of technologies licensed during the last few years have entered into regular production. The technology for manufacture of ISRO patented OLFEX has been in great demand and now has been additionally licensed to two more firms considering the expanding market. A number of technologies and application software packages are in various stages of development and will soon be available for commercialisation. Domestic GIS software (IGIS) jointly developed by ISRO was taken up for know how transfer. Through a Memorandum of Understanding (MoU) with industry, the development and supply of Cryo Adhesives (CAS resin) and Crystobalite, a filler material used in silica tiles, has been entered into with industry.

Manufacturing Enterprises

These are divided into domestic and foreign manufacturers.

A. Domestic manufacturers

(i) Hindustan Aeronautics Limited (HAL)

HAL is a major player in the global aviation arena. It is a defence state owned company and has built up comprehensive skills in design, manufacture and overhaul of fighters, trainers, helicopters, transport aircraft, engines, avionics and system equipment. Its product track record consists of 12 types of aircraft from in-house R&D and 14 types by licence production inclusive of 8 types of aero engines and over 1000 items of aircraft system equipment (avionics, mechanical, electrical).

HAL has produced over 3550 aircraft, 3650 aero-engines and overhauled around 8750 aircraft & 28400 engines besides manufacture/overhaul of related accessories and avionics. The Company has the requisite core competence base with a demonstrated potential to become a global player. HAL has 19 production divisions for manufacture and overhaul of aircraft, helicopters, engine and accessories. It has also 9 R&D Centres to give a thrust to research & development.

HAL's major supplies/services are to Indian Air Force, Indian Navy, Indian Army, Coast Guard and Border Security Force. Transport aircraft and Helicopters have been supplied to airlines as well as State Governments. The Company has also achieved a foothold in export in more than 20 countries, having demonstrated its quality and price competitiveness. HAL is a major partner for the Space Vehicle programmes of the Indian Space Research Organisation (ISRO). It has also diversified into the fields of industrial and marine gas turbine business and real-time software business. HAL is now ranked 34th in the list of world's top 100 defence companies.

The company has made supplies to almost all the major aerospace companies in the World like Airbus, Boeing, IAI, IRKUT, Honeywell and Ruag etc. In 1988 Airbus entered into an agreement with Airbus to make doors for its A320. Primary interviews with HAL reveal that 50 percent of the doors for Airbus are manufactured by HAL. The company has also entered into an agreement with for the production of flaperons[5] for use on Boeing's 777 series commercial jetliner.

All the production Divisions of HAL have ISO 9001-2000 accreditation and sixteen divisions have ISO-14001-2004 environment management system (EMS) certification. Six divisions have also implemented the aerospace sector quality management system requirements stated in AS 9100 standard and obtained certification. Four of these divisions have also obtained NADCAP certification (National Aerospace Defence Contractors Accreditation programme –USA) for special processes such as NDT, heat treatment, welding etc.

In order to meet with the challenges in the 21st Century, the Company has redefined its mission as follows: "To become a globally competitive aerospace industry while working as an instrument for achieving self-reliance in design, manufacture and maintenance of aerospace equipment, Civil Transport Aircraft, helicopter & missiles and diversifying to related areas, managing the business on commercial lines in a climate of

[5] The 777 flaperons are a highly complex composite assembly that is instrumental in controlling the airplane's maneuverability in flight.

growing professional competence."

HAL has successfully designed and developed the Advanced Light Helicopter, which is currently being operated by the defence services of India and private companies. The Advanced Light Helicopter also has great export potential. Apart from licence production of front line fighters like Su-30 MKI, HAL is also developing the following products through design and development:

(i) Intermediate Jet Trainer (IJT);

(ii) Light combat helicopter (LCH);

(iii) Weaponization of Advanced Light Helicopter (ALH); and

(iv) Tejas-Light Combat Aircraft.

As a result of these expansions of its activities, HAL's total sales have increased on an average at a rate of 16 per cent per annum. See Table 1. Its export intensity has doubled during the period under consideration while it has maintained its research intensity around 7.4 per cent of its sales turn over. This is in fact one of the highest research intensities in the country.

Table 1 Trends in HAL's Domestic Sales, Exports, Export Intensity and Research Intensity

	Domestic sales (Rs Millions)	Export Sales (Rs in Millions)	Total Sales (Rs in Millions)	Export Intensity (%)	R&D Expenditure (Rs in Millions)	Research Intensity (%)
1994-95	13529.5	358.9	13888.4	2.65	961.2	6.92
1995-96	15387.8	281.3	15669.1	1.83	1258.7	8.03
1996-97	17305.7	396.4	17702.1	2.29	819.5	4.63
1997-98	18288.8	410.5	18699.3	2.24	1298.3	6.94
1998-99	20037	440.3	20477.3	2.20	1463.5	7.15
1999-00	23539.2	469.6	24008.8	1.99	1716.6	7.15
2000-01	23879.4	586.1	24465.5	2.45	2040.9	8.34
2001-02	27079.6	668.5	27748.1	2.47	2037.2	7.34
2002-03	30165.3	1038.9	31204.2	3.44	2650.6	8.49
2003-04	35844.3	2153.5	37997.8	6.01	3138.1	8.26
2004-05	43837.5	1500.5	45338	3.42	3066.3	6.76
2005-06	51553.1	1861.9	53415	3.61	4335.8	8.12
2006-07	75131	2705.1	77836.1	3.60	6377.9	8.19
2007-08	82842.5	3410.9	86253.4	4.12	6621.4	7.68
2008-09	99368	4365.8	103733.8	4.39	6747.8	6.50

Source: Hinduthan Aeronautical Limited (2009).

(ii) Taneja Aerospace and Aviation Limited (TAAL)

TAAL is the only listed company in aerospace manufacturing in India. It manufactures small civilian aircraft, aero-structures and aircraft parts, provides aircraft maintenance services and represents Cessna Aircraft Company, USA, for the sale of its aircraft in India. It is the only private sector company manufacturing entire aircraft in India.

Part of the Pune based Indian Seamless group, TAAL was established in 1994 as the first private sector company in the country to manufacture general aviation i.e. non-military aircraft. The company's vision at the time was to create a nucleus facility for the development of an aeronautical industry in India and in particular to promote affordable general aviation in the country. To kick-off this process, TAAL entered into a collaboration with Partenavia of Italy to manufacture the six-seat twin piston-engine P68C aircraft and the eleven-seat twin turbo-prop Viator aircraft.

While TAAL continues to manufacture Light Transport and Trainer Aircraft, the company has since diversified its activities and has established a significant presence in many segments of the aviation and aeronautical industries in India.

TAAL has three distinct Business Divisions, namely, aerostructures, airfield & MRO and aircraft sales and support. Aerostructure business division has evolved from the initial business of the company, which was to manufacture the Partenavia P68C, six seat, twin-engine aircraft in India TAAL currently manufacture aero structures for Hindustan Aeronautics Limited (HAL), Indian Space Research Organization (ISRO), National Aerospace Laboratories (NAL) Aeronautical Development Establishment (ADE). Of these, the largest structures that the firm manufactures are for ISRO where the company builds most of the structural assemblies for the Booster rockets of the GSLV program. The company has also built major structures of SARAS.

TAAL's core competence in this area is in the manufacture of sheet metal details, machining, composites and assemblies. Facilities are augmented and upgraded to address the domestic and Global Technological requirements on a continuous basis.

- Manufacture of the P68C, a six seat twin piston-engine aircraft. All detailed parts and assemblies including seats, electrical looming, cable assemblies etc. were manufactured at TAAL's facilities;
- was involved in building up the first three prototypes of the 14 seat, SARAS aircraft for the National Aerospace Laboratories (NAL). TAAL has manufactured the entire airframe of the aircraft (excluding the wings which are manufactured by HAL) including tooling, parts and assembly.
- was associated with the National Aerospace Laboratories (NAL) for the production of the two-seat all composite (glass fiber) trainer aircraft called the "HANSA";
- is manufacturing the airframes for the full composite (carbon and glass -wet lay up and room temperature cured) NISHANT, Remote Pilotless Vehicle developed by the Aeronautical Defense Establishment (ADE);
- is manufacturing all the composite components (Tail cone, Nose cone and air-intake) for the LAKSHYA, Pilotless Target Aircraft (PTA). This aircraft is now in series production;
- is manufacturing the Elevator and Stabilizer for the Intermediate Jet Trainer (IJT) manufactured by HAL;
- is manufacturing a variety of aircraft tooling (bakelite), Sheet Metal Parts etc., for the Advanced Light Helicopters (ALH); Light Combat Aircraft (LCA) Light Combat Helicopter (LCH); Sukhoi (SU-30) & MIG Series projects of Hindustan Aeronautics Limited (HAL);
- is manufacturing auxiliary fuel tank, stretcher, Armour Panel and interiors for Advanced Light Helicopters of HAL and also interiors for Defence Service Helicopter;
- parts for Jaguar Drop tanks and Incendiary Containers;
- is doing space structures for PSLV and GSLV of Indian Space Research Organization (ISRO);
- manufacture of THORP T211 two seater aircraft for Domestic and Export Markets; and
- In the past TAAL has undertaken certain sub-contract work for the Israel Aircraft Industries (ISI) in Indi

In other words TAAL is very much linked to HAL and NAL deriving both contracts and knowledge from these two actors in the cluster. In addition it has also formal contacts for knowledge transfer from western aerospace firms.

(iii) Dynamatic Aerospace

Dynamatic Aerospace is known for the development of complex aero structures like wing, rear fuselage, ailerons flaps, fins, slats, stabilizers, canards and air brakes. Dynamatic Aerospace closely partners with agencies like Ministry of Defence, Hindustan Aeronautics Limited and other defence establishments on several key projects. It has the largest infrastructure in the Indian private sector for manufacture of exacting air frame structures and precision aerospace components.

(iv) Bharat Electronics Limited (BEL)

BEL was established in 1954 to meet the specialised electronic needs of the country's defence services, is a multi-product, multi-technology, multi-unit company. It serves the needs of domestic and foreign customers with the products/services manufactured in its nine state-of-the-art ISO 9001/2 and ISO 14000 certified manufacturing plants in India.

BEL manufactures a wide repertoire of products in the field of Radars, Naval systems, Defence Communication, Telecommunication and Broadcasting, Electronic Warfare, Opto Electronics, Tank Electronics and Electronic Components. With the expertise developed over the years, the company also provides turnkey systems solutions and Electronic Manufacturing Services (EMS) on "Build to Print" and "Build to Spec" basis. BEL has become a US $ 1 billion company in the financial year 2007-08.

BEL has entered into MoUs with aerospace majors like:

- Lockheed Martin, Boeing, EADS & Northrop Grumman for opportunities arising out of offsets
- Elisra, Israel, for working on various airborne electronic warfare programmes for the Indian defence
- IAI-Malat for working in the field of Unmanned Aerial Vehicles (UAV)

- BEL signed a term sheet with Rafael, Israel, which is expected to lead to the formation of a joint venture, for missile electronics and guidance technologies

B. Foreign Companies in the aerospace cluster

(i) The Airbus Engineering Centre India (AECI)

AECI – a 100 per cent Airbus-owned subsidiary is one of the most important foreign aircraft manufacturing enterprises in the Bangalore aerospace cluster. Specialising in high-tech aeronautical engineering, the India engineering centre works hand-in-hand with other Airbus Engineering offices around the world, as well as with the Indian aviation industry. As of early 2009, 100 people were working at the facility – including home-grown engineers and other employees – and this number is expected to grow to 400 over the next four years.

The Bangalore-based centre focuses on the development of advanced capabilities in the areas of modelling and simulation, covering such areas as flight management systems, computational fluid dynamics (CFD), as well as digital simulation and visualisation – which are critical factors in the design and production of high-performance aircraft such as the A380 and the A350 XWB. As part of the Airbus Engineering Centre India's activity, a simulated A380 flight management system is being developed in cooperation with Airbus engineers in Toulouse, France. This effort will help Airbus systems engineers provide mature specifications for the suppliers of flight management systems (FMS) – which are key elements of modern jetliners, and also can be used in research and development work on evolved FMS functions for new programmes such as the A350 XWB. As part of AECI Research & Technology activity, Airbus is in negotiations with the Indian Institute of Science, Bangalore, the Indian Institute of Technology and the National Aerospace Laboratory to commence several projects during 2009. In addition, Airbus Training India (ATI) initiated its operations in Bangalore and has since provided maintenance training to Indian-based airline operators.

Airbus is working in partnership with CAE of Canada to establish ATI as a full-fledged flight training centre, with the capability to train up to 1,000 pilots annually utilising 10 simulators. It also will offer maintenance courses in fully equipped, state-of-the-art classroom facilities. This centre currently is under construction near the new Bengaluru International Airport, and the facility's initial two simulators have been operational since 2008 for recurrent training.

Airbus also works directly with Indian companies in the design and manufacture of aerostructures and strongly encourages its major Tier 1 partners to do so as appropriate. Dynamatic Technologies Limited from Bangalore has partnered with Spirit AeroSystems to manufacture a complex machining component and assembly (Flap-Track Beams) for the A320, the world's most popular single-aisle aircraft programme.

Through its Tier 1 suppliers, Airbus also is engaging local companies such as TATA, HAL and Quest for the manufacture of sub-assemblies and detail parts. Additionally, the Airbus Aero-structures Supplier Council has identified India as one of the top "Cost Competitive Country" destinations for aerostructure manufacturing. Furthermore, Airbus has initiated several engineering projects with Indian companies. Infosys, HCL, CADES, Satyam and Quest have been selected to provide Engineering Services to various aircraft programmes, including the A380 and A350. In addition, Sonovision-Aetos in Bangalore (and Infotech in Hyderabad) have been set up as dedicated centres for work on Airbus Technical Publications.

(ii) Boeing in the Bangalore cluster

In 2005, Boeing entered a research partnership with the Indian Institute of Science (IISc), Bengaluru. The Boeing-IISc partnership focuses on research in nanotechnologies, structural alloys, composites, smart materials and structures, process modeling and simulation, manufacturing technologies, prototyping through substructure fabrication and testing. The strategic alliance with the IISc—the first of its kind at Boeing in the area of materials science—is expected to spur aerospace innovation and contribute to the advancement of Boeing's aircraft design capabilities. Approximately a year ago (in March 2009) Boeing opened its Boeing Research and Technology-India centre, which marks a major milestone for Boeing's aerospace research and technology activities in India. The centre will be the focal point for all Boeing technology activities in India, collaborating with Indian R&D organizations, including government agencies and private sector R&D providers, universities, and other companies. It will work with strategic research and technology partners to develop high-end technology, particularly in the areas of aero structures and avionics. This is Boeing's third advanced research centre outside of the U.S.

Software firms in the cluster:

Apart from this hardware related entities in the cluster, the Bangalore cluster is also very well known for a number of software firms which have become important players in the software requirements of some of the international aerospace industry. Mention may be made of two of them, namely WIPRO and Quest. See Box

Box: Software firms active in the Bangalore aerospace Cluster

WIPRO

- Agreement to work jointly on commercial aerospace projects with Britain's BAE Systems
- Entered into an agreement with Boeing to develop wireless and other network technologies for aerospace-related applications (PPP)
- Partnered with Lockheed Martin to create demonstration centers showing new capabilities for linking multiple control centers, aircraft and vehicles
- Wipro became the largest hydraulics company in India and the second-largest globally after an acquisition in Sweden. It is assessing the possibility of creating new designs for smart landing gears and brakes.

Quest

QuEST supports its aerospace customers on global programmes related to aero structures, engines, accessories, actuation systems, aircraft interiors and ground support equipment.It also specializes in complete end-to-end solutions for the aerospace industry right from design and analysis to manufacturing

• QuEST has been selected as EADS E2S preferred supplier for engineering services, manufacturing capabilities, ability to offer offset fulfillment and Risk Sharing Partnerships. The firm recently entered into a JV to launch India's first independent processing facility for aerospace manufacturing and has setup a Special Economic Zone (SEZ) in Belgaum

Source: PricewaterhouseCoopers (PWC) and Confederation of Indian Industry (CII) (2009).

Based on the qualitative and quantitative data on the major entities in the Bangalore cluster, the main difference between the aeronautical and astronautical components of the cluster is the important fact that the cluster is now increasingly getting organized around civilian projects especially in the case of the aeronautical sector. Further the aeronautical cluster is increasingly getting integrated with the international aerospace industry. The astronautical sector, on the contrary, focuses much more on forging linkages within the country even though here too we could detect change in the form of a number of emerging international linkages.

In the aeronautical sector some of the important linkages observed are:

(a) Airbus has been assessing ways to use India for component manufacturing and R&D. It had announced that India will be one of the key centers for design and development of their new A350 aircraft. Airbus Engineering Centre India is the company's high-tech aircraft component manufacturing facility in Bangalore. The facility works on the development of tools to design the aircraft, software for analyzing the stress and strain on airplanes and structural analysis of the aircraft, among other things.

(b) Snecma, a leading global aerospace company, established its R&D center in India in 2002. This center is engaged in carrying out studies and developing engine components, aircraft equipment and onboard software.

(c) Several foreign and private players that have entered the Indian R&D sphere followed the Public Private Partnership (PPP) model for sharing technology/knowledge and commercializing aerospace manufacturing. Prominent partnerships include:

(d) In 2008, Boeing had entered into agreements with Indian Institute of Science, Wipro and HCL to develop wireless and other network technologies for aerospace related applications.

(e) In 2007, Mahindra and Mahindra had signed an agreement for the design and development of a new general aviation aircraft with National Aerospace Laboratories (NAL), CSIR and the Government of India. This is the first public private JV in the aircraft design sector in India

2.3. Autoparts Firms Diversifying to Aerospace Industry

Finally important finding of the study is that a number of autoparts manufacturers have actually entered the aerospace industry: Indian automotive companies are also well-positioned to leverage their strengths towards aerospace. The auto component sector is growing at approximately 20 percent per year and many global OEMs and Tier 1 companies have started sourcing components from India, due to the high quality standards followed by Indian manufacturers. For instance, India has the largest number Deming Award winning companies outside Japan (11) in the auto component sphere and proven practices such as 5S, TPM, TQM and JIT are used by companies. The companies are also conversant with the multiple automotive standards followed in different parts of the globe. Several players are planning to enter the aircraft components production. Most are primarily becoming involved with precision engineering, machining, aircraft lighting, manufacture of tyres and transmission components. For example, Tata Automobile Ltd (TAL) entered into an agreement with Boeing to manufacture structural components for their 787 Dreamliner airplane programme.

The auto component majors have indicated several reasons (PWC and CII) for the entry of these

- Suppliers into the aerospace sector:
- Diversification of product portfolio and de-risking of business;
- Skills and manufacturing processes are similar to those required for aircrafts allowing them to effectively utilize existing capacities and capabilities;

- Higher margins in the sector; and
- Leveraging the benefits of the large quantum of work to come through the offset clause.

This is thus an extremely dynamic cluster evolving continuously.

3. PERFORMANCE OF THE BANGALORE AEROSPACE CLUSTER

In the previous section, we have mapped out the contours of the Bangalore cluster and then focused our attention on some of the lead players in the cluster. We found that there was fair amount of knowledge flows within the various actors and increasingly between these actors and foreign firms, customers and suppliers. Both the aeronautical and astronautical sectors have built up a fair amount of domestic technological capability in designing, manufacturing and selling aerospace products not only in India but even abroad. We therefore focus on the performance of this cluster. We do this separately for both the aeronautical and astronautical sectors of the industry in terms of two broad sets of indicators. First we discuss some macro performance indicators in terms of exports and competitiveness. Second, we discuss in detail a micro performance indicator, namely India’s attempt at developing civilian aircraft. However, before we actually presenting these indicators for measuring the performance of the two sectors, a caveat is in order. It is virtually impossible to get data on performance just for the Bangalore cluster alone. Therefore the data on exports that we have used refer to the country as a whole. However given the important place of Bangalore in the Indian aerospace industry, this may not to be a problem at all as most of the exports may have actually emanated from Bangalore-based entities.

3.1. Macro Performance Indicators

An important finding of the study is that the firms have, hitherto, been serving the export markets and the linkages that they have been having are more with other larger aircraft manufacturers outside the country. The main direct indicator of this link is the tremendous growth in exports, especially since the late 1990s. Exports have been growing at an average annual rate of 82 per cent (in nominal terms) during the period, 1988 through 2008. See Table 2.

Table 2 Exports of aerospace products from India, 1988- 2008 (in Millions of US $)

	Aeronautical	Astronautical	Aerospace	Growth rate
1988	5	3	8	
1989	9	2	11	38
1990	7	1	8	-31
1991	10	9	20	148
1992	10	0	10	-48
1993	5	0	5	-49
1994	6	1	7	31
1995	5	2	7	4
1996	6	1	7	-1
1997	43	1	44	516
1998	12	1	12	-72
1999	30	0	30	143
2000	52	1	53	77
2001	66	3	70	32
2002	86	3	89	28
2003	70	5	75	-17
2004	40	14	54	-28
2005	50	12	62	16
2006	43	14	57	-8
2007	292	80	372	552
2008	1210	275	1485	299
Average Growth Rate (%)				82

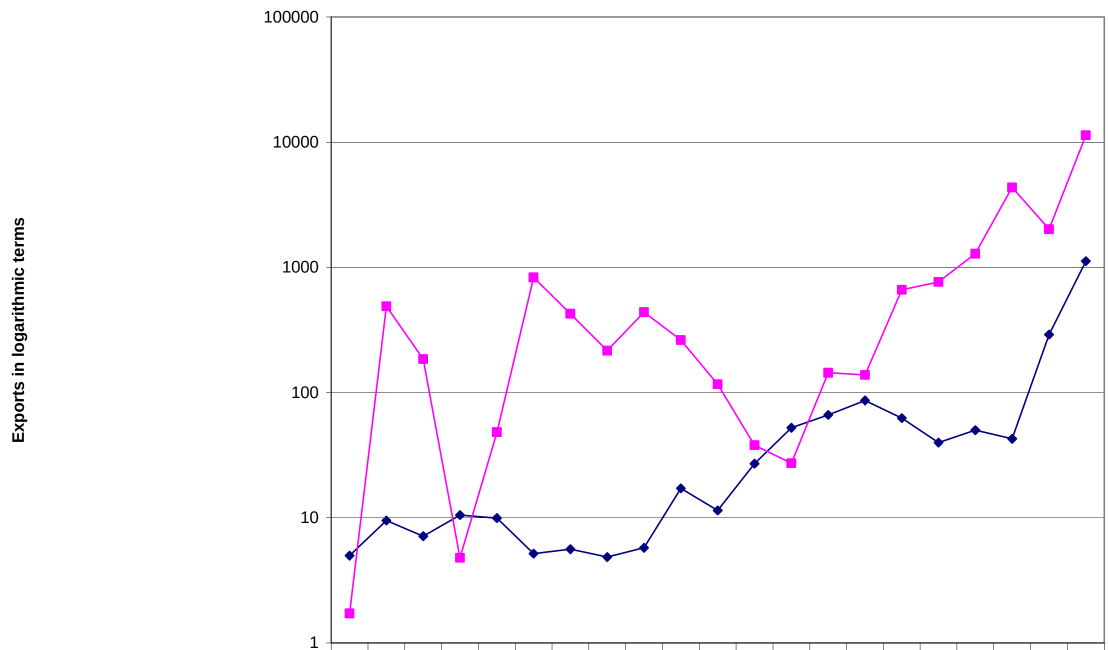
Source: Compiled from UN Comtrade.

Our analysis shows that almost the entire quantity that is exported is composed of parts of aircrafts.[6]

It is seen that the country is largely an exporter of aeronautical rather than astronautic products. This is because between the two, there is relatively speaking a larger domestic market for the latter in view of the ongoing and increasing space

[6] We have used the HS 1996 classification system for extracting the data on exports from the database UN Comtrade. The following three types of parts (a) aircraft propellers, rotors and parts thereof (880310); (b) aircraft under-carriages and parts thereof (880320); and aircraft parts nes (880330) accounts for the largest share of exports from India.

programmes of the ISRO. So it is not incorrect to conclude that in the case of aeronautic component of the aerospace industry the most dominant linkage that you find in the cluster is between domestic component and smaller aircraft manufacturers with large aircraft manufacturers abroad. In the case of the astronautic component the linkages are between domestic manufacturers and their main consumer which is the ISRO. The link between ISRO and their suppliers is actually forged through a commercial subsidiary of ISRO namely the Antrix Corporation.



	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Export of aeronautical parts	5	9	7	10	10	5	6	5	6	17	11	27	52	66	86	63	40	50	43	291	112
Import of aeronautical equipment	2	489	185	5	48	832	426	216	440	263	117	38	27	144	138	662	766	128	434	201	113

Figure 4 Relationship between Imports of Aeronautical Equipments and Exports of Aeronautical parts, 1988-2008

Source: Computed from UN Comtrade.

The government recently announced the new policy for capital acquisitions in which the minimum requirement is of 30 percent offsets in all acquisitions where the purchase cost exceeds Rs.3 billion. Nearly 80 percent of all offsets are in the area of aerospace. As result of this offset policy increasingly equipment suppliers to India are sourcing some portion of their components from India. So the increased exports of essential aeronautical parts from India are actually a result of this offset policy. In order to check this, we have plotted the export of aeronautical parts against import of aeronautical equipments. Given that the level of exports and imports vary considerably, we have transformed the two series into logarithmic values and this plotted against each other over time (Figure4). The figure shows that the two series are correlated with each other with the zero order correlation co-effient between the two working out to +0.92.

For measuring the performance of the astronautical sector, we rely on the space competitiveness index (SCI) computed by Futron Corporation (2008). The SCI evaluates the space faring nations across 40 individual metrics that represent the underlying economic determinants of space competitiveness. These metrics assess national space competitiveness in three major dimensions: government, human capital, and industry. The ranks obtained by the ten major space faring nations are presented in Table 3.

Table 3: India's rank in the Space Competitiveness Index in 2008 and 2009

Rank	Country	Government	Human Capital	Industry	2009 Score	2008 Score (Rank)
1	U.S	38.42	13.96	37.94	90.33	91.43(1)
2	Europe	19.32	9.03	18.46	46.80	48.07(2)
3	Russia	18.57	3.04	10.83	32.44	34.06(3)
4	Japan	15.80	1.72	3.65	21.16	14.46(7)
5	China	12.42	2.98	4.06	19.46	17.88(4)
6	Canada	12.89	3.42	1.82	18.13	16.94(6)
7	India	12.24	1.71	1.39	15.34	17.51(5)
8	South Korea	8.39	1.34	2.31	12.03	8.88(8)
9	Israel	6.72	0.56	1.42	8.70	8.37(9)
10	Brazil	6.10	0.49	0.50	7.08	4.96(10)

Source: Futron (2009).

India was ranked 5 in 2008. Her rank has since slipped to 7 out of 10, although her score is better than Brazil- a country that is very strong in the aeronautical sector.

Finally India's aerospace industry compares less favourably with that of China's (Table 4).

3.2. Micro Indicator of Performance

India's efforts at developing a civilian aircraft industry: It was seen earlier that NAL had developed two civilian aircraft, one a two-seater trainer and the second one a 14-seater multipurpose turbo prop one. In this section we discuss whether through these R&D projects NAL had actually fostered a cluster of aerospace units manufacturing a range of components and other parts required for these two projects. In discussing these two cases we supplement our primary data source with the data obtained from one of the recent Comptroller and Auditor General Reports (CAG, 2008) on scientific establishments in the country. Both the cases are first discussed separately and then some common threads are deduced from these two related cases.

The HANSA Case

The project was initiated in 1988 at a total estimated cost of Rs 5 million and was expected to be completed in about two to three years. Market research by NAL showed that considerable demand existed for this type of small aircraft to be used primarily for training and for remote sensing purposes. The project suffered serious time and cost overruns- the project could be completed only in 1998 at a final cost of Rs 55 million implying a time overrun of around 7 years a whopping cost overrun of 1000 per cent. While time and cost overruns are standard for especially high tech R&D projects, what was disquieting was that the aircraft was designed with 100 per cent foreign components and no effort was made by NAL to source even a small proportion of the total components required from domestic sources. Consequently the project had very little linkage effects within the Bangalore cluster or elsewhere in the country. NAL was also unable to transfer the HANSA technology to the only other private sector aeronautical manufacturing company namely TAAL. However TAAL refused to participate as a risk sharing partner but chose to work as a contractor. As result NAL decided to undertake the certification, production and marketing of the aircraft by itself. The initial demand for HANSA was restricted to 10 aircraft demanded by the Directorate General of Civil Aviation (DGCA) for eventual supply to the flying clubs around the country. NAL incurred a total expenditure of Rs 4.34 million per aircraft as against the initial target of Rs 0.05 million per craft. Of the 10, NAL was able to supply the DGCA with only 8 up to the end of June 2007. Nothing much is known about the remaining two as to whether it has been supplied or not. Of the eight, two met with accidents, but according to the CAG Report (p.25, para 1.8.1.3) NAL did not have any documents on investigations on these accidents done by either they themselves or the DGCA and so could not even create an institutionalized mechanism for learning from these mistakes. Also it was very clear that not much demand existed for these crafts beyond the original eight.

From the case, the following general points emerge. NAL does not appear to have done a systematic project preparation in terms of first assessing the market for this technology, second keeping a tab on both the time and cost of the project and in developing an indigenous vendor network and finally in instituting a framework within the lab to learn from its failures as these kind of failures are usually a fact of life in complex technologies such aerospace. Success lies in learning from these failures and then taking appropriate actions for further improvements.

The SARAS Case

This was one of the most ambitious projects that the NAL had undertaken. The idea, as noted before, was to develop a multi purpose Light Transport Aircraft (9 to 14 seats).

Under the project, two prototypes were to be fabricated to obtain DGCA certification. The competent financial authority (CFA) approved a budget of Rs1314 million for the project. Of this, Rs.653.1 (50 per cent) million was to be contributed by Technology Development Board, Rs.90 million (7 per cent) by HAL and balance Rs.571 million (43 per cent) by CSIR. While Prototype-I was targeted to fly in January 2001, the Prototype-II was expected to fly in December 2001. As against the target of January 2001, the Prototype-I flew in May 2004, i.e. after a delay of more than three years. Prototype-II undertook its first flight in April 2007, after a delay of more than five years. Due to the above time overrun, the cost of the project increased by Rs.225.30 million i.e., a cost over run of about 17 per cent. Right through the beginning the two prototypes developed had a problem wrt its weight (in specific terms it was over weight). This meant that its certification by DGCA has been delayed and from press reports it is leant that the certification may be available only towards the end of 2011 as a third and lighter prototype has to be made for that purpose. In the mean time, it is also understood that the Indian Airforce has expressed an interest to order 15 SARAS aircraft. The actual manufacturing of these aircraft will be by HAL. It is not immediately clear whether NAL has sourced the components and sub systems used in the aircraft were sourced from within the Bangalore cluster or from vendors elsewhere in the country. The only system that was purchased from indigenous sources was the auto pilot unit. However we had seen earlier that TAAL has manufactured the entire airframe of the aircraft (excluding the wings which are manufactured by HAL) including tooling, parts and assembly. In this way, the SARAS project did have linkages, albeit of a limited nature, with other units in the Bangalore cluster. Once the commercial manufacturing starts, these linkages are bound to increase manifold.

3.3. India’s Performance in Comparison with Other Developing Countries:

In the realm of aerospace development there are essentially two success stories from among the developing countries. The earliest one is from Brazil and the more recent one from China. The Brazilian aeronautical industry could be traced as far back to 1969 and the only Brazilian aircraft company, Embraer is an important player in the world market for regional transport aircraft. The case of Embraer is very widely discussed in the literature (Ramamurthy, 1987; Frischtak, 1994; Marquess, 2004).

The Embraer success could be traced to a number of favourable factors such as the timing of its entry, the active patronage of state in terms of public technology procurement, tax incentives and outright subsidies. Further the technology development was actually done in a company setting and not in a laboratory where the R&D team could constantly interact with the marketing and production departments so that the designs could be adapted to the requirements of the market and the availability of key components etc. The state-owned firm, Embraer, that was created in 1969 could inherit key R&D personnel from the Brazilian Aerospace Technical Centre (CTA, the Brazilian equivalent of India’s NAL). Embraer also had foreign collaboration with an Italian aeronautical firm, Alenia Aermacchi, and this helped the firm to secure state-of-the art technologies and also get its technical personnel well trained at the latter’s facilities. After a series of financial crises, the firm was privatized in 1994. In subsequent years, by launching new products for the defense market, and entering the executive aviation market, Embraer significantly increased its market share, resulting in growing revenues in diversified marketplaces. It has at the end of 2009, 17.000 employees, sales across the globe (but 43 per cent of its sales are in the competitive North American market), sales revenue of about US $ 6 billion, R&D expenditure of US $ 200 million, 244 aircraft deliveries and a firm order for 1762 aircraft (Embraer 2009). The Embraer story is one of a developing country state having a clear focus and strategy and very pro active in times of difficulties in taking bold decisions etc. Compare this with NAL's experience of the state not being having any clearly articulated policy or instruments of support.

The Chinese is still another case of strategy and support by the state to nurture a high technology industry. The Chinese also have managed to have close collaborations with large foreign aerospace companies such as Airbus industries. She has now become an assembler of a certain type of Airbus commercial jets in the country. A comparison of the aerospace industry in China and India is presented in Table 4.

Table 4: The Aerospace Industry in China and India

	China	India
Aircraft manufacturing	• China is ahead of India in production of commercial aircraft and also exports to the US. China merged its two largest aircraft makers (Avtc-I and Avtc-II) to form the Aviation Industry Corp. of China. This body has emerged as a world class aircraft manufacturer with aviation products including a 150-seat jumbo jet. • China flew its first passenger ARJ21 regional jet in September 2008 and also plans to develop 150 seater mainline jets in the medium term. • China started developing turbo propelled regional aircraft Modern Ark 700 (MA 700) for the high-end international market.	• India maintains capabilities in designing and manufacturing military aircrafts (by HAL) but has been unable to establish its presence in passenger aircrafts. • Recently, CSIR approved a plan for its Bangalore aerospace lab to design an airplane that can carry 90 passengers on short flights. • NAL is also building the regional transport aircraft. India is expected to launch the first series of regional jets only in 2012 partnership with Bombardier and Embraer.
Assembly	• Airbus assembly plant in China (Airbus Tlanjin Final Assembly Company) began operations in September 2008. The new plant is expected to assemble 44 aircraft a year by 2011. • China also jointly assembles the Embraer ERJ-145 regional jet.	• India still does not have a complete assembly line set up by any global OEM though the Government is looking to set up an assembly unit for 25-60 seater turboprop aircraft in collaboration with EADS. • India plans to assemble 108 Medium Multi Role Combat Aircrafts (MMROA) out of IAF's purchase of 126 planes. • BAE Systems partnered with HAL to produce Hawk which involves assembling 11,000 components sourced by BAE Systems from UK.

Source: PWC and CII (2009), p. 59.

In fact with a significant increase in India's exports in 2008 (300 per cent over 2007), her level of aerospace exports to both Brazil and China has improved considerably (Figure 5). It is expected that this ratio will continue to improve over time in view of the new manufacturing projects that are underway.

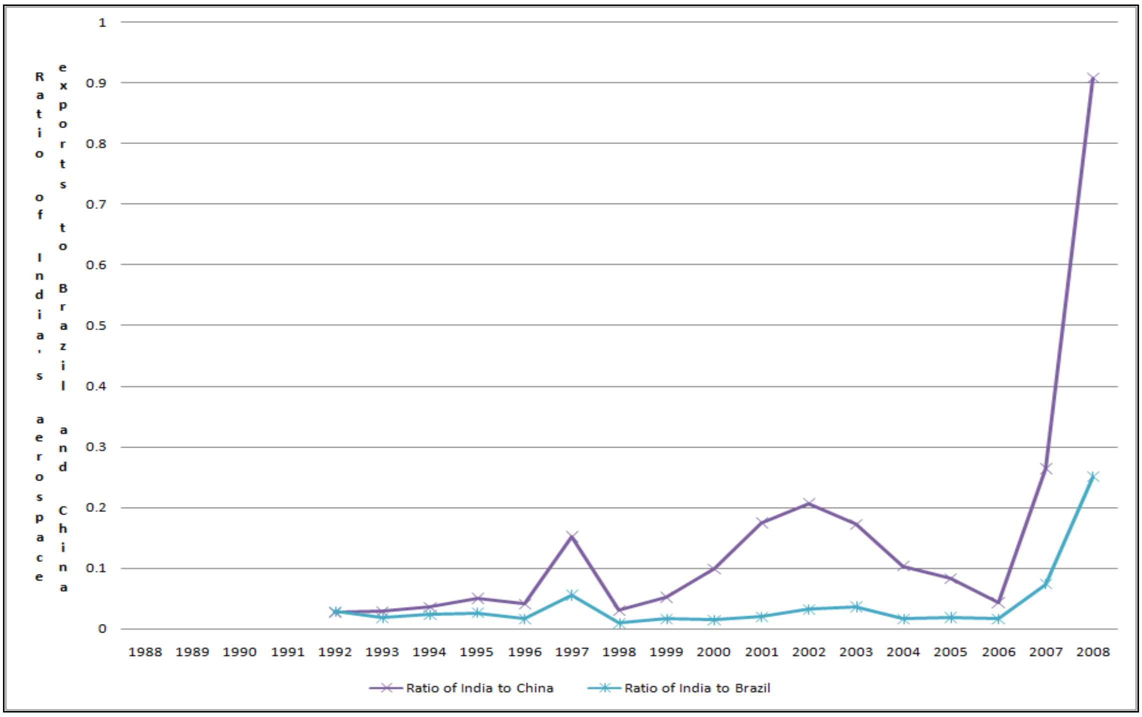


Figure 5 Ratio of India's aerospace exports to that of Brazil and China, 1992-2008

Source: Computed from UN Comtrade.

4. CONCLUSIONS

India's aerospace industry is slowly but steadily evolving from its defence focus to civilian ones. This can be seen in both its aeronautical and astronautical sectors. In the aeronautical sector, India is in the process of developing civilian aircraft which is capable of serving the regional routes- something which Brazil has accomplished several decades ago and that too with great success. Further the country has become a source of parts, components and software solutions to the International aerospace industry. The Bangalore cluster has been particularly dynamic from this point of view having been very successful in attracting two of the leading aerospace companies in the world, namely Airbus and Boeing to establish both research and manufacturing facilities in the cluster. The new policy on Special Economic Zones too have been very helpful in furthering the geographic spread of the Bangalore cluster to the periphery of the city of Bangalore thus relieving itself of the infrastructural bottlenecks that the city has now become rather notorious for.

Although India has a very clearly articulated policy and targets for the astronautical sector (see the government component of the SCI in Table 3), she does not have a clear policy for developing the aeronautical sector. The government hopes to turn this constraint into an advantage through the offset clause, mentioned in the Defence Procurement Procedure (DPP). It wishes to encourage private sector involvement, and is hoping to have $30 billion generated in offset opportunities. The effective implementation of such an offset policy can facilitate the absorption and indigenisation of foreign aeronautic technologies that accrue to the country by way of offset deals. In doing this, the government wishes to emulate the success of Brazil. Discussions with industry and an engagement with the relevant literature (Behera, 2009) shows that the government by fine tuning the offset policy can use public technology procurement as a policy instrument through which it can place the industry to a sure flight path to success. But the government seems to be too much preoccupied by the domestic aviation industry rather than the aerospace industry as such. Another area where concerted action is required is both in the quantity and quality of aerospace engineers although some efforts in this direction are already visible.

REFERENCES

Baskaran, A (2005) “From Science to Commerce: The Evolution of Space Development Policy and Technology Accumulation in India,” *Technology in Society*, Volume 27, Issue 2, pp. 155-179.

Behera, Laxman Kumar (2009) “India’s Defence Offset Policy,” *Strategic Analysis*, Vol. 33, No. 2, pp. 242-253.

Embraer (2009) *Embraer in numbers*, *http://www.embraer.com/english/content/imprensa/embraer_numeros.asp* (accessed March 9, 2010).

Frisctak, Claudio R (1994) “Learning and Technical Progress in the Commuter Aircraft Industry: an Analysis of Embraer's Experience,” *Research Policy*, Volume 23, Issue 5, pp. 601-612

Futron Corporation (2009) *Futron’s 2009 Space Competitiveness Index, A Comparative Analysis of How Nations Invest in and Benefit from Space Industry*, http://www.futron.com/resource_center/store/Space_Competitiveness_Index/FSCI-2008.htm (accessed March 5 2010).

Hindusthan Aeronautical Limited (2009) *Annual Report 2008-09*, http://www.hal-india.com/financials.asp (accessed March 5 2010).

Kasturirangan, K (2004) “Indian Space Programme,” *Acta Astronautica*, Volume 54, Issues 11-12, June 2004, pp. 841-844.

Malerba, Franco (2004) *Sectoral Systems of Innovation: Concepts, Issues and Analyses of Six Major Sectors in Europe*, Cambridge: Cambridge University Press.

Marques, Rosane Argous (2004) “Evolution of the Civil Aircraft Manufacturing System of Innovation: A Case Study in Brazil,” in Sunil Mani and Henny Romijn (eds.), *Innovation, Learning and Technological Dynamism of Developing Countries*, Tokyo: United Nations University Press, pp. 77-106.

Murthi, K.R. Sridhara, A. Bhaskaranarayana and H.N. Madhusudana (2010) “New Developments in Indian Space Policies and Programmes—The Next Five Years,” *Acta Astronautica*, Volume 66, Issues 3-4, pp. 333-340.

OECD (2007) *Space Economy at a Glance*, Paris: OECD.

PricewaterhouseCoopers and Confederation of Indian Industry (2009) *Changing Dynamics, India's aerospace industry,* New Delhi: Confederation of Indian Industry.

Rajan, Y (1988) "Benefits from Space Technology: A View from a Developing Country," *Space Policy*, Volume 4, Issue 3, pp. 221-228.

Ramamurthi, Ravi (1987) *State-owned enterprises in High Technology Industries, Studies from Brazil and India*, New York: Paeger.

Sankar, U (2006) *The Economics of India's Space Programme: An Exploratory Analysis*, Delhi: Oxford University Press.

Satheesh K G (2009) *Diffusion of Public Sector Innovation: The Case of Remote Sensing Technology in India,* Unpublished M.Phil dissertation, Jawaharlal Nehru University, New Delhi.

2

Production Linkages and Industrial Upgrading: Case Study of Indonesia's Automotive Industry

Haryo Aswicahyono and Pratiwi Kartika

Abstract

This study is on the subject of global production network and its impact on domestic industrial upgrading through technology spillover, using a case study of Indonesia's automotive industry. For this purpose, this study uses secondary data and conducts interviews of two business associations, seven autoparts makers, and one car manufacturer. The result indicates the importance of Japanese investors in the development of Indonesia's automotive industry and in the technological learning of Indonesian engineers. This implies a need for the Indonesian economy to remain open to foreign investors with the intention of continuing their contribution to the development of local industry and improvement of local capabilities. The MNCs' (Multinational companies) authority to allocate their activities across countries should also be a motivational factor for Indonesia to provide established industrial areas and international-quality service links in order to attract MNCs to locate their high value-added activities in Indonesia.

1. INTRODUCTION

The relationship between business network and industrial upgrading has been studied by many authors. Dunning (1993) shows evidence of the technology spillover brought by foreign direct investment. More specifically, Ernst (2004) argues that linkages through engagement in a global production network (GPN) stimulate innovation in companies engaged in that network. A survey of 150 manufacturing companies conducted in 2009 by Narjoko (2009) also finds that firms which have international linkages through foreign ownership have been more successful in industrial upgrading than domestic-owned firms. Extending these studies, this research tries to find evidence of that relationship in the Indonesian automotive industry. The research contributes to the general literature of this subject through insights from interviews of ten prominent institutions in the industry.

While Irawati (2008) focuses her study on knowledge transfer as a result of Indonesia's automotive cluster by using Toyota and Honda as case studies, this research examines supporting data on the involvement of Indonesia in the global automotive production network (GAPN), on the impact of that involvement to the occurrence of technology spillover, and on innovations carried out by Indonesian establishments. In addition, secondary data are also briefly analyzed to gain knowledge of the current situation and prospect of Indonesia's automotive industry.

This study finds that while Indonesia's automotive industry is involved in the global automotive production network, its involvement is in the lowest position in the value chain ladder, which is manufacturing/assembling. This is seen in the case of the foreign-brand non-sedan 4x2 cars,[1] which account for around 70 percent of the country's car sales. On average, these cars have 70 percent local content. However, in general, the main business activity of Indonesian companies is merely in assembling CKD (Completely Knocked Down)[2] and local parts.

The global linkage of the country's industry leads to knowledge transfer and innovation. The common knowledge transfer is in the form of training local engineers on how to run machines. However, there seems to be very limited transfer, if at all, in terms of the main technology and design of the automotive production system. Similar to innovation in other developing economies, innovation in Indonesia is mostly conducted in the production process for the purpose of cost efficiency. There seems to be minimal innovation on products.

This study also indicates a positive outlook for Indonesia's automotive industry

---

[1] Non Sedan 4x2 includes MPV (Multi Purpose Vehicle is a multi-passenger vehicle based on a car platform with maximized interior space, it is usually used by families and range in size from compact cars to almost van-like dimensions), City Car and SUV 4x2.

[2] CKD part is a fully disassembled item (such as an automobile, bicycle, or a piece of furniture) that is required to be assembled by the end user or the reseller. Goods are shipped in CKD form to reduce freight charged on the basis of the space occupied by (volume of) the item.

both for domestic and export markets. The motor vehicle's domestic sales and autoparts export have been growing fast after the recovery from the 1998 Asian financial crisis. Brief data analysis also suggests a more competitive Indonesian autoparts industry in the world for the last nine years or so. This competitiveness is supported by a policy environment that has removed trade and industry barriers.

The rest of the paper is organized as follows. Section 2 describes the theoretical framework of the study. It uses the value chain concept which refers to the value created by each activity in the global production and marketing network and the types of innovation possibly generated by engaging in the global network. Section 3 is the core of the paper which discusses Indonesia's automotive industry in terms of its market, competitiveness, business activities, level of innovation, and knowledge transfer. The effect of past and current government policies on the performance of the industry is also briefly discussed here. Finally, Section 4 draws out some policy implications based on the findings of the study.

2. THEORETICAL FRAMEWORK

2.1. Value chain

Although the value chain concept was developed back in the 1980s, it is still an important concept in industrial economics and in the business studies literature. Porter initiated the concept of value chain which is similar to the concept of production network in the economic development literature. Value chains can cover enterprises of a local, regional and also global economy. The structure and dynamism of the market value chain are essential factors because they can influence innovation possibilities of enterprises. Generally, low income or price elastic markets tend to stimulate innovation on processes while high income markets tend to stimulate product and functional innovation (UNIDO, 2004).

In terms of the value chain process in the innovation system, Figure 1 illustrates the type of value chain functions -- primary and secondary chain functions -- which drive innovation (UNESCAP, 2008). The primary value chain refers to the primary activities in the company while the secondary value function refers to activities that do not create the value directly but support primary value functions. Market, government, industry, university and society are the elements of this chain and their interaction activities are mostly about money, human resources, information and technology, among others. The actors' interaction meanwhile will constitute some sort of network. The network can be open or closed networks as well as local or global, and can be formed between users and producers (UNESCAP, 2008). The multinational companies are frequently piloting the network in the globalized economy. They distribute their production and research and development (R&D) units to the prospective locations and coordinate the global value chain process in order to achieve their business purposes.

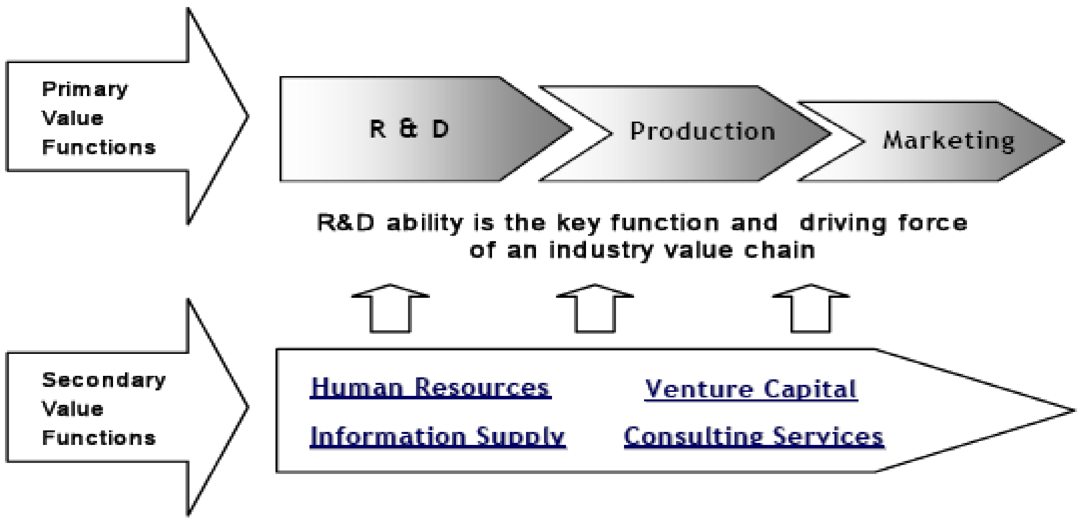


Figure 1 Value chain process in the innovation system

Source: UNESCAP, 2008.

The Happy Face graph below describes the value created by each stage in a firm's activities. The graph shows that manufacture and assembly create the lowest added value compared to other activities in the value-added process. Therefore, to generate higher value-added, firms could shift to the left, namely, standardization, innovation, R&D and design or shift to the right, namely, logistics, marketing and brand. Another alternative to generate higher added value is to move up, that is, to advance the firm's manufacturing technology. Thus, an economy could position itself to be an R&D/innovation centre or high value-added product and service centre or global logistics centre.

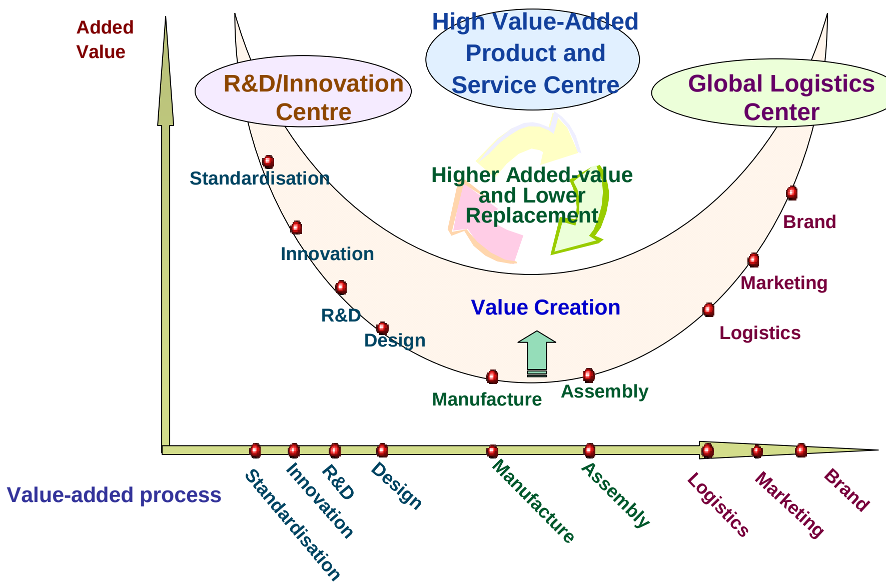


Figure 2 "Happy Face": conceptual model of the shift to a high value added and globally integrated economy

Source: Drake-Brockman, 2010.

2.2. Industrial upgrading and innovation

To create higher added value, firms should make efforts to attain industrial upgrading and/or innovation at any level. Many studies have expounded on industrial upgrading and innovation. The coverage of upgrading may include introduction of new products, higher capabilities in design and development, and improved and more integrated business process system (Aswicahyono et al., 2009). The concept of upgrading by Porter (1990) and Kaplinsky (2000) as cited in Giulani et al. (2003) and frequently used for examining competitiveness involves making better products, making them more efficiently or moving into more skilled activities. Gereffi (2005) specifically defines industrial upgrading as the process by which economic actors (nations, firms, and workers) move from low value to relatively high value activities in the GPN (Sturgeon and Gereffi, 2009).

Upgrading is firmly related to innovation. Upgrading which involves process, product and organizational innovation is a necessary condition to maintain or improve competitiveness. Thus, upgrading can also be defined as innovating activity to increase value added. Enterprises may achieve this condition in various ways; for example, by entering higher unit value market niches, by entering new sectors or by undertaking new productive (or service) functions (Giulani et al., 2003).

There are four types of upgrading which effectively describe the enterprises' works within the value chain, namely: process upgrading, product upgrading, functional upgrading and intersectoral upgrading (Humphrey and Schmitz 2000 cited in Giulani et al., 2003). Process upgrading is a type of upgrading which transforms inputs into outputs more efficiently by reorganizing the production system or introducing superior technology. Product upgrading is moving into more sophisticated product lines in terms of increased unit values. Functional upgrading is acquiring new and superior functions in the chain such as design or marketing or abandoning existing low-value added functions to focus on higher value=added activities. Meanwhile, intersectoral upgrading is applying the competence acquired in a particular function to move into a new sector

(Giulani et al., 2003).

In terms of innovation, Huiping et al. (2008) state four characteristics of technological innovation. One, technological innovation stimulates market innovation to conduct and change the structure of supply and demand. Technological innovation creates new demand to upgrade the industrial structure. It may also lead to economic growth, industrial development and improvement of people's living standards. Two, technological innovation requires institutional innovation to achieve policy adjustment. The benefits of technological innovation are obtained through the application and spread of technology and technology operation efficiency which determines the effectiveness of incentive mechanism (Huiping et al., 2008).

Three, an overflow and spread of innovative technology induces the transfer of comparative interests. When an innovative technology is being broadly commercialized, it will inevitably be accompanied by a spillover of innovation and the transfer of comparative interests. And four, technological innovation improves the core competitiveness of enterprises within industry. Technological innovation highly relies on the qualities and conditions of enterprises and takes effects ultimately through the improvement of core competitiveness of enterprises within industry. Hence, product innovation can develop new products, improve existing products, and optimize the variety of product structure. Meanwhile, process innovation can improve quality, increase the technical content and added value as well as optimize the product structure (Huiping et al., 2008).

3. DISCUSSION OF FINDINGS

3.1. Key findings from interviews and secondary data

3.1.1. On the Indonesian automotive industry: domestic, export, and the impact of government policies

The prospect for the Indonesian automotive market seems optimistic. Demand for cars and motorcycles is forecast to remain high in the coming years. This implies a bright outlook for motor vehicle/motorcycle industry and also for the autoparts industry as a supporting industry of the former. The market for both commercial and passenger cars is expected to remain promising in the years ahead following the buoyant forecast of the country's economy and given the poor condition of the country's public transportation. This positive outlook for the industry is based on data of motor vehicle sales which show a strong growth of more than 50 percent for the period 2002-09. This is in contrast with data in Japan where most of Indonesia's investors in the automotive industry come from, which show a reduction of around 20 percent for the same period. This might encourage the Japanese to shift parts of their business to emerging markets such as Indonesia.

The development of the autoparts industry follows the path of the motor vehicles/motorcycles industry. Indonesia's export of autoparts on average grew very well at 22 percent per annum for the period 2002-07 (Table 1). The largest contributor of total autoparts' export value is motor vehicle parts. However, data show that the motor vehicle parts export declined about 13 percent per annum during the period. The product which grew very fast during the period under study is gearboxes. According to Narjoko (2008), export of gearboxes could have been enhanced because the product's share in global export grew far higher than its share in Indonesia's total export for the period 2002-07.

Table 1 Indonesian Main Auto-parts Exports Performance, Average of the Period 2002-07

HS Code	Commodity	Value (Million USD)		Annual growth (%)	Export share of the main to overall products (average 2002-07)
		2002	2007		
	All auto-parts	**352.7**	**1160.5**	**22.1**	**100.0**
	Main auto-parts:	**261.9**	**724.0**	**20.2**	**72.9**
870899	Motor Vehicle Parts	141.7	213.0	-12.8	31.1
870870	Wheels, Parts and Accessories for Motor Vehicles	55.7	213.0	2.5	17.0
871419	Motorcycle Parts	45.7	73.4	-6.2	11.8
870840	Gearboxes for Motor Vehicles, including Parts of Gearboxes	0.6	210.0	73.9	11.5
851190	Parts of Electrical Ignition or Starting Equipment	18.2	14.6	-22.7	2.9

Notes: 1. All auto-parts are defined as a group of 36 auto-parts products, defined at six-digit HS Code level. The list and description of these products are presented in Appendix 1a.
2. Main auto-parts are defined as a group of the Top-5 Indonesian auto-parts products by their share of exports the total Indonesian auto-parts export. The all Top-5 exports account for about 70% of the total Indonesian auto-parts exports. The Top-5 products are identified in Appendix 1a.

Source: Narjoko, 2008.

Figure 3 illustrates the rapid increase of Indonesia's autoparts export starting from 2003; then the export began to stagnate and slightly turned down in 2005. The figure is consistent with the data on the number of autoparts manufacturing plants which doubled from 1995 to 2007 (Table 2). The Indonesian autoparts industry seems to be relatively competitive in the Southeast Asia region. Table 3 shows that the Revealed Comparative Advantage of the country's products increased from 2000 to 2007 and was relatively higher than that of Malaysia, the Philippines and Thailand in 2007. This is consistent with data on the relative export share of 2007 to 2000 which shows a slightly more than two-fold increase of Indonesia's export share of said products in the world. All these reinforce the idea of Indonesia's involvement in the GAPN.

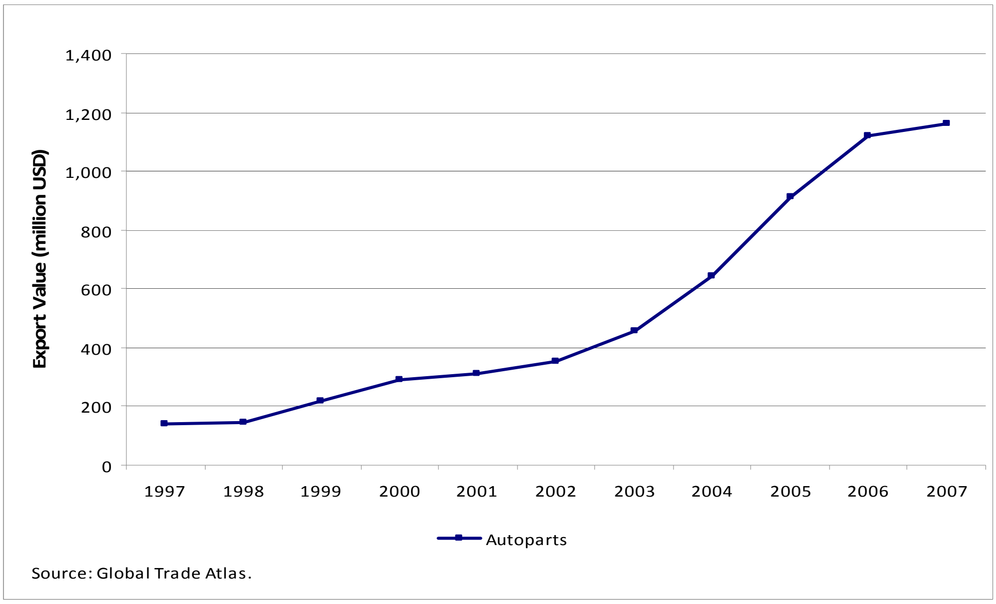


Figure 3 The trend of the Indonesian auto-parts exports, 1997-2007

Source: Narjoko, 2008.

Table 2 Number of manufacturing plants in Indonesia, 1995 and 2007

	Motor vehicle bodies	Motor vehicle component and apparatus	Motor vehicles	Motorcycle component and apparatus	Motorcycles	Total automotive
1995	124	121	14	47	4	310
2007	84	200	18	162	24	488

Source: Central Bureau of Statistics.

Table 3 Competitiveness of the Indonesian Main Auto-parts Exports, Average of the Period 2002-07.

Reporting Country	RCA		World export share (%)		Relative export share (2007 to 2000)
	2000	2007	(1) 2000	(2) 2007	- Ratio of (2) to (1) -
Indonesia	1.21	1.39	0.2	0.5	**2.18**
Malaysia	0.97	0.86	0.1	0.2	**1.76**
Philippines	1.23	1.34	0.5	0.7	**1.57**
Thailand	1.40	1.33	0.6	1.8	**3.02**

Source: Narjoko, 2008.

Government policy has historically affected the development of the country's automotive industry. Policies in the 1970s forbidding the import of Completely Built Up (CBU) cars and requiring certain local content seem to contribute to the current existence of Indonesia's automotive factories, surely at the cost of protection. The Indonesian automotive industry is claimed to have started in 1974 when the policies were implemented (Irawati 2008). The present policy however supports business competitiveness in the industry. This more or less began in 1999 when the government removed the local content requirements and reduced other trade barriers. In 2006, import duty on autoparts of cars for export market was eliminated permanently and in 2007, import duty on raw materials for autoparts industry was abolished temporarily. In addition, Indonesia's automotive sector seems to have gained from the ASEAN Economic Community (AEC) liberalization scheme because the sector is claimed to have made the most of the AEC scheme among the twelve priority sectors.

The past government policy, together with the change due to 1998 Asian financial crisis, had shaped the performance of automotive business in Indonesia. Regarding ownership and division of responsibilities, it seems that the heavily foreign-owned companies conduct the manufacturing while their domestic partners concentrate on distribution. For instance, Mitsubishi Krama Yudha Motor and Manufacturing (MKM), which is 65 percent owned by Japanese, carries out the manufacturing while Krama Yudha Tiga Berlian, the MKM's domestic partner, focuses its activities on sales and marketing. Likewise, Suzuki Motor Corp., a heavily Japanese-owned firm, does the manufacturing while Indomobil Niaga International, the Suzuki's domestic partner, is responsible for the domestic sales and marketing (Pasha, forthcoming).

3.1.2. On the activities, business upgrading and linkages of Indonesian automotive firms

In general, the main activity of Indonesian automotive companies is assembling, either intermediate goods, e.g., autoparts, or final goods, i.e., car and motorcycle. The technology is mostly from Japan obtained through companies' sharing ownership with technology-advanced Japanese companies, purchasing of license and machineries from foreign firms, and engaging as suppliers of large and technology-intensive firms. Majority of the inputs of the Indonesian firms are imported CKD parts. Thus, the car/motorcycle firms merely assemble the CKD parts into final goods ready to be marketed to consumers. Likewise, nearly all autoparts makers only assemble the inputs with technology purchased/provided by consumers for the products supplied to those consumers. This kind of activity seems to be the nature of the Indonesian automotive manufacturers.

The role of the local manufacturers is significant in a way that a large proportion of the manufacturers' products is to serve domestic market. The autoparts makers produce parts for cars and motorcycles to be largely sold in Indonesia. Similarly, assemblers of final goods produce cars and motorcycles which have considerable market shares in the country. Non sedan 4x2 is the type of car which has around 70 percent market share of total car sales. The local content of this kind of car is also about 70 percent. This fact may show the existence of a local automotive industry. Furthermore, Daihatsu has just expanded its investment in Indonesia for the country to be its second largest production base after Japan. Given this information and the fact that all of the manufactured cars are under foreign brand, it may be reasonable to argue that Indonesia's automotive industry has participated in the GPN to some extent.

In the GPN, the major activity conducted by the Indonesian automotive firms seems to be in the lowest rung in the value chain ladder, which is, as mentioned earlier, in the manufacturing/assembling industry. Other activities such as R&D, innovation, design, logistics, and global strategic marketing are mostly handled by parent companies which are generally in Japan. The interviews find a company which has started to be involved in design and engineering but this seems to be more the exception rather than the rule in the prevailing cases of the Indonesian companies. Majority carried out innovation only in car accessories and production process. The innovation in car accessories is usually merely small modification to adjust to the domestic market's requests. The innovation in production process aims to reduce production and logistic costs. For instance, in the shortcutting production stages, utilization of scraps of inputs thereby reducing waste, and decrease in the volume-to-weight ratio of containers. This kind of innovation highlights the importance of service links such as delivery service and hard infrastructure in supporting business engagements in the production network.

This result strengthens the argument raised by UNIDO (2004) that low-income countries tend to innovate in production process, not in the product and function. The reason is perhaps that firms in emerging countries such as Indonesia aim to increase quantity of production to serve the growing market. Meanwhile, firms in high-income countries aim to produce higher value-added products by developing new products.

Technology transfers through global-local linkage do happen although the technology transferred is not the main production know-how such as the design and machineries for the creation of a car's system. The spillover seems to be taking a form of knowledge transfer to Indonesian engineers on how to operate and do maintenance of machines in the factories. Knowledge transfer is also via the application of Japanese work ethics to its Indonesia-located companies. Although this knowledge spillover cannot be considered negligible, it is also interesting to note that employees in the Japanese-owned firms seldom move to other firms, e.g., the pure domestic-owned firms or starting his/her own business using skills acquired from the Japanese employers.

Majority of the autoparts companies serving Japanese car producers as first-tier suppliers have capital tie-ups with Japanese companies. There is a slight suspicion among the interviewees that there are some unknown barriers in the Japanese-principal production network that exclude the requirements on quality, cost, and delivery. Because of this, some autoparts makers shift their strategy to after-market activities, i.e., producing products for general markets. Furthermore, after-market became a lucrative market after the 1998 Asian financial crisis when people began to shift their autoparts purchase from authorized dealers to general retailers.

3.1.3. Excerpts from interviews

The interviews were conducted from January-February 2010 among 10 institutions. Two of these institutions are the business association of autoparts & components producers and the business association of motor vehicle producers; six are car parts and components producers; one is a motorcycle parts producer; and another is a car producer. Among the seven autoparts makers, six are Original Equipment Manufacturers (OEM) which act as first-tier suppliers to final goods establishments and the other does transactions in the after-market.

Among the chief functions of business associations are collecting data from their members and advocating policies to the government, particularly the Ministry of Trade and the Ministry of Industry. The motor vehicle association has a larger participation of foreign investors in the domestic firms resulting from the acquisition of domestic shares in the aftermath of the 1998 Asian financial crisis. The autoparts & components association, meanwhile, noted that there seems to be some secrecy among the Japanese investors in terms of their main production technology. However in general, both associations scrutinize government policies which are perceived to be non-supportive of their members such as in the imposition of luxury tax on premium cars.

(i) Firm 1

Products: Passenger Car

Main Characteristics: Large and Joint Venture

Firm 1 was established in 2001. Before 2001, Nissan products had been widely distributed in Indonesia through a local automotive business group. Gradually, Firm 1 began to operate in Indonesia independently of the local business group in manufacturing and distributing vehicles with a joint venture capital consisting of 80 percent foreign and 20 percent domestic capital. The 20 percent domestic capital is owned by the local business group which previously functioned as Nissan's distributor. Firm 1 employed around 100 permanent workers and about 300 temporary workers in 2001. The increase in Firm 1 sales led to an increase in the number of employees to about 300 permanent workers and 500 temporary workers in 2010.

In Indonesia, Firm 1's core operation is the assembly/assembling of cars with multi-sourcing inputs (Figure 4). According to the respondent, this form of operation is due to the tax benefit gained from assembling CKD parts in the country rather than from importing CBU units. The majority of inputs are from Thailand and Japan, and a small amount of inputs (less than 20%) come from local suppliers which are mostly affiliated with Japanese companies such as tire from Dunlop and Bridgestone or the rim of wheels from Enkei.

Innovations created by Nissan Global aim to cut the logistic cost and implement green policy. Therefore, the innovations in Nissan take the form of enhancing efficiency in the delivery of inputs and taking into account the volume-to-weight ratio of containers. These policies are discussed and disseminated every year in Nissan's global meeting, and applied in all Nissan companies globally. Innovation in Nissan's product is also carried out according to requests and demands from the regional market. In Indonesia, as an example, the market demands a vehicle capable of carrying many passengers and being efficient in fuel consumption. This kind of vehicle is designed by Nissan's R&D centre abroad and is then produced in Indonesia. Nissan has four R&D

centers in four large economies, i.e., Japan, China, Europe, and the United States. Innovation at the local level which is conducted by local engineers is merely modification of car accessories. For the production process, the innovation is shortcutting the production process with the purpose of meeting high demand.

Firm 1 also employs local suppliers for supplies used in stamping and seat tailoring as well as for bumpers and rims of wheel. Firm 1 has around 30 suppliers; 40 percent of which are big and joint venture companies. The production operation of these suppliers conforms with Nissan’s global standard. Some of them use inputs supplied by Nissan.

Nissan has two approaches in choosing suppliers. One, for several parts and components, the suppliers are assigned by Nissan Motor Ltd. (NML) in Japan. These companies supply the products for NML in Japan and Nissan companies in other regions/countries. The suppliers’ branches will supply to Nissan located in the corresponding country. For example, the tire in Nissan’s vehicle is supplied by Bridgestone for Nissan X-Trail and Dunlop for Nissan Grand Livina. And two, Nissan will conduct an open bidding for the supplier. The steps in the bidding are as follows:

1. Nissan announces the specification and drawing details of the product supplied.
2. Potential suppliers will then submit the sample of their product together with the quotation.
3. Nissan will test the quality and cost of the product supplied (if it conforms with the minimum standard of Nissan called Nissan Design Standard (NDS)).
4. If the product does not meet the standard, potential suppliers will be asked to make appropriate improvements. Potential suppliers which meet the standard will be given opportunities to revise their quotation in accordance with the cost required.
5. Nissan will choose the supplier.

Firm 1 does not provide training or capacity building for the suppliers because they are chosen based on their capability (that meet Nissan's standard). In this case, Firm 1 only provides tools. Occasionally, there are a few Nissan engineers who visit the local supplier companies, and vice versa. Meetings to discuss Nissan's goals are held annually to maintain the business relationship.

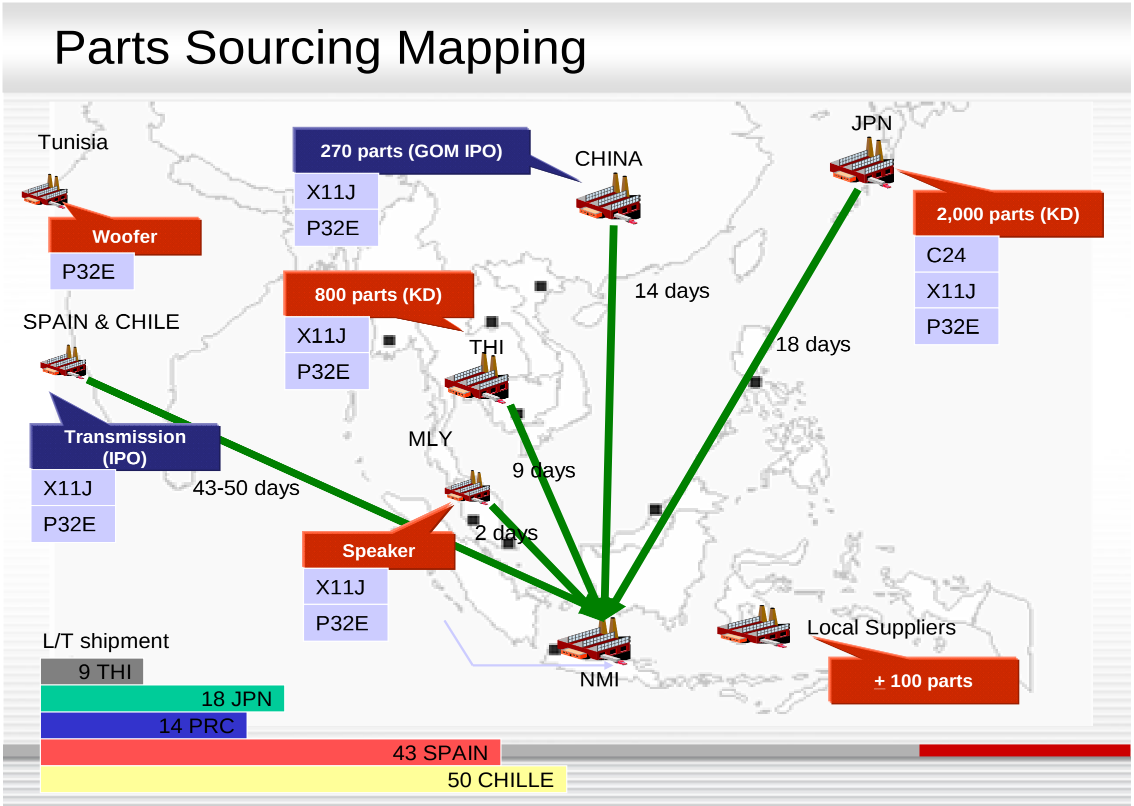


Figure 4 Firm 1 Parts Sourcing Mapping

Source: Firm 1, 2010.

(ii) Firm 2

Products: Engine for commercial trucks; Body parts

Main Characteristics: Large and Joint Venture

The company was established in 1973. At that time, the company produced both passenger cars and commercial cars. However, production of passenger cars was stopped due to severe competition. After several mergers and acquisitions resulting from internal changes in the firm and developments in the world market, the company is now currently owned by four shareholders. Two of them are domestic investors while the other two -- the major shareholders -- are Japanese and German. The German’s share is through its ownership of a Japanese-based company.

The firm’s activity is engine assembling and truck body stamping. Its production is based on order from its affiliated company (KTB) which is the domestic minor shareholder of the Firm 2. The affiliated company handles the sales and marketing of the final products. It also imports parts and components from Japan to be supplied to Firm 2 as inputs (Figure 5 and Figure 6).

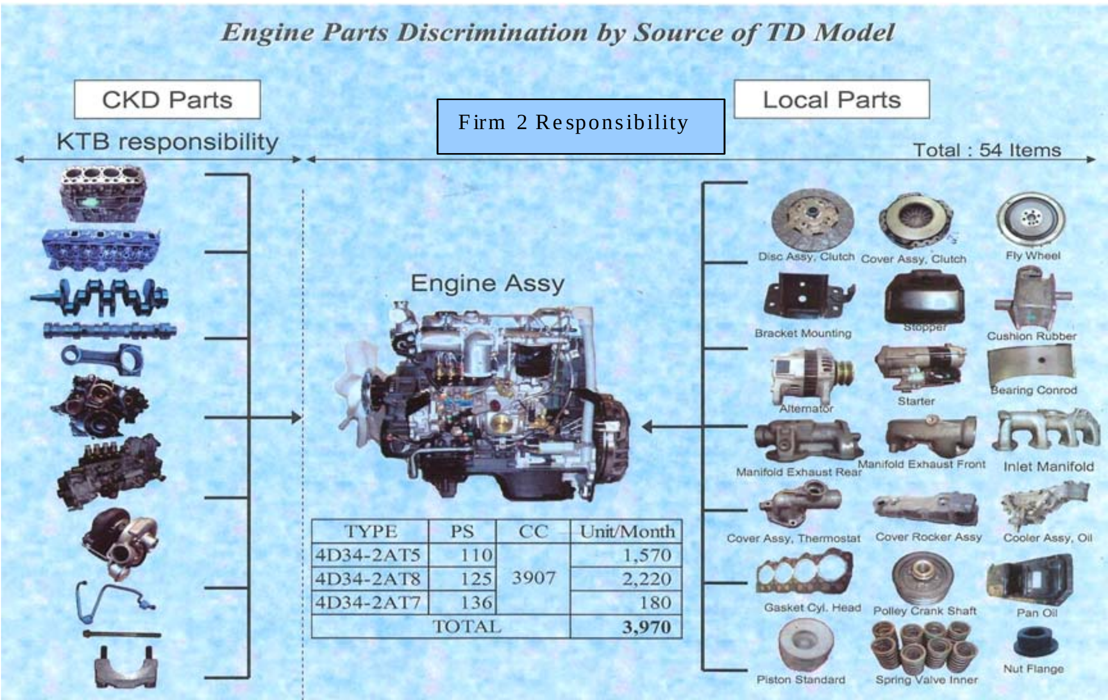


Figure 5 Engine Parts of Firm 2

Source: Firm 2, 2010.

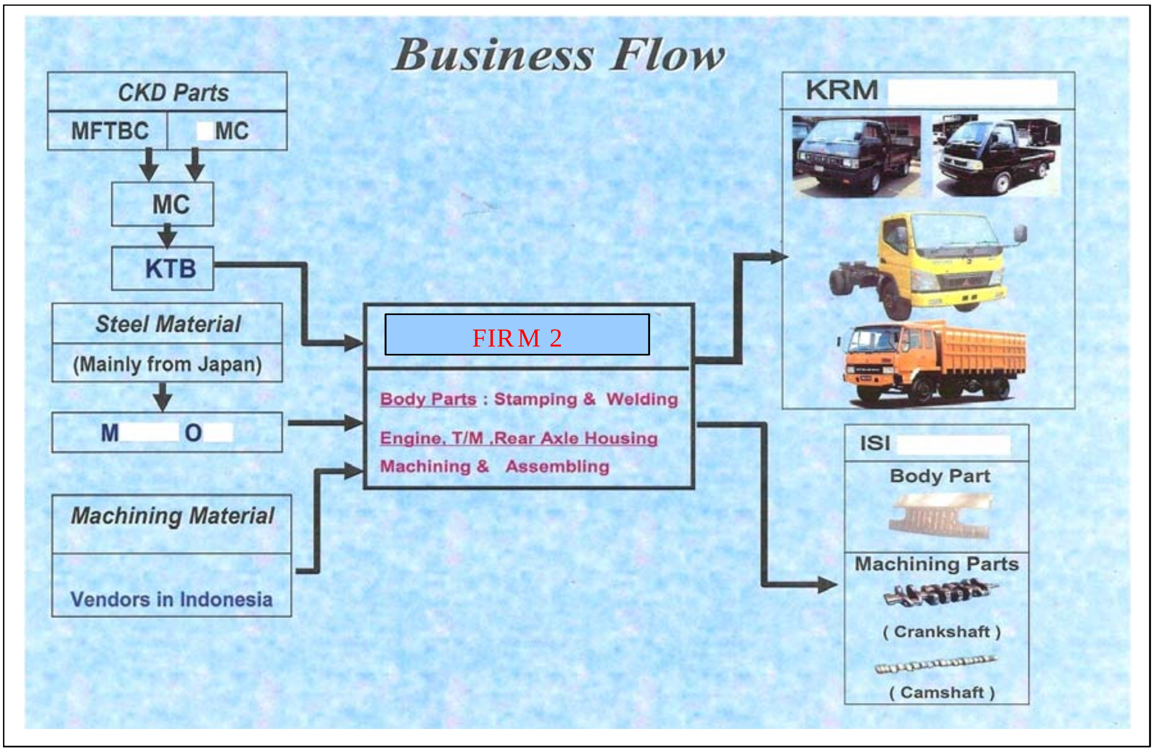


Figure 6 Business Flow of Firm 2

Source: Firm 2, 2010.

The rest of Firm 2's inputs are supplied by local vendors. These local vendors have been supplying Firm 2 for decades on average. Some of them are also joint venture and medium or large companies. Therefore, training among these local vendors is not often conducted. It is only done when there is a new adopted technology or special products ordered to the vendors. However, interestingly, retired engineers from Firm 2 are most of the times employed by the domestic vendors. This seems to be the knowledge transfer mechanism in the global-local linkage.

Firm 2's technology is from its parent company in Japan. This technology is transferred to Indonesia's factories through the exchange of engineers. Eight Japanese are stationed in Firm 2 in Indonesia for the positions of director and manager. Furthermore, every year, Indonesian engineers are dispatched to Japan for around two months to learn the production process and the operation of new machines.

In general, Firm 2 does not conduct R&D except for minor modifications. Products are sometimes modified due to specific domestic conditions such as the lack of certain inputs. Modifications are also carried out to improve yield rate (known as 'budomari' in Japan). For example, innovations were made to optimize the use of materials and therefore reduce wasted scraps. It is noteworthy to mention that Firm 2 revitalized some of its machines as a result of the German's acquisition of the Japanese company which previously owned Firm 2.

(iii) Firm 3

Products: Frame chassis and press parts

Main Characteristics: Large and domestic firm

Firm 3 was established in 1980, owned by two local business groups. The company produces two autoparts, namely, frame chassis and press parts. The company supplies its products to Mitsubishi (46%), Toyota (17%), Nissan (5%), Hino (3%) and others (29%). Included in "others" is Firm 4. The products are supplied mostly for the domestic vehicle production and only a small amount from total production is directly exported overseas.

Currently, Firm 3 is in the process of capturing a new customer, i.e., Volvo India. For this customer, Firm 3 has to compete in an open bidding with China and Thailand. The information about this potential customer is obtained from Nissan as one of the firm's customers since part of Nissan's ownership has been acquired by Volvo.

Firm 3 produces several types of products because each customer requires a different standard. Particularly for the export requirement to Volvo India, the company plans to invest in new machineries to produce the product being demanded. However, apart from this, there has been no significant innovation in the company since its establishment. According to the respondents, the reason is that the technology currently used in the company is capable enough to produce the product.

The company’s value added is 35 percent, which is relatively large compared to the value added generated by other companies under the same business group. Another 65 percent constitute raw materials as input of the product. This input is mostly imported from Japan, Thailand and China. Therefore, the company’s finance depends largely on exchange rate. However, the company explained that it has no problem in getting the imported input so far, either from the regulation side or from the supply of the raw material.

(iv) Firm 4

Products: Front and Rear Axle; and Propeller Shaft

Main Characteristics: Large and domestic firm

Firm 4 was established in 1982, and is owned by three local business groups. Each of the two business groups has 40 percent share of the company. One of these two is also the owner of Firm 3. The other owner business group has 10 percent share of the company. The company produces products with 18 percent value added. Firm 4 imports 30 percent of its input while the rest of the input comes from local companies. Included as suppliers are Firms 5 and 6.

Firm 4 produces two autoparts, i.e., Front and Rear Axle, and Propeller Shaft. The propeller shaft has 67 percent local content. Its products are supplied to Daihatsu (53%), Toyota (35%), and others (12%). The customers provide Firm 4 with technical assistance. The customers’ affiliated companies, namely, Toyota Motor Corp., JTEKT, and Akashi–Kikai sell royalties to Firm 4.

The innovation for design of products started in 2005, which was a big improvement for the company. The company made the design of a propeller shaft for one of Daihatsu’s car, Gran Max. The innovation led to a major development for the company as the car is highly demanded by the local market. Usually, designs for Firm 4 products are given by customers, and Firm 4 only manufactures according to the given designs. The innovation in the product design comes from Astra's vision as the parent company of Firm 4. The design of the propeller shaft for Daihatsu took 1.5 years. In the process, one of Firm 4's staff was sent to the United Kingdom (UK) to study autoparts and the testing of the product.

Common Features of Firms 3 and 4

Firms 3 and 4 are under a business group. Their products do not have competitors in Indonesia. The owner asked for protection of their products in the 1980s. The protection was abandoned after the 1998 Asian financial crisis but up until now, there has not been a new player in this market because the investment in this industry is high. In general, the main business activity of Firms 3 and 4 is merely the assembly/assembling of CKD and local parts with existing design and technology. The business processes of the firms are depicted in Figure 7.

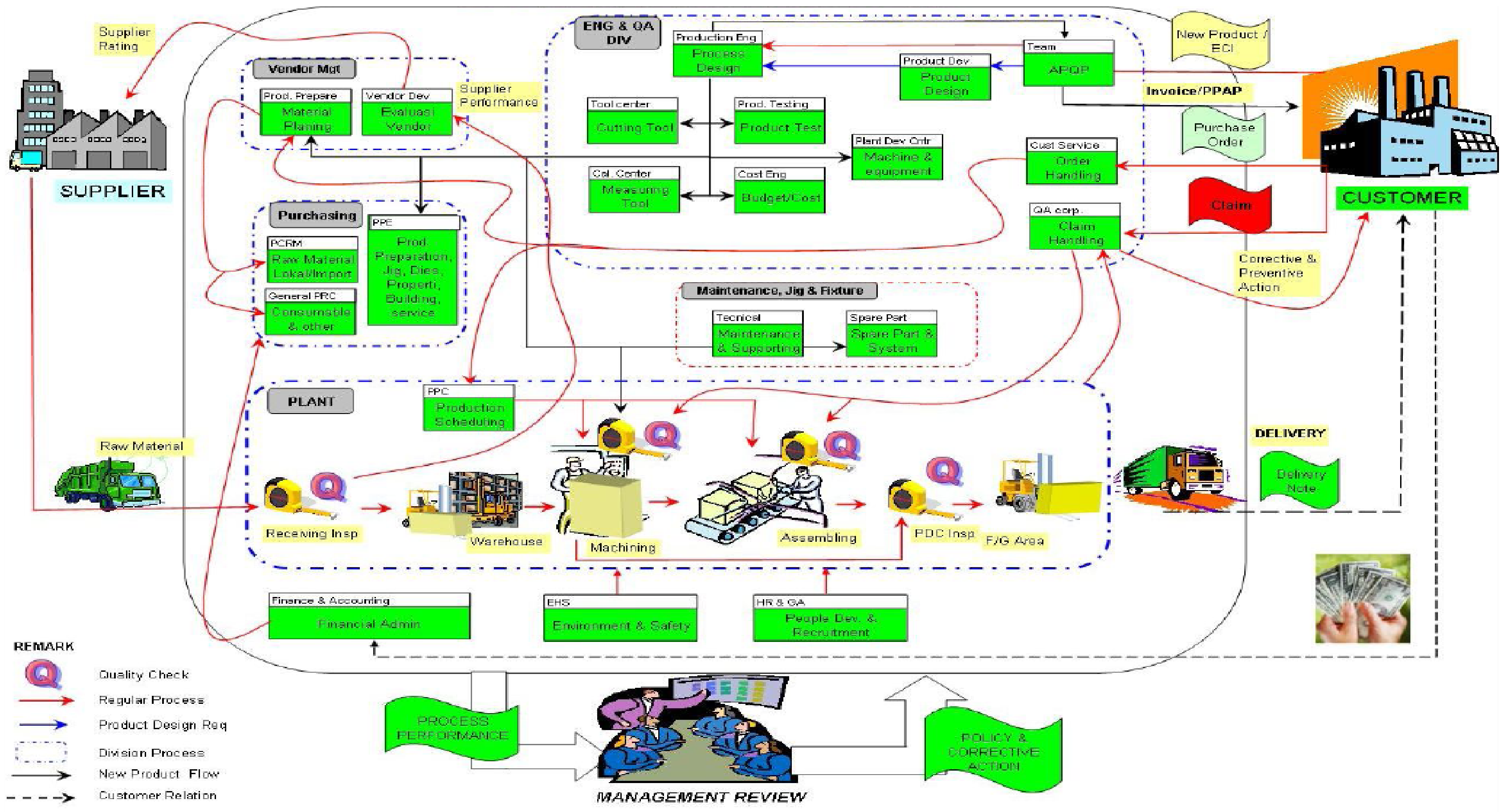


Figure 7 Business Process of Firm 3 and 4

Source: firm 3 and 4, 2010.

(v) Firm 5

Products: Differential manufacture

Main Characteristics: Medium and Joint Venture

Firm 5 is characterized as a medium firm since it has 67 full-time employees. The firm was established in 2005. The capital structure of Firm 5 is joint venture where Japan has 74 percent of ownership. Meanwhile, 26 percent is owned by a local firm which is Firm 4. The Japanese shareholder has a capital tie-up with Daihatsu Motor Corp. Japan which is strongly affiliated with Daihatsu Indonesia.

Moreover, Firm 5's value added is 18 percent and about 70 percent of its inputs are imported from Japan. This company is dedicated to supply autoparts to Daihatsu Indonesia. However, in the firm's business cycle, the autoparts that it produces should be supplied to Firm 4 first before sending them to Daihatsu. The reason for this is because Firm 5's products should be merged or equipped with Firm 4's products.

(vi) Firm 6

Products: Transmission manufacture

Main Characteristics: Large and joint Venture

Firm 6 is a joint venture company which is owned by a Japanese firm (51%) and a local business group (49%). The Japanese firm has a strong affiliation (*keiretsu)* with Daihatsu Motor Corp. Japan. Meanwhile, the local business group is the group that also owns Firms 3 and 4. The Japanese ownership is through the acquisition in 2006 after the firm was left by its most important customer, Toyota. At that time, Toyota moved its car's transmission operation to the Philippines.

Similar to Firm 5, all the products of Firm 6 are exclusively supplied to Daihatsu Indonesia after they are sent to Firm 4. Firm 6's value added is worth 15 percent. The local inputs of the products are only 20 percent while the other 80 percent are sourced from imports.

Common Features of Firms 5 and 6

Both Firms 5 and 6 confirmed that the major problem of their business is the exchange rate. This is understandable because most of the inputs come from other countries. In the meantime, they engage in cooperation with local suppliers based on the following requirements: quality, cost, and delivery. The selection of suppliers needs an approval from the respective Japanese shareholders and the whole process of selection takes more or less one year. The technology used by both firms originates from their Japanese shareholder. There are two Japanese who are working in each of the two firms. Furthermore, technology spillover in both firms also takes place through the training of local engineers held in Japan.

Common Features of Firms 3, 4, 5, and 6

Firms 3, 4, 5 and 6 are firms under one business group. They are located in one large area and have a total number of 2057 workers. Their production has reached full capacity. In relation to domestic suppliers, they have a division of vendor management which tackles difficulties concerning domestic vendors and the evaluation of their performance (Figure 7). Unlike other manufacturing firms, these companies basically do not have problems with road and transportation because as the most important customer, Daihatsu Indonesia picks up the orders from the companies and the companies' inputs are delivered by their suppliers.

(vii) Firm 7

Main Products: Automotive batteries

Characteristics: Large and domestic-owned company

The firm's initial owner is Indonesian and it started its operation in Indonesia in 1991. In 1997, the firm was merged with another automotive battery company whose 50 percent share is owned by the Japanese. The company is now being managed by the initial owner and has the status of a domestic-owned company.

Its distribution of sales is 20 percent for the domestic market and 80 percent for the export market. The marketing of around 60 percent of its sales is conducted by its affiliated company in Japan. Most of its exported products are therefore shipped to Japan and then redistributed to other countries around the world.

The products are sold in after-market, i.e., automotive batteries for the replacement of used batteries. The firm does not supply car manufacturers such as Japanese branded car manufacturers because of several problems. One, the car producers ask for a relatively low price of batteries compared to the after-market segment. Competition among battery producers is severe because being a supplier for the car producers could leverage the branding of the batteries. Two, meeting requirements of the car producers takes time and is costly. For example, the batteries need to pass initial testing in Japan for about one year. And three, few car producers tend to choose companies from their business groups to be their suppliers.

Roughly 95 percent of inputs are imported and the other 5 percent are supplied by domestic producers. The firm has a Vendor Development Program which aims to assist its domestic suppliers in terms of quality control. The assistance includes dispatching engineers and giving trainings to the domestic subcontractors. As for the international suppliers, the firm does not have this kind of relationship because the firm imports natural mining resources from other countries.

Production of the firm jumped 2.5 times from 2004 to 2009 owing to China's protection of its timber resources and the firm's brand recognition in the world market. The surge in the world's demand has encouraged the firm to upgrade its production and managerial systems. The upgrading has been in many aspects of the production process such as in the re-arrangement of the factory layout, adoption of international standards, increase in the batteries' life time, improvement of the quality of batteries' calcium plate, and many others.

It is also worthy to note that the company began with 1500 workers but since 1998, the number of workers has gradually declined until it reached 950 in 2010. However, as mentioned above, the production did not decrease but instead increased substantially. This is because the firm renewed its machines and is now planning to change its machines for automated ones which can give another 50 percent increase in the firm's production in 2013.

Having discussed the drivers of the upgrading, it is obvious that the source of new technology and industrial upgrading is the firm itself. The firm reports that recruiting local mid-career engineers contributes considerably to the company's improvement. The incentive for the firm to expand its production capacity is the prospect of a large market.

The Japanese buyer has its representative stationed in the company to control the production quality. However, according to the company's director, this kind of assistance has only served to limit the contribution to the company's advancement of technology.

(viii) Firm 8

Main Products: Motorcycle's parts and components

Characteristics: Large and domestic-owned company

The company's product is sold only to its affiliated company located in the Greater Jakarta area. The company produces motorcycle parts and its customer produces the motorcycles by assembling all the parts and components.

The company's inputs are both imported and purchased from local suppliers. The local suppliers are large and foreign-owned which sell products only to this company. The suppliers are not allowed to sell products to the retail market. The company provides detailed instruction, including the mould, dice, and drawing to the suppliers. The suppliers' performance is also evaluated frequently and transaction can be discontinued if the performance is not satisfying.

The firm does not conduct R&D. The technology is obtained through purchasing license from its parent company in Japan. The firm purchases its machines from its parent company and sends its engineers to Japan to learn the operation of the machines.

4. POLICY IMPLICATIONS

In sum, from the demand side, the Indonesian automotive market is booming while from the supply side, production could still be boosted due perhaps to the current limited number of automotive establishments. At present, one of the study's firm respondents is Indonesia's only producer of propeller shaft, a part that is absolutely needed in every car. This opportunity should draw the government's attention to create a conducive policy environment that would attract business to tap this chance.

The study also reveals the importance of foreign investors' role, particularly the Japanese, in this industry. Their large ownership shares in the Indonesian automotive firms require their role as principals to manage the firms' activities in each part of the world. As such, Indonesia should therefore open up its economy, particularly in terms of the investment and trade policies in order to keep them doing business in the country.

Furthermore, the significance of the Japanese's role in the industry jibes with the UNIDO study (2004) which indicates that MNCs allocate their production base and

R&D centers in the most suitable and favorable location for each activity and coordinate the global value chain's process for their corporate purposes. Consequently, Indonesia should offer enough attraction to influence the MNCs' decisions to locate the high value generating activities in Indonesia. Measures to build up its attractiveness could be categorized according to Deardoff's study (2001) on GPN, namely production block and service links. Constructing an established production block may mean making attempts to have areas with easy access to capital, market and information of products, market condition, and technology. The country's education system is vital in order to produce qualified human resources. High-skilled human resources and protection of intellectual property rights are critical factors needed by companies carrying out R&D and innovation. In addition to these, international-quality service links should be ensured by providing inexpensive telecommunication and transportation.

REFERENCES

Aswicahyono, Haryo, Pratiwi Kartika, Mochamad Pasha, and Widdi Mugijayani (2009) "Research Report of a Firm-level Survey on Innovation and Upgrading," *ERIA Related Joint Research Paper*, Bangkok Research Center, JETRO and CSIS.

Dunning, J.H. (1993) *Multinational Enterprises and the Global Economy*, Wokingham: Addison-Wesley.

Ernst, Dieter (2004) "Global Production Networks in East Asia's Electronics Industry and Upgrading Prospects in Malaysia" in S.Yusuf, M.A.Altaf, and K.Nabeshima (eds.), *Global Production Networking and Technological Change in East Asia*. Washington DC: The World Bank, 89-157.

Giuliani, Elisa, Carlo Pietrobelli, and Roberta Rabelloti (2003) "Upgrading in Global Value Chains: Lessons from Latin American Clusters," *Clusters, Value Chains and Competitiveness Project Paper*. AGORA 2000 Italy and the Micro and SME Division, Department of Sustainable Development (SDS/MSM) of the Inter American Development Bank (IDB).

Huiping, Huang, Yang Zhenhua, and Zhao Yulin (2008) "On the Mechanism of Technological Innovation: As the Drive of Industrial Upgrading," *School of Economics, Wuhan University of Technology.*

Irawati, Dessy (2008) "Technology and Knowledge Capability in the Global Automotive Production Network: Knowledge Transfer Process in the Indonesian Automotive Cluster," *Newcastle University-Business School.*

Narjoko, Dionisius A. (2008) "Mata Rantai Nilai Industri Alas Kaki, Furnitur, Perlengkapan Rumah Tangga, Komponen Otomotif dan Garmen," *Laporan Daya Saing Ekspor 2008*, USAID, SENADA, *pdf.usaid.gov/pdf_docs/PNADN191.pdf (*accessed February 2, 2010).

Narjoko, Dionisius A. (2009) "Industrial Agglomeration and Technology Upgrading and Innovation: the Experience of Indonesia," *ERIA Related Joint Research Paper*, Bangkok Research Center, JETRO and CSIS.

Pasha, Mochamad and Setiati, Ira. (Forthcoming) "A Case in International Production Networks and Trade Liberalization: Indonesia's Automotive Industry," Chapter in ARTNeT Regional Study on Multilateral Trade Liberalization and Regional Integration.

Sturgeon, Timothy J., and Gary Gereffi (2009) "Measuring Success in the Global Economy: International Trade, Industrial Upgrading, and Business Function Outsourcing in Global Value Chains," *Transnational Corporations*, Vol. 18 No. 2, August 2009.

UNESCAP (2008) “SME and Innovation System,” *UNESCAP*, *www.unescap.org/tid/publication/indpub2507_chap4.pdf* (accessed on January 15, 2010).

UNIDO (2004) “Inserting Local Industries into Global Value Chains and Global Production Networks: Opportunities and Challenges for Upgrading with a Focus on Asia,” *UNIDO Working Paper*, Vienna: UNIDO.

3

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

Avvari V. Mohan

Abstract

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

1. INTRODUCTION

Penang, a small island state in the northern part of Malaysia adopted a strategy somewhat akin to industrial clustering in the 1970s and was been able to reap much economic benefits from its industrial cluster. It has been recognised as one of the top ten most unique industrial clusters in the world by the United Nations. Penang can be considered as an industrial cluster /agglomeration, particularly for the Electrical and Electronics (E&E) sector. This report seeks to understand the innovation activities that firms in Penang are involved in and also what are the linkages that these firms have with different actors in the regional (within Penang) / national innovation systems for supporting their move into Innovation related activities.

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

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

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

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

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

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

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

2. AGGLOMERATION AND PRODUCTION NETWORKS FOR UPGRADING AND INNOVATION

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

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

Table 1 Penang: Economic Indicators

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

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

2.1. Some general Malaysian Trade and Labour issues

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

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

2.2. Labor Force and Employed - Malaysia 2003-2008

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

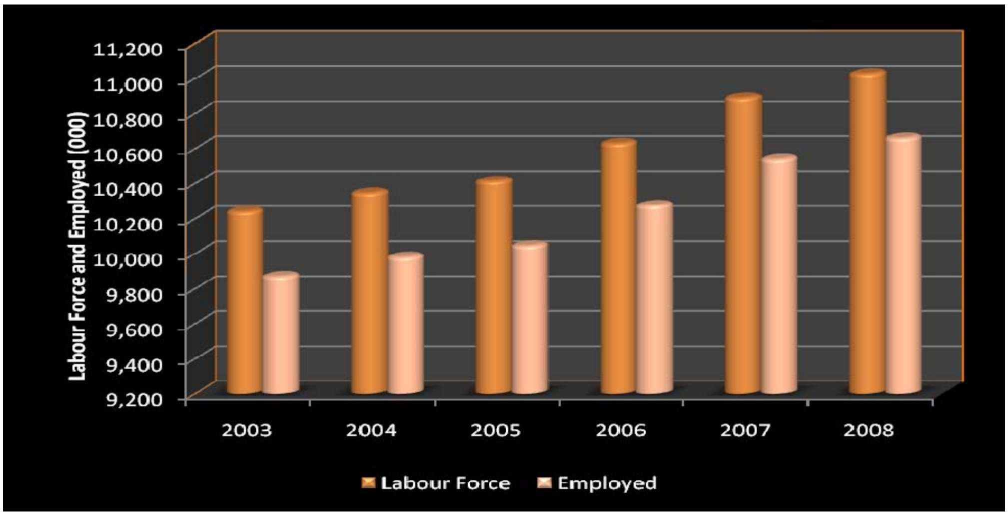


Figure 1 Labour Force in Malaysia from 2003- 2008

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

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

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

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

Table 2 Structure of the E&E Industry

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

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

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

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

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

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

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

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

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

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

Table 5 PENANG: APPROVED MANUFACTURING PROJECTS

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

Source: MIDA Penang.

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

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

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

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

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

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

2.5. Education Indicators to support Innovation

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

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

One of the important indicators for Innovation, be it in from the 'Innovation Systems view or the more recently popular 'Open Innovation' framework is sources external to the firm. Be it links with customer or suppliers, other institutions and variety of sources of information are important for Innovation to take place within an organisation. Overall the more prevalent forms of innovation, as indicated by the firms participating in the survey, improvements in products or process developments – and while for process developments there are factors outside the firm as sources – both new product developments and product improvements seem to be based on sources within the firms.

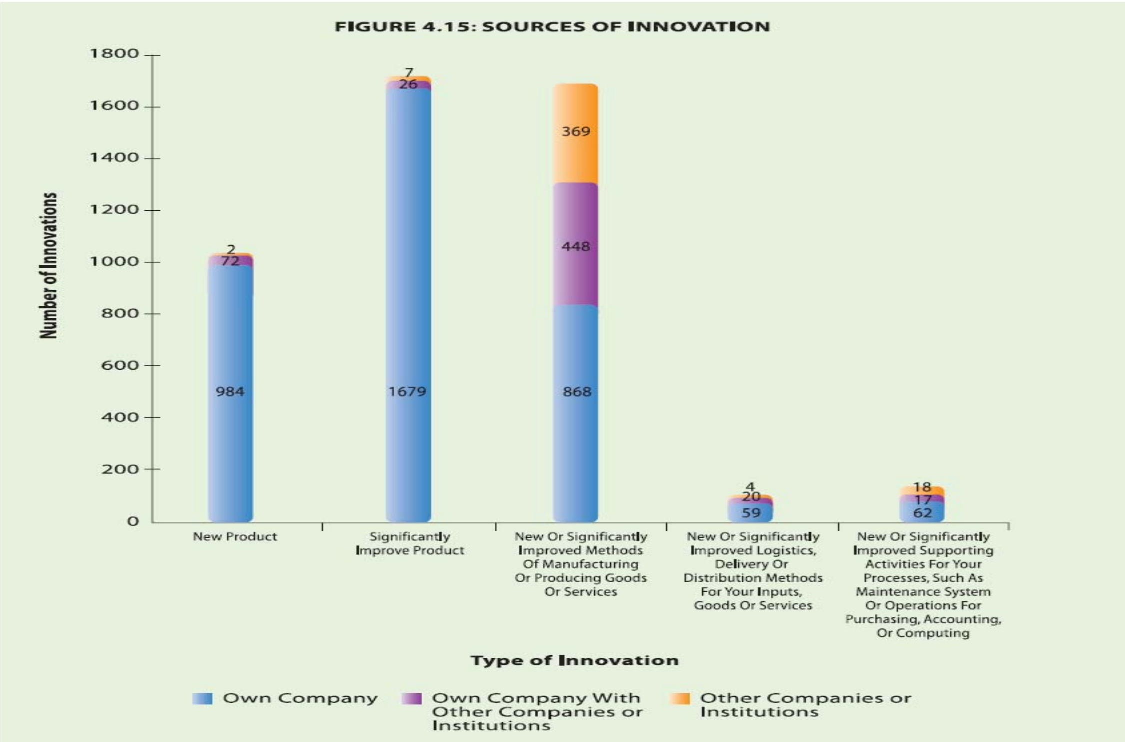


Figure 2 Sources and Type of Innovation among Malaysian Firms in general

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

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

2.7. Government Policy for Upgrading and Innovation

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

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

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

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

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

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

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

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

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

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

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

Table 6 Structure and Content of Innovation Policy – Malaysia

<table>
<tr><th colspan="2">Fiscal Instruments</th><th rowspan="2">Non-Fiscal Instruments</th></tr>
<tr><th>Tax Incentives
for R&D</th><th>Research Grants</th></tr>
<tr><td rowspan="5">There are nine different types of tax incentives</td><td>Industry R&D Grant Scheme (IGS)</td><td rowspan="5">Not Clearly Articulated</td></tr>
<tr><td>Technology Acquisition Fund (TAF)</td></tr>
<tr><td>Multimedia R&D Grant Scheme (MGS)</td></tr>
<tr><td>Intensification of Research in Priority Areas</td></tr>
<tr><td>Commercialization of R&D Fund (CRDF)</td></tr>
</table>

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

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

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

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

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

3. CASE STUDIES

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

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

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

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

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

3.1.1. Factors Attractive in Penang for Manufacturing

In addition to the factor of low costs, the altruistic nature of the firm was to set up manufacturing plants developing economies to help them through employment opportunities and gain the benefit of low cost locations. Main motivation to start in Penang (in the 70s) was the efforts of the then Chief Minister – to promoting and developing certain factors conducive for setting up of manufacturing plants – the location factors including availability of cheap labour and supportive policies of the federal government and good infrastructure. Starting as a manufacturing unit for exports, GAE Penang moved into R&D (product development) and now is an independent subsidiary responsible for design, manufacturing and marketing car multimedia and navigation products under its umbrella.

3.1.2. Types of and Motivations for Innovation

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

3.1.3. Key Drivers and Support for Innovation

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

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

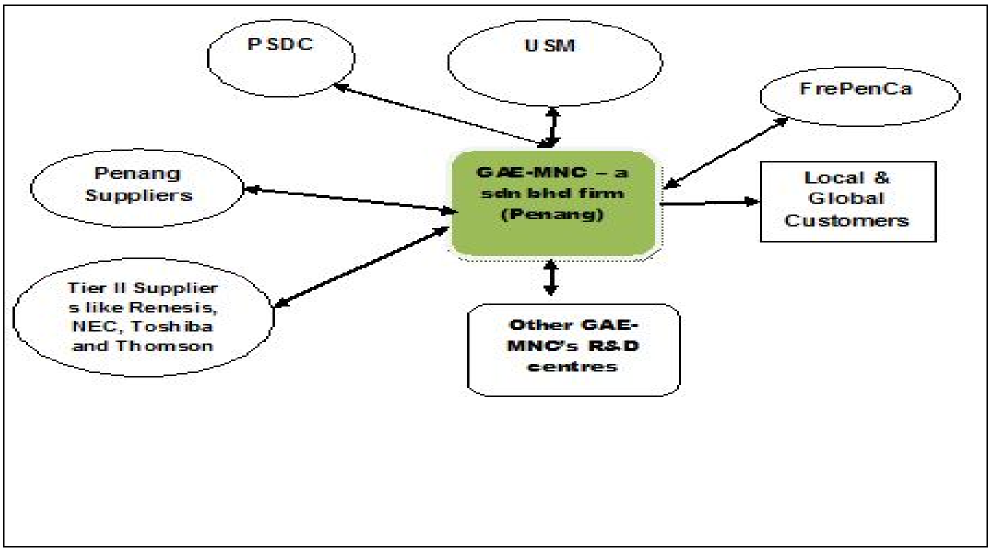


Figure 3 Diagram of Firms Linkages of the GAE MNC in Penang

3.1.4. Linkages or Collaborations

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

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

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

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

3.1.5. Issues in Policies related to Innovation

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

3.1.6. Conclusion

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

3.2. Case # 2 - Intel Malaysia

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

3.2.1. Factors Attractive in Penang

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

3.2.2. Innovations at Intel Penang

More than 70% of the global design and development work at Intel is at the Penang facility. Among the more recent innovation is the Pine Trail platform, the next version of the company's successful Atom line, which reduced the number of chips in the Atom chipset down to two from three. Intel will start production of its 32-nanometre process technology under the 2010 Roadmap, with the 32-nanometre West mere processors designed to deliver higher integration and energy-efficient performance.

Intel Malaysia Sdn. Bhd - Products and Services

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

Source: Bernama Times website (http://www.btimes.com.my/Current_News/BTIMES/articles/20091125174808/Article/index_html accessed on January 25th 2010) and Interview).

3.2.3. Support for Innovation

The main sources for Innovation at Intel are their own laboratories around the world and also several consultants that Intel hires on project to project basis. Key institutions that are supportive to Intel for Innovation include the MIDA and MOSTI at the national level and PSDC and to a smaller extent USM, the cluster university.

3.2.4. Linkages and Collaborations

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

3.2.5. Issues in Linkages / Collaboration

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

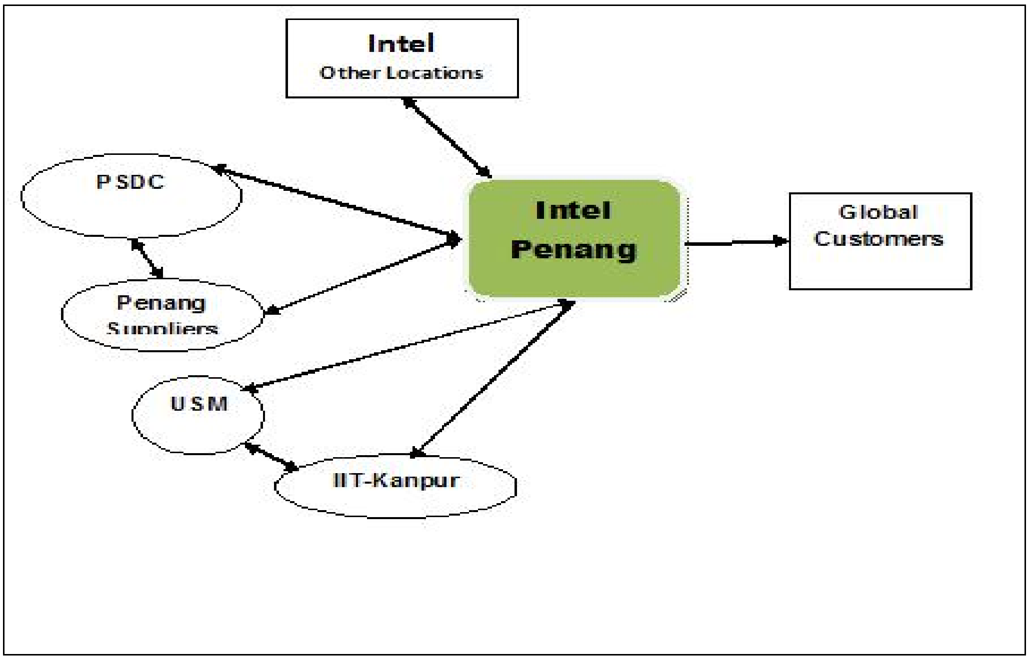


Figure 4 Diagram of Intel-Penang's Linkages

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

3.2.6. Conclusion

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

3.3. Case #3 - Eng Teknologi Holdings Bhd

Engtek Group is a home-grown Malaysian primarily involved in precision engineering and manufacturing. The Engtek Group currently comprises seven key operating subsidiaries of which three are based in Malaysia, and one each in the Philippines, China, Singapore and Thailand. The Group has an annual sales in excess of RM240 million and its cumulative investments over the years have exceeded RM200 million. It started operations in 1974 in Penang and is considered amongst the top precision engineering and manufacturing supply chain players for the electronics industry in the Asia Pacific region. Eng Teknologi Holdings Bhd (ETHB), the Group's parent company, is located in Penang and serves as the regional headquarters. It is listed under the technology section on the Main Board of the Kuala Lumpur Stock Exchange (KLSE). Eng Teknologi's Integrated Engineering Centre has manufacturing facilities of more than 75,000 sq. metres with approximately 1,000 units of CNC machines – which are strategically located throughout Asia Pacific Region, enabling it to meet its customers' specific requirements. This case is focused on Eng Tekhnologi's business encompassing the design & manufacturing of quality precision components and assemblies which are categorized into the global Data Storage Group (DSG).

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

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

3.3.2. Types and Motivations for Innovation

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

3.3.3. Key Drivers and Support for Innovation

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

3.3.4. Linkages or Collaborations

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

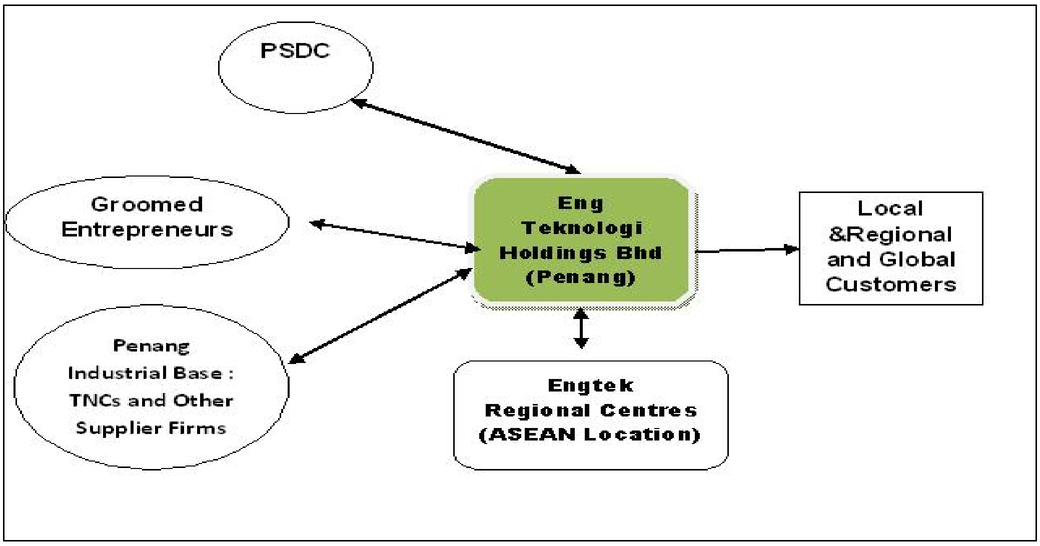


Figure 5 Diagram of Firms Linkages of Engtek Penang

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

3.3.5. Issues in Policies related to Innovation

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

3.3.6. Conclusion

Overall the main support factor for innovation are skilled manpower base in Penang, a strong industrial base - with a mix of TNCs and local firms – offering support as customers and also as suppliers. Support from governments is in terms grants, tax reliefs, and development of infrastructure. Key actors in the region/cluster include TNCs, PSDC and the government. Although they have had experience in a joint venture (with Adventist of Japan in mid 90s) they prefer to ‘go it alone’ in upgrading their activities from manufacturing to design and development.

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

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

3.4.1. Types and Motivations for Innovation

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

3.4.2. Key Drivers and Support For Innovation

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

3.4.3. Linkages of Innovation

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

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

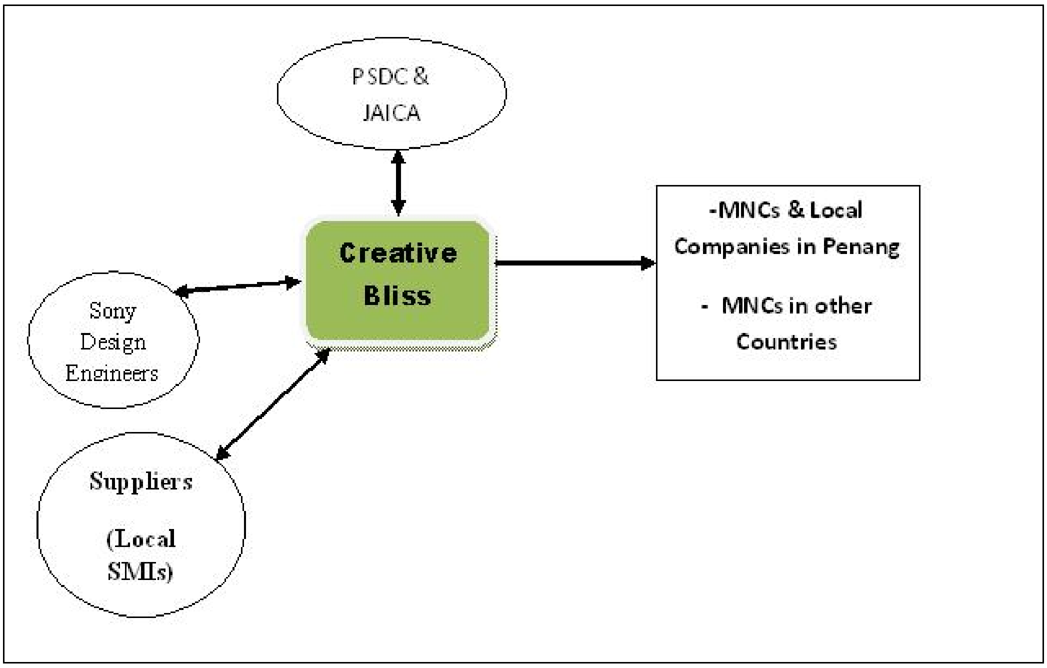


Figure 6 Diagram of Creative Bliss' Linkages

3.4.4. Issues in Policies related to Innovation

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

3.4.5. Conclusions

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

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

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

3.5.1. Factors Attractive in Penang for Manufacturing

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

3.5.2. Types of Innovation and Motivations for Innovation

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

3.5.3. Key Drivers and Support For Innovation

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

3.5.4. Linkages or Collaborations

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

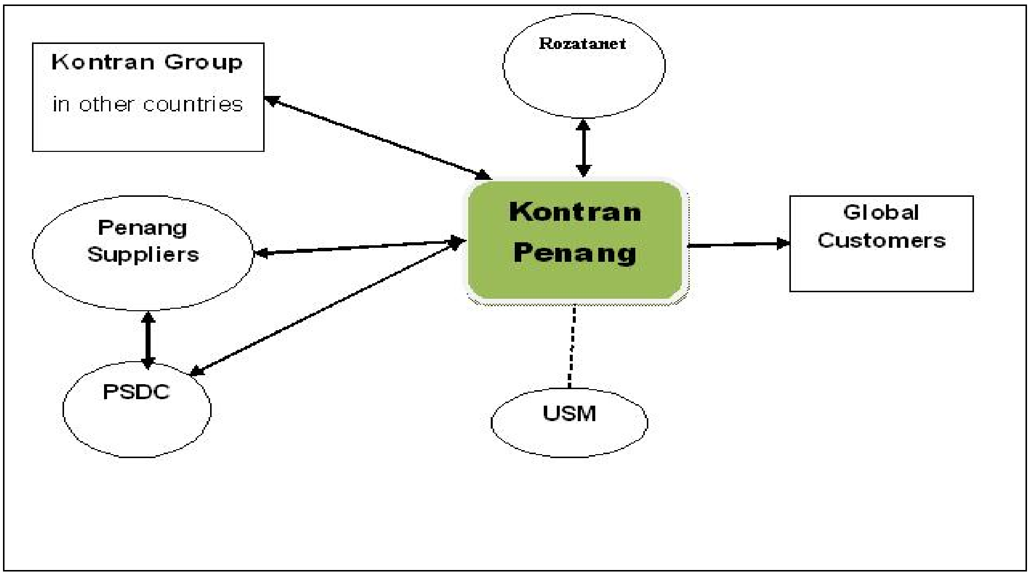


Figure 7 Diagram of linkages for Kontron (Penang)

3.5.5. Issues in Policies related to Innovation

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

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

3.5.6. Conclusion

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

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

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

XYZ (SDD TECH.) Penang has a new facility built on 10.5 acres of land, of which 6 acres are currently utilized. The plant currently has a built-up area of 210,000 sq feet which houses manufacturing cells and SMT lines, as well as an R&D laboratory, offices, and other amenities including a multiple conference rooms equipped with full video conferencing facilities to manage the global integration of XYZ (SDD TECH.)'s business. XYZ (SDD TECH.) is currently experiencing growth and evidenced through recruiting additional engineers and manufacturing-based employees to support the company's production ramp. XYZ (SDD TECH.) is also hiring R&D engineers to complement the existing R&D team in Penang. The R&D team in Penang is engaged in advanced ASIC & firmware Design and Implementation as well as New Product Prototyping. The team also performs Product Level Testing.

3.6.1. Product and Services

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

3.6.2. Drivers and Support for Innovation

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

3.6.3. Linkages and Collaborations

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

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

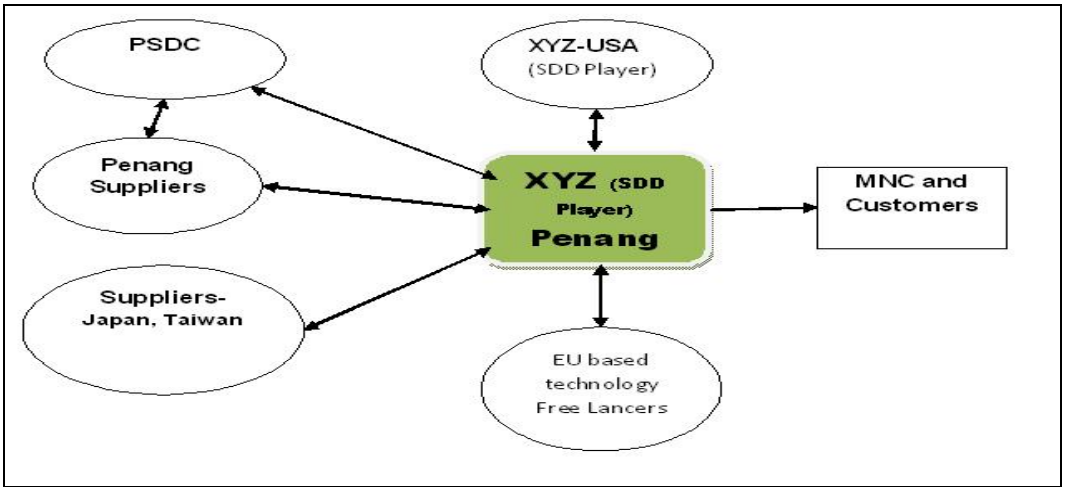


Figure 8 Diagram of XYZ (SDD TECH.) - Penang Linkages

3.6.4. Issues in Collaboration and policies for Supporting Innovation

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

3.6.5. Conclusion

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

3.7. Case #7 – ViTrox Corporation Bhd

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

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

3.7.1. Motivation and Drivers for Innovation

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

3.7.2. Support For Innovation

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

3.7.3. Collaborations

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

There is both direct through the PSDC linkage – for training facilities and indirect support also as PSDC provides training and skill development support for the local supplier base. There is some linkage with the cluster university. There is strong linkage with a university (Multimedia University) located in the ICT cluster of Cyberjaya – joint projects with the faculty there and also student internships are the innovation supporting activities. This linkage has important implications for other such firms for supporting R&D in the E&E sector. There is also a link with a university in the USA for technology development (through the US office).

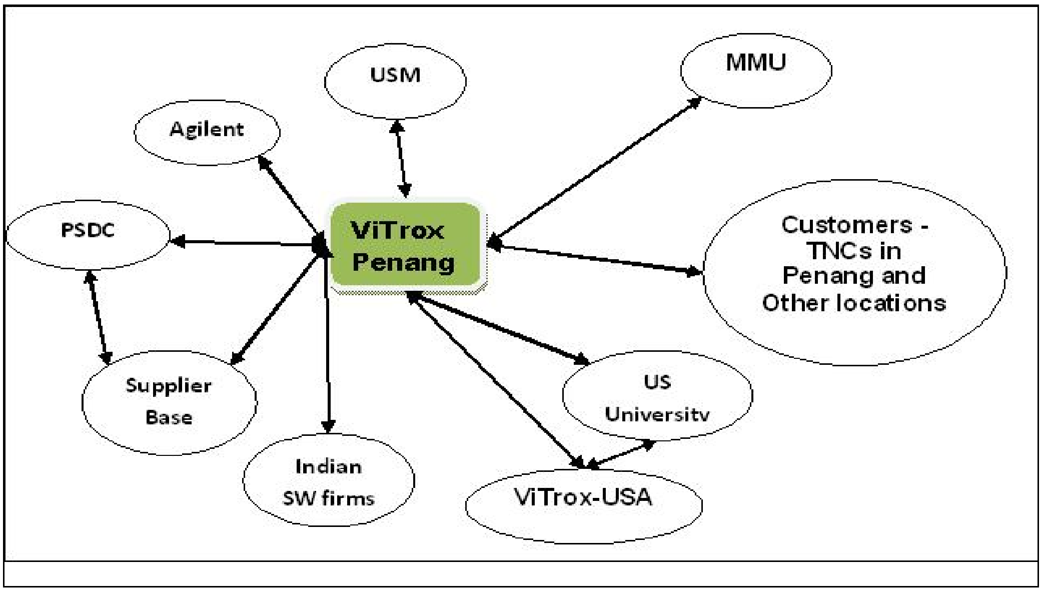


Figure 9 Diagram of ViTrox Linkages

3.7.4. Issues in Collaboration and Conclusions

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

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

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

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

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

3.8.1. Factors Attractive in Penang for Manufacturing

Mayang chose Penang to setup its manufacturing unit due to the availability of skilled technical staff and cheap labour, and low operation costs. Supportive policies of the federal government and good infrastructure in Penang also helped Mayang to start its production quickly. The presence of a large TNC base as a market was a critical factor. Though the initial operations were mainly in manufacturing, later Mayang started distribution of laboratory and high-end technical equipment.

3.8.2. Types and Motivations for Innovation

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

3.8.3. Support for Innovation

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

3.8.4. Linkages of Innovation

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

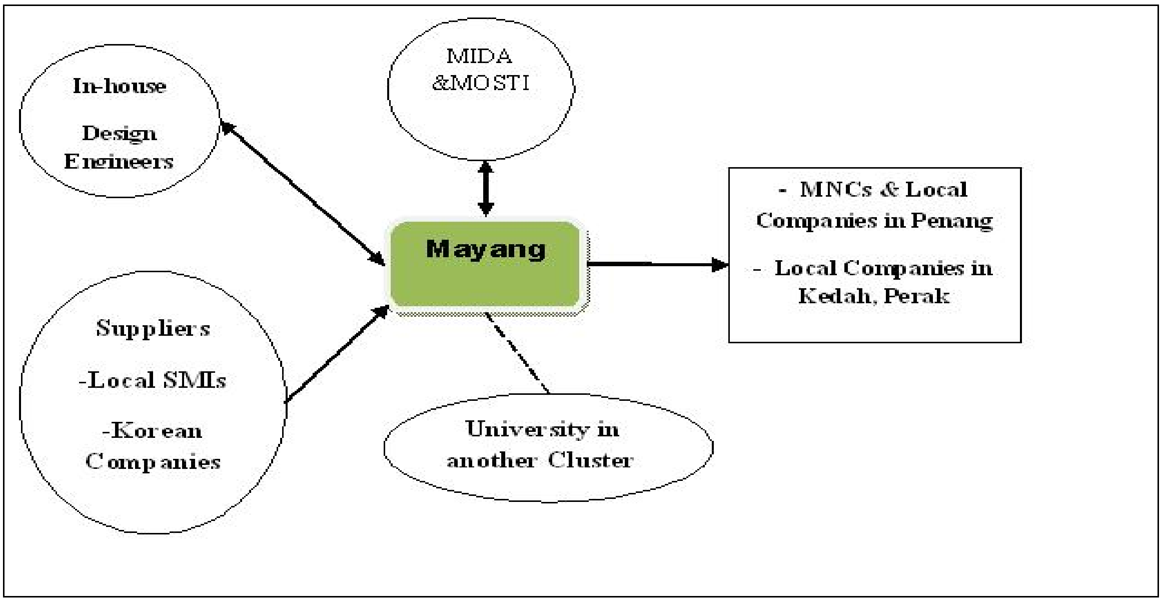


Figure 10 Diagram of Mayang Linkages

3.8.5. Issues in Linkages/Collaboration

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

3.8.6. Conclusion

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

3.9. Case #9 - Motorola Malaysia

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

Each of these laboratories perform specific stringent product tests ranging from transmissions levels and unwanted noise to product stress and durability levels to ensure that they are compliant within the industry's standard regulations requirements. Motorola is considered the leading communication vendor offering solutions compliant with two industry leading open standards – TETRA (TErrestrial Trunked RAdio) and APCO P25 (Association of Public-Safety Communications Officials Project 25). A large volume of Motorola's TETRA and APCO P25 systems, professional two-way radios for both mission and business critical use, mobiles, accessories are designed and produced in Penang for the worldwide market. Motorola's prime focus is to strongly promote 'Made in Malaysia' (MIM) products and solutions designed and manufactured in Penang for the global markets and Malaysia.

3.9.1. Support for Innovation

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

3.9.2. Linkages and Collaborations

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

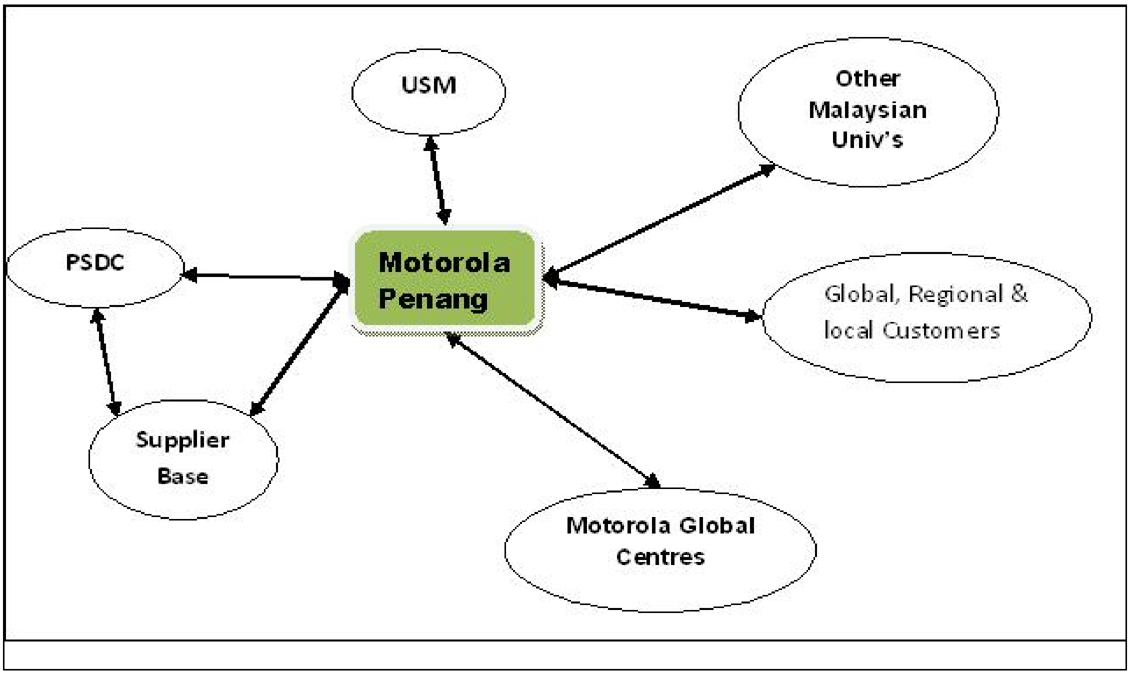


Figure 11 Diagram of Motorola Linkages

3.9.3. Conclusion

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

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

4. SUMMARY OF FINDINGS AND DISCUSSION ON CASE STUDIES

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

4.1. Innovation Activities and Motivations for Innovation

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

4.2. Information For Innovation Activities

The MNCs had extensive internal sources of data – databases of key publications in their area of interest, participating in key conferences, intra-group meetings, links to universities at the HQ. Among the local firms - while all did use the internet in general – also checked out information on competitors' as a source of information for innovation. One of them sought more information from the MNC within the cluster with whom it co-develops products and also uses academic journals in the area of its research. A second local player had developed linkages with independent / free lance researchers in EU as its important source in addition to their office in USA being a base for information for innovation. One of local firms which has internationalized - has regular intra-group seminars / conferences. All the firms depend heavily on customers as the major source of information for driving innovation.

4.3. Collaborations /Cooperation Issues

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

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

One of the key institutions in Penang with which all the firms have some form of association is the Penang Skills Development Corporation (PSDC) – which is credited for training operators needed for the manufacturing part of the firm and now training higher level skills personnel for the Design function also – and in addition providing some facilities for testing. Linkages with universities within / near the cluster are generally for student internships and they are seen as suppliers of manpower. An MNC (involved in consumer electronics) has stronger links with the University for accessing services (including testing and analysis work). Dispatching or acceptance of technical personnel amongst the firms within the cluster is nonexistent – in the case of MNCs and local firms with international presence (one has manufacturing plants and design centre across the region and the others have a 'US' office) there is extensive movement of engineers between their different global locations.

4.5. Obstacles for Innovation

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

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

4.6. Public Policies Supporting Innovation Activities

Overall the current policies – be it related to infrastructure development, tax incentives, Grants etc are all considered critical for the moving up the value chain into design and development activities by the firms in Penang. Key institutions at the national level include the Ministries for Intl Trade and Industry (MITI) and Science, Tech. and Innovation (MOSTI), MIDA – the industry development authority. The policies that have attracted MNCs to have a major presence in the cluster are important – the MNCs play multiple roles – as a employers of qualified engineers, as large customers, as developers of supplier firms, as developer of human capital (one of the local R&D firms calls it the ‘musical chair movement’ of high caliber engineers from MNCs to local firms).

4.7. Differences between TNCs Vs Local Firms

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

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

4.8. Differences for Linkages for Product Differentiation Vs Cost Reductions

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

4.9. Cultural Factors

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

5. CONCLUSION AND RECOMMENDATIONS

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

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

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

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

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

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

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

5.2. Attracting Consultancy Firms into the cluster

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

5.3. Promotion of Policy and Incentives Available for Innovation

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

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

5.4. Entrepreneurial Culture for Innovation

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

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

REFERENCES

Chandran V.G.R, Rasiah R and Wad P. (2009) "Malaysian Manufacturing Systems of Innovation and Internationalisatin of R&D," Working Paper # 11. *CBDS Working Paper Series.*

Freeman, C. (1995) "The 'National System of Innovation' in Historical Perspective," *Cambridge Journal of Economics* 19: 5-24.

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

Lye King,T and Avvari V. Mohan (2010) Factors of Regional Innovation System to help firms move up the Value Chain –A Multi-stakeholder Study in Penang Cluster to be presented at *ASIALICS Conference* 2010. Taipei.

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

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

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

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

<u>Information and Statistics related to S&T Indicators and R&D Activities were gleaned from the portal of Malaysian Science and Technology Information Centre</u>
www.mastic.gov .my

Appendix A

Science and Technology Incentives from Government of Malaysia.

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

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

→ INDUSTRIAL AND R&D GRANTS

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

Some of the grants provided are explained below

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

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

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

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

→ LOAN & VENTURE CAPITAL

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

S&T TAX INCENTIVES

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

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

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

In-house R&D

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

R&D Company

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

➔ HCD FUNDS

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

APPENDIX B

Statistics of Student Enrolment in Public and Private Educational Institutions

(MALAYSIAN SCIENCE AND TECHNOLOGY INDICATORS 2006 REPORT EDUCATION IN SCIENCE AND TECHNOLOGY. www.mastic.gov.my accessed *January 20th 2010*)

Statistics of Enrolment and Graduation in Public Educational Institutions

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

Enrolment and Graduation in First Degree Courses at Public Educational Institutions

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

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

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

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

Enrolment and Graduation in Doctoral level Courses at Public Educational Institutions

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

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

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

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

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

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

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

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

4

Case Study of the Electronics Industry in the Philippines: Linkages and Innovation

Mari-Len Reyes-Macasaquit

Abstract

The Philippine electronics industry is one of the most critical industries in the Philippines. In 1996, it has surpassed the agriculture sector as the top export earner of the country and has not been toppled from that position ever since. In its more than three decades of existence, the industry has concentrated on the lowest segment of the value chain, assembly and testing, and have seemingly created a niche in this area, particularly in semiconductor electronics. However, this study found that even in that position, electronics firms in the Philippines have done upgrading covering products, processes and substantial organizational innovation. There were exceptional firms that have moved up the value chain and into design and more advanced production processes. The location of these firms, indeed, the industry's concentration in CALABARZON has enabled the transfer and exchange of knowledge coming more strongly from the production side, than from the holders of knowledge such as the academe, research institutions and other sectors. The participation of the firms in the regional and global production networks have also contributed to their upgrading efforts. In turn, the industry has transformed the region into a manufacturing/industrial hub that augured well for local economic development. This study which looked at cases of ten electronics firms located in CALABARZON provides detailed account of inter-firm production linkages and collaboration with knowledge stakeholders as pathways toward industrial upgrading and innovation. It was found that production linkages are the stronger mechanism and that internal strategies and toolkits by the firms themselves drive their innovative activities as stimulated by competitive pressures and demands of customers. Insights from this case study would contribute towards developing the framework for the establishment of a pan-industrial corridor in the Asian region taking into account the participation of Philippine electronics firms in the regional production networks.

1. INTRODUCTION

The Philippines, like its neighbors in Asia, is a destination for large foreign firms (multinational enterprises) that outsource production processes or have opted to adopt a process of fragmentation in their business configuration. The country's competitiveness is widely believed to rest on the back of its low cost human resources that offer an edge when it comes to producing quality outputs. Another leveraging factor is the advantage of Filipino manpower when it comes to the language of business, with English considered a second language in the country. This influx of foreign investments came on the heels of liberalization and deregulation policies that eased their entry and enabled the formation of industrial agglomerations. The region that benefitted most from this phenomenon is CALABARZON (Cavite-Laguna-Batangas-Rizal-Quezon), whose proximity to Metro Manila, the National Capital Region, made it an alternative to the increasingly congested metropolis. It helped that many of the industrial economic zones that sprouted all over the country was located in this region. Soon it became apparent that manufacturing activities in the country were concentrated in CALABARZON, while Metro Manila focused on the burgeoning services sector.

In 2008, a paper looking at the sources of innovation of Philippine firms based on a survey of 204 firms engaged in different manufacturing activities located in CALABARZON, found empirical evidence that production linkages have a strong influence on the propensity of firms to undertake industrial upgrading. It was also found that firms in the region have weak collaborations with knowledge stakeholders within and outside the region (Macasaquit, 2008). Following through on this study, this paper aims to take this past effort further and present concrete evidences of inter-firm production linkages as well as firm-knowledge stakeholders' collaboration in relation to industrial upgrading and innovation. The evidences of inter-firm production linkages relating to upgrading; the factors that hinder the formation of linkages; types of partners considered to matter when it comes to innovation; the modes of collaboration; and the role of public policies and programs, will be examined in the context of firms' location in an industrial agglomeration.

This study will involve a case study of firms in the Philippine electronics sector to delve deeper into the linkages involved, determine the mechanisms and trace the pathways to industrial upgrading and innovation. Among all the manufacturing industries in the Philippines, electronics is the most entrenched in the regional/global production networks. Moreover, it has the largest contribution to export earnings and highly concentrated in CALABARZON. As the industry has existed for more than 30 years, it is interesting to determine if it has evolved from low value added production activities to higher segments of the value chain in order to improve its competitiveness in the face of increasing penetration of China in the global electronics industry. In this context, to what extent has its participation in production networks improved its technological capability to upgrade and innovate? More than production linkages, what is the extent of contribution of the firms' collaboration with knowledge stakeholders, if any? Given the characteristics of the electronics industry in the Philippines, it is assumed that the most important partners for upgrading and innovation are their affiliates, customers and suppliers that are located within, across agglomerations or outside of the country. Their linkages with knowledge stakeholders are limited, as it is true for other industries in CALABARZON, since technological capabilities in the government and academe are perceived to be lacking and still needs significant improvements.

The paper is organized as follows. The next sub-section provides an overview of CALABARZON as the premier industrial manufacturing cluster in the country, its role and contributions to national output. This will be followed by a brief profile of the Philippine electronics industry which is the subject of this case study. The second section provides a brief background on the current conditions of production networks in the region and where the electronics industry can be situated. It is also in this section where the Philippine electronics sector is described in the milieu of the current technological capabilities of the country. The following sub-section provides information on government policies directed towards the industry. Meanwhile, the third main section presents the summary of the results of the firm interviews, followed by the analysis based on the survey of firms conducted in the latter half of 2009 and on the case study itself. The final section concludes and attempts to enumerate policy recommendations.

2. OVERVIEW

2.1. The CALABARZON Region

The CALABARZON region, also known as Region IV-A comprises half of the so called Southern Tagalog provinces (with the other half composed of Region IV-B or the MIMAROPA provinces). As described in the Regional Development Plan for the region for the years 2004-2010, CALABARZON is claimed as one of the country's major economic hubs and a global industrial region. Together with the National Capital Region (NCR) and the industrial parts of Central Luzon, CALABARZON rounds up part of the so-called Metropolitan Manila Growth Network. This refers to the country's "biggest aggrupation of urban areas performing various roles such as main industrial core, financial and commercial center, seat of national government, and transshipment points for goods and services for domestic and international distribution (NEDA, 2004)."

While collectively described as such, the region is a diverse amalgamation of provinces that are partly urban and partly rural that can be observed by their physical attributes and socio-economic characteristics. In the spatial strategy for the region, development planners have laid down two broad areas of development, the urban growth cluster and the non-urban growth cluster, to capture the regional context as a whole. Said to be at the core of the region, the urban growth cluster is composed of highly urbanized and contiguous municipalities and cities where the industrial sector can mostly be found. This particular cluster serves as a magnet for employment and migrants from the rural areas seeking out opportunities in the urban areas. In fact, the region earned the distinction of being the most populous region in the country in 2007, surpassing Metro Manila, with more than 11.7 million people to the latter's 11.6 million. The region's population growth rate from 2000 to 2007 reached 3.24 percent, higher than the rate for NCR and even, the national level.

In terms of its contribution to the national output, CALABARZON's Gross Regional Development Product (GRDP) grew by 4.0 percent from 2003 to 2004 but dipped to 2.6 percent in the period spanning 2004 to 2005. The region's GRDP recovered from 2005 to 2006 to a significant 4.6 percent. Highlighting the importance of the region to the nation's income, its tandem with NCR and Region III accounted for about 60 percent of the country's total output in 2002. Reflecting the economic structure of NCR, CALABARZON's industry and services sectors have contributed the most to the regional coffers. In terms of the region's industry sector, the main contributor was manufacturing which in turn was being boosted by the performance of the economic zones mainly scattered throughout Cavite, Laguna, Batangas, and to some extent, Rizal. The products coming out of the manufacturing plants in these provinces are primarily semiconductors and electronics outputs intended for the export-market. It was noted that the share of the industry sector in CALABARZON's GRDP has consistently been the biggest among the three major sectors, however, the services sector has been closely catching up, driven mainly by the sub-sectors finance; trade; transport, communication and storage; and private services.

Despite the shifting economic structure in the region in favor of services sector which is growing faster than the industry sector, CALABARZON would still be known as the manufacturing cluster of the country owing to the 42 economic zones existing across the region, with 9 more being developed as of December 2009. This total accounts for about a quarter of the total economic zones dotting the country. While these ecozones are mainly into export-oriented manufacturing, a few are concentrating on information technology-based services like business process outsourcing.[1]

Based on the mid-term assessment of the National Economic and Development Authority (NEDA) conducted in 2008 on the performance of the region based on the CALABARZON Development Plan for 2004 to 2010, there were unmet GRDP and unemployment targets and foreign and domestic investments were not within desired levels. This underperformance was attributed to the declining growth of the manufacturing sector though remaining positive during the reference years, which were said to be caused by hindering factors affecting the efficient operations of the firms even those located in economic zones. Moreover, the flows of investments were not at par with the country's neighbors. The report highlighted the fact that there is a need to improve the pull factors in the region through better infrastructure facilities, improved human capital, maintenance of peace and order, and overall, a better business environment conducive to new and additional investments. Beyond these measures however, there is a need to upgrade the productive activities in the industrial cluster from low value added manufacturing towards the higher segments of the value chain particularly in the face of increasing competition from other countries with similar attributes. In theory, firms in industrial clusters, aided by the spillovers of technological knowledge by the various actors within it, should graduate from mere production to higher value added activities like design, high grade research and development (R&D), advanced marketing strategies, among others. The opportunity and the means to innovate is one of the advantages of being in an industrial agglomeration.

Partly aimed at determining if firms in CALABARZON have undergone innovation

[1] For more detailed discussion about the attributes of CALABARZON and each of its 5 provinces, see Macasaquit, 2008 which is part of the sub-supporting study for the ERIA research project implemented in 2008 to 2009.

and mainly to find out their sources of technological knowledge, a survey of firms in the area was conducted in late 2008 involving over 200 firms engaged in different business activities. It was found that majority of the firms surveyed have undergone both product and process innovations. In terms of the former, new products were introduced to the market albeit mostly for existing ones and produced by utilizing existing technologies. On the other hand, process innovation was mainly through acquisition of new machines, improvement of existing ones, adoption of international standards in order to be certified, and institution of internal mechanisms for improvement. These innovations were achieved despite having only about 25 percent of firms with formal R&D units, indicating that there were other sources of technological information. The study concluded that production linkages as well as interaction with other firms (including competitors) matter to a firm's propensity to innovate as evidenced by the responses from manufacturing firms in CALABARZON. In fact, this type of linkage mattered most to these firms than intellectual linkages which were found to be weak (Macasaquit, 2008).

The results of that study alone have shown that firms in CALABARZON do innovate whatever the level and degree, and have different sources of technological information that matter to innovation. In as much as the study involved firms engaged in different business activities and therefore shows the macro picture, it would be interesting to look at particular sectors and find out what drives them to innovate, if proximity or being located in an agglomeration does matter for innovation and what specific pathways or linkage mechanisms are at work that lead to firm-level upgrading.

2.2. The Electronics Industry in the Philippines

In terms of industry profile, the clusters that emerged in CALABARZON included food, electronics, textiles and garments, automobile and auto parts, and agribusiness.

Over the years, these eventually became the drivers of Philippine industry, generating export earnings and employment. In the last decade, the electronics industry in the Philippines has been its top export earner and a primary recipient of foreign investments. This remains true despite the fact that export earnings were practically chopped into half, from around US$31 billion in 2007 to around US$15 billion in 2009 due to the global economic slowdown. The electronics industry has been a significant provider of employment as it has absorbed over 460,000 persons deployed in 476 firms as of October 2009 (BOI, 2009). These companies were located mainly in CALABARZON and Metro Manila, while Cebu and other parts of Luzon were also hosts to these enterprises. In the listing obtained recently from the Philippine Economic Zone Authority (PEZA), it was noted that among locators in economic zones in the country, 372 firms were classified under the electronics and semiconductor industry. This implies that a significant number of electronics firms are export oriented.

The electronics industry in the Philippines is primarily engaged in assembly and test manufacturing, but also in other highly technical but labor intensive activities. It is in this area where the country has carved a niche for participation in the regional/global production networks. Regional or global production networks are recent business configurations wherein a flagship firm breaks down the value chain in its various essential components and locates them where they can be more efficiently produced, thereby improving the firm's access to resources and capabilities. Relocating components of their value chain enables the firm to focus on its core business, while reducing costs of production given its outsourcing option.

The electronics industry in the Philippines is being classified into nine categories namely:

(1) Components and devices: Pentium IV, integrated circuits, transistors, diodes, resistors, coils, capacitors, transformers, lead frames, PCB

(2) Computer-related products and electronic data processing: personal computers, HDDs, CD ROM, mother boards, software development, data encoding and conversion, systems integration customization
(3) Automotive electronics: telematics – global positioning system, hybrid car and safety
(4) Consumer electronics: flat panel TV, high definition TV, set top box, iPod, digital cameras
(5) Office equipment: photocopy machines and its parts, electronics calculators
(6) Communications and radar: 3G handset, TV reception in handset, mobile services, radars
(7) Telecommunications: telephones, scanners, satellite receivers, cellular phones
(8) Control and instrumentation: PCB assembly for instrumentation equipment
(9) Medical and industrial: RFID, energy saving control, green electronics, optical recognition.

The history of the electronics industry in the Philippines can be traced to the 1950s when US electrical companies came in to produce home appliances. The same type of production was done by Japanese companies when it followed suit and as with US investments, also went into joint venture endeavors with local entrepreneurs. Next came the back-end processes of semiconductor assembly in the 1970s, which was again introduced by US-based companies, The manufacturing of semiconductors was oriented towards exports while home appliances production was for the local market. In the mid-1980s, electronics companies from Japan, triggered by *endaka*, moved their production sites to ASEAN countries such as Singapore, Thailand and Malaysia. Due to political instability reigning in its shores during this period, the Philippines was bypassed by this first wave of Japanese investments. Recovering from decades of political instability and stagnant growth, a flurry of liberalizing policies were instituted in the 1990s in an attempt to reform the country's image and make some necessary structural adjustments. In 1994, these efforts paid off as large inflows of foreign investments poured into the manufacturing sector in the country (Morisawa, 2000). Japanese investments in the Philippines during this period in the electronics industry were mainly in the production of personal computer peripherals such as floppy disk drives (FDD), hard disk drives (HDD), mother board, among others. Between 1994 and 1996, four major Japanese HDD companies came into the country accompanied by a number of Japanese supplier firms (Tecson, 1999).

2.3. The Rationale for Upgrading/Innovation

In an environment of increasing globalization, changing market environment, reconfiguration of organizations (fragmentation versus integration), widening opportunities presented by regional and global production networks, industry players – mainly the firms –have to undergo structural transformation by means of shifting from the production of low value added goods and services to more diverse, complex and high value added production. This is one of the ways to buttress their competitiveness in the face of fierce competition. Increasing competitiveness require the adoption of measures to modify production processes, introduce new products, initiate improved organizational systems, apply new marketing methods, and tap new markets. All these denote efforts toward industrial and/or firm-level upgrading or the application of innovation in production and within the organization. There are numerous sources of technologies that could lead to industrial upgrading and innovation.

It is claimed by many firm-level studies that the process of technological learning among firms is characterized with externalities and linkages. It is driven by links with suppliers of inputs or capital goods, competitors, customers, consultants, and technology suppliers. Also important are interactions with firms in unrelated industries, technology institutes, extension services, universities, business associations, and training institutions (Lall 2001 as cited in ADB 2009). The first refers to production stakeholders where primary transactions are in the areas of buying and selling. This also covers the firm's own mechanisms or strategies for generating technological knowledge and applying them to its production, organization, and marketing. On the other hand, the second major source of technological information are the knowledge stakeholders, generators and repository of technical research, science and technology data and materials, results of experimentation, among others.

Production linkages and the occurrence of technology transfers can lead to innovative activities, with the location of firms – industrial clusters – as an important site of information exchange. Indeed, it has been empirically proven that knowledge spillovers do occur in such agglomerations and proximity matters. In addition, collaboration with the so-called knowledge stakeholders that are sources of science and technology ideas such as universities, public and private research institutions and industry associations can likewise stimulate technological learning and adoption. This is particularly true in advanced economies where university-industry linkages do exist. Previous studies have shown that this may not be the case in developing or emerging economies as their main suppliers of technological information have so far been those within their production web.

The Philippine electronics industry is in a critical juncture. Parties claim that it seems to be the only shining star remaining in the country's manufacturing sector. Yet, it is facing tougher competition from China and other countries that also offer low-cost labor and at the same time, enticing foreign investments with more lucrative incentives. According to the Congressional Committee on Science and Technology and Engineering (COMSTE), the key to the continued success of the electronics industry in the country is the development of a strong applied R&D infrastructure and innovative culture. There is a need for it to move up the value chain through innovation; transfer technology from the universities; grow local markets for its products; and attract new investments in growth areas such as chip design, green technology and biomedical electronics (Tangonan, 2008). The next section provides information on the current milieu where the Philippine electronics industry is situated.

3. THE PHILIPPINE ELECTRONICS INDUSTRY: AGGLOMERATION AND PRODUCTION NETWORKS FOR UPGRADING AND INNOVATION

The importance of the electronics industry in the Philippines cannot be denied. From 1998 to 2007, the industry contributed 60% to almost 70% of total export earnings of the country. The figures recently went down to 58% in 2008 and about 57.8% in the first three quarters of 2009 due to the impact of weak demand arising from the global economic slowdown. Still, it remains apparent that electronics in the country continuous to be its top export earner and indeed, an export winner.

Many of the electronics firms in the country, big or small, are located in economic zones concentrated in the CALABARZON region. This implies the export orientation of these firms, whether directly or indirectly to various parts of the world. The US, Japan, Netherlands, and Hong Kong are traditionally the major destinations of electronics outputs, with China beginning to take on the role of major market for Philippines electronics in recent years. In 2008, mainland China earned the distinction as the top export destination of Philippine electronics, having had the highest percentage among 11 of its major trading partners, followed by Hong Kong. In terms of niches, it has been observed that the Philippines have taken on the role of assembler and tester for the electronics industry as a whole, and mainly on semiconductors in the past 30 years. This denotes that many of the electronics firms in the country find themselves in the lower tier of the production chain. There are however, notable exceptions to this fact indicating that there are firms that were able to evolve from assembly and testing activities to turn key production.

3.1. The Regional Production Network in Asia and Philippine Electronics

The industrialization of countries categorized as newly-industrializing economies (NIEs) namely, Singapore, Hong Kong, Korea and Taiwan is closely tied up to the search of Japanese multinational companies for quick and low-cost production sites.

From simple and labor-intensive assembly and testing of parts and components, the NIEs caught up and soon became OEMs in their own right. Perhaps due in part to this and their new-found development, labor costs in NIEs begun to rise in mid-1990s, causing firms in the NIEs to shift their manufacturing in other areas in the region, specifically to the ASEAN-4. This resulted in a radically different regional/geographical production arrangement with the NIEs now serving as first-tier suppliers to the lead firms, and the ASEAN countries (including China and India) taking the role of second-tier suppliers to the NIEs, doing many of their assembly and testing requirements. This is evident in the surge of foreign direct investment (FDIs) flows in ASEAN particularly in the electronics manufacturing sector. Austria (2008) also noted the increasing role of the ASEAN region to the global electronics production, as seen on rising export and market shares.

Eventually, ASEAN countries including the Philippines were able to develop their respective niches in this new production network. Malaysia and Thailand gained strength in components assembly while the Philippines is seen to be most competitive in semiconductor as it practically dominated the country's electronics export products, and supplies 10% of the world's semiconductor manufacturing services requirements (SEIPI, 2007).

The Philippines' participation in the regional electronics production network significantly altered its economic and trade structure. From a predominantly agri-oriented exporter in 1976,[2] the country now exports billions worth of microchips and electronic devices. Moreover, from a mere $1.5 billion in 1990 (CPBO, 2009), the industry's export revenues rose to $31 billion in 2007, accounting for over 60% of the country's total exports for the period 2000-2007.

Table 1 Philippine Exports of Electronics, By Sub-Sectors, 2004-2009
Value (in million US$)

	2004	2005	2006	2007	2008	2009[p]
Total Exports	39,680.52	41,254.68	47,410.12	50,465.72	49,023.17	27,639.13
Electronics	26,726.08	27,298.73	29,500.20	31,085.27	28,500.91	15,981.66
Components/Devices (Semiconductors)	18,706.78	20,207.31	22,321.80	23,624.39	21,046.84	11,395.02
Electronic Data Processing	6,193.10	5,504.28	5,557.08	5,458.36	5,213.66	3,354.89
Office Equipment	209.96	194.63	268.08	335.54	315.15	173.37
Medical/Industrial Instrumentation	4.04	6.45	13.10	33.33	31.88	21.72
Control And Instrumentation	10.24	15.58	17.17	38.79	53.58	29.10
Communication And Radar	449.18	269.55	234.37	276.04	290.44	237.81
Telecommunications	177.69	136.90	213.58	124.62	261.07	99.28
Automotive Electronics	363.06	397.31	415.95	610.71	809.65	455.71
Consumer Electronics	612.03	566.73	459.06	583.50	478.63	214.76

Note: p Preliminary figures for January to September.
Sources: For 2004-2006: Department of Trade and Industry (available at: http://tradelinephil.dti.gov.ph/betp/trade_stat.expcod_sumprod)
For 2007-2008/1Q2009: National Statistics Office (available at www.census.gov.ph).

[2] According to SEIPI, 49% of the country's exports in 1976 were agro-based.

Table 2: Philippine Exports of Electronics, By Major Trading Partners, 1995-2009
Value (in million US$)

	2004	2005	2006	2007	2008
Total Exports	39,680.52	41,254.68	47,410.12	50,465.72	49,023.17
Total Electronics	26,726.08	27,298.73	29,500.20	31,085.27	28,500.79
U.S.A.	2,869.02	3,300.29	4,112.76	4,152.69	3,936.77
Japan	5,625.22	4,845.64	4,263.90	3,413.41	3,455.15
Germany	1,103.94	950.02	1,348.16		2,007.31
Netherlands	3,151.41	3,530.67	4,274.43	3,671.70	3,111.67
Hong Kong	2,662.08	2,855.28	3,101.20	5,036.57	4,257.58
South Korea	650.75	977.92	856.06	1,058.23	1,220.84
Taiwan	1,820.53	1,414.73	1,489.73	1,505.38	1,253.91
Singapore	2,219.34	2,144.38	2,469.68	2,194.80	1,588.35
Malaysia	1,729.93	2,117.17	2,140.95	1,964.52	1,366.74
China	2,055.27	3,502.16	3,814.57	4,508.63	4,593.66
Others	2,838.59	1,660.45	1,628.75	3,579.34	1,708.81

Sources: For 2004-2006: Department of Trade and Industry (available at: http://tradelinephil.dti.gov.ph/betp/trade_stat.expcod_sumprod)
For 2007-2008/1Q2009: National Statistics Office (available at www.census.gov.ph).

As expected, this rise in exports was also accompanied with a dramatic increase in job opportunities. In terms of employment, the sector contributed close to 23% of the total manufacturing employment which translates to 462,000 jobs in 2008. This is a big jump from 74,000 jobs generated in 1992 (see chart). The sector likewise commanded a sufficiently large amount of investments.

Table 3 Employment in Electronics Industry (In thousands)

	2001	2002	2003	2004	2005	2006	2007	2008
Total Employment in Manufacturing Sector	2047	2016	2280	2247	2275	2227	2282	2047
Manufacture of machinery and equipment, n.e.c.	54	44	66	40	61	53	50	
Manufacture of Radio, Television and Communication Equipment and Apparatus	157	182	200	229	269	270	306	
Manufacture of Medical, Precision and Optical Instruments, watches & clocks	33	21	18	23	23	16	13	
Total Employment in Electronics Industry	244	247	284	292	353	339	369	462
Growth Rate		1.23	14.98	2.82	20.89	-3.97	8.85	25.20
% Share to Total Manufacturing	11.92	12.25	12.46	13.00	15.52	15.22	16.17	22.57

Source: BOI; House of Representative, Congressional Planning and Budget Department.

3.2. The Philippine Innovation System

The electronics industry is a high technology industry that combines both manual operations and the use of state of the art equipment. It involves working on the smallest components, i.e. chips to the operation of big machines. Spanning the spectrum of the electronics value chain are low value added (assembly) to high value added (design) activities. The Philippine electronics industry is concentrated more on the low value segment of the supply chain, that is, assembly and testing, but involves the production of high technology outputs. At the floor level, operators need not be college graduates to be able to operate machines or manually assemble parts and components. Firms typically train their operators before or on the job. However, since high-technology inputs are involved, firms also require engineers and technicians in their manpower. Some has R&D units, production teams, and engineering departments. In this type of business units more highly skilled manpower is required -- college graduates, technical school graduates, licensed engineers.

It has often been claimed that there is disconnect between the number and quality of graduates of universities/technical schools and the manpower requirements of industry. Experts point to the weaknesses of the curriculum, the quality of education versus the quantity of board passers dichotomy, the lack of a prevailing innovative culture in the country, brain drain of engineers, among others.[3] If we look at standard indicators of scientific and technological capabilities, we find that the Philippines have much work to do in relation to the development of the national innovation system.

[3] Based on interviews with industry experts who represent the industry in policy discussions.

Table 4 R&D Indicators

	1992	1996	2002	2005
Total R&D Personnel (headcount)	15610	15837	9325	
No. of Scientists and Engineers (headcount)	9960	11215	7203	
Population Size (in million people)	65.34	71.9	80.16	
No. of R&D Personnel per million population	239	220	116	127
No. of Scientists and Engineers per million population	152	156	90	
GDP (current prices/ in million pesos)	1351559	2171922	3963873	
GNP (current prices/ in million pesos)	1375838	2261339	4218883	
Total R&D Expenditures (current prices/ in million pesos)	2940.5	4144.9	5769.75	6,326.74
R&D Expenditures as % of GDP	22%	19%	15%	12%
R&D Expenditures as % of GNP	21%	18%	14%	
Public R&D Expenditures (current prices/ in million pesos) and % to total	2088.8	2482.8	1615.59	1,622.09
	71%	60%	28%	25.6%
Private R&D Expenditures (current prices/ in million pesos) and % to total	851.7	1662.1	4154.16	3,961.93
	29%	40%	72%	62.6%
Per Capita R&D Expenditures (current prices, in thousand pesos)	188.4	261.7	618.7	

Note: In 2005, other sources of R&D expenditures were segregated from the general public and private categories such as higher education, private non-profit, from abroad, and not specified. The private category was reclassified as business.

Source: Department of Science & Technology.

The above data reveals that there has been a steady decline in R&D intensity spanning years 1992-2005. The percentage of expenditures devoted to R&D has significantly declined, from 0.22 percent of GDP in 1992, 0.19 in 1996, 0.15 in 2002, to a meager 0.12 percent in 2005. With the low R&D expenditure registered in 2005, the Department of Science and Technology’s (DOST) target R&D expenditure of 0.30 percent of GDP by 2004 was not attained. Given this trend, DOST’s target R&D expenditure of 1% of GDP by 2010 is unlikely to be realized.

Previous analyses on Philippine R&D point out the low share of private R&D expenditures and the need to significantly increase their share relative to the other sectors. From the available data covering 1992-1996, the public sector has always been the major contributor to total R&D expenditures in the country. In 2002, the trend significantly changed with the bulk of R&D expenditure coming from the private sector, claiming 72 percent to total R&D expenditure.

3.3. Government Policy for Upgrading and Innovation

The Philippine Constitution recognizes that S&T are essential for national development and progress and essentially dictates the components that should become part of the Philippine technology policy. In terms of a policy framework that sets the S&T objectives and detailed guidelines for attaining these, the country has had four major ones so far since 1986. Currently, the long-term National S&T Master Plan, 2002 to 2020 serves as the guiding framework for technology policy in the country. During its formulation, the Plan is said to have correctly diagnosed the problems faced by the S&T system such as low investment in R&D, poor quality of S&T education, lack of private sector participation in R&D, inadequate attention to the needs of the market as basis for R&D and innovation, and lack of technology transfer and commercialization.

In 2007, technology stakeholders including those coming from the government, industry, academe, and the private sector held an exhaustive forum that launched FilipINNOVATION, the brand for the country's national innovation system. In the first National Conference on Innovation, formal agreements were fostered, two of which included: the open technology and business incubation partnership between DOST and PEZA for start-up companies in the ICT industry and the work plan of the Engineering Research and Development for Technology Consortium (ERDT) comprised of seven engineering schools in the country and includes policy research and scholarship offerings as major activities. The FilipINNOVATION framework may yet jumpstart the need to develop a culture of innovation among the Filipinos. This is viewed to be essential to battling the protracted problems faced by the S&T system including prioritizing the channeling of resources for R&D pursuits that would respond to the needs of industry. Dialogues with industry players reveal that they would like to see a science and technology government agency teeming with scientists and PhD holders that undertakes research and develop trailblazing technologies that can be applied and commercialized; and the establishment of common facilities including those for prototyping, calibration and testing. A stronger S&T system would inspire confidence among industry players and foster linkages and cooperation between knowledge stakeholders in the government and private firms.

Currently, the annual planning exercise of DOST involves the participation of industry as represented by various priority sectors. Since it has been dubbed, export winner, representatives from the electronics industry have been attending these consultations. Earlier this year, a similar forum was held wherein sectoral priorities for R&D were discussed including the necessary resources to bring them to fruition. During the discussions, it became apparent that there are synergies between and among the sectors represented in terms of the technology that they need. Aside from the opportunity of aligning research spending priorities better with these needs, the sectoral representatives were able to pinpoint possible areas for technological cooperation between them.[4]

In terms of policies to support industry development, the government direction is to continue attracting investments into the country, both local and foreign, through the provision of incentives as embodied in the Omnibus Investments Code of 1987 and the Special Economic Zone Act of 1995. In terms of an industry guiding framework, the government comes up with an annual Investment Priorities Plan (IPP) that clarifies entitlement to incentives; equity ownership; and equity requirement; and reiterates continued efforts for regional dispersal of industries. The IPP identifies the priority activities that will be pursued by the government as well as the selected industries that it

[4] This information was shared by an electronics industry insider and former head of an electronics industry association.

would aggressively promote.

Specific to the electronics industry, the Board of Investments (BOI) identified five areas that are essentially being pursued in support of Philippine electronics. For one, human resource development is being promoted through unified competency development; unified microelectronics program for MicroEd/ERDT university participants; and, IC design training program which is a collaborative undertaking with the Taiwanese authorities. Under industry development, there is a Test Development Program for MicroEd/ERDT university participants, and in the near future, conduct of Supply Chain Analysis of the Philippine Electronics Industry to be spearheaded by JICA. The BOI also claims to have an aggressive industry marketing campaign and that manufacturing excellence is being promoted through best practice sharing, people productivity programs and power/water conservation and reduction of cost of doing business in the country. According to BOI, they have been working closely with various electronics industry associations and support their activities (BOI, 2009).

The agency also works in tandem with the privately-run Advanced Research and Competency Development Institute (ARCDI), which provides highly technical and cost effective training and competency development support to semiconductor and electronics industry players. Its training modules are dedicated on specific competency areas which are claimed to be centered on industry requirements. According to the head of ARCDI, they will soon start pursuing the conduct of breakthrough/advanced research to push the technology frontier in the electronics industry in the Philippine context. Although the limited focus of ARCDI does not make it the counterpart of Taiwan's Industrial Technology Research Institute (ITRI), it is available and accessible to cater to the training needs of electronics firms.

On the supply side, the ERDT is playing a very important role. A consortium of six engineering colleges across the country, ERDT was able to secure a PhP3.5 billion funding support from the government in 2007 covering three years of operations. According to Dean Rowena Cristina Guevarra, Executive Director of ERDT, their operations are aimed at filling the lack of R&D activities in the country and developing a critical mass of researchers, scientists and engineers (RSEs) with advanced degrees on programs vital to the national development. She attributes to the dearth in RSEs, with capabilities to translate R&D outputs into viable industries, undertake high impact research, share scientific knowledge, and set S&T directions, the slow growth of developing economies, like the Philippines. She noted that typically, developing countries have about 3.4 RSEs per 10,000 population while the Philippines only has 1.08. Dean Guevarra claims that it will take the country at least seven years to attain even the developing country average.

Further, Dean Guevarra mentioned that ERDT consults industry associations in their formulation of their R&D agenda, which enabled them to narrow down priorities into four areas: energy, environment and infrastructure, ICT, and semiconductor electronics. While the industry prefers that ERDT focus on manufacturing and failure analysis, it is the view of the latter that this is nearsighted and would only serve the immediate needs of the industry. In order to compete globally, R&D directions should include design, new materials and new electronics products. To compromise, the ERDT's research agenda for semiconductor electronics comprise five subfields: two are intended to address current needs and three for strategic purposes.

However, findings from previous studies indicate that many of the individual firms in CALABARZON were not aware of the government policies and program offerings that they can avail of. The DOST admits that there is a need to intensify its promotional campaigns to widely disseminate their various programs and technologies and truly reach their publics. It said that various promotional programs are underway to create awareness among firms and the public in general about their programs.[5] Indeed, the DOST website and those of its attached agencies contain useful information about their technology promotion and commercialization programs. Perhaps, what would be more effective is for DOST and DTI to undertake firm-level discussions and consultations to disseminate their programs more effectively and strengthen interface with those they serve, in order to make their policies, programs and activities more responsive to the needs of industry.

Meanwhile, firm level studies like this paper is hoped to aid in putting forward the views of industry players on various issues that affect them and lay down the areas where closer interface and cooperation can be realized.

4. RESULTS OF THE CASE STUDY

The Philippine case study involved 10 firms: four are locally-owned, four are foreign-owned or affiliates of MNCs and two are joint venture firms. These 10 firms include some of the biggest names in the industry, particularly among Filipino-owned companies. They are a mix of lead and follower firms and all are located in the different economic zones in CALABARZON, but mainly in Cavite and Laguna. Half of these firms manufacture end-products, while the rest are into components assembly and testing. Table 5 provides a summary of the profiles of each firm covered by the case study.

Three of the 10 firms requested that the names of their firms not be disclosed. Many of them cautioned against mentioning the names of their actual customers and a firm even went to the extent of not divulging details with regard their plans to

[5] Lifted from the letter of Undersecretary Fortunato dela Pena responding to the formal written query sent to their office early 2009.

collaborate with a university. This paper is therefore, limited by the extent that the firms are willing to disclose details about their operations and their cooperative endeavors. However, most of them did not object to having their names cited in the paper.

Table 5 Profile of Case Study Firms

	Location	Ownership	Year Established	Business Activity	Respondent
M2 Fabrication, Inc.	Cavite Export Zone	Filipino	2006	Steel casing for electronics	Chief Executive Officer
Firm A	Laguna Techno Park	Filipino	1980	EMS	Chief Executive Officer
EMS Components Inc.	Laguna Techno Park	Filipino	2004	EMS	Director for Business Development
BELL Electronics Corp.	Carmelray Industrial Park, Laguna	Filipino	2000	Packaging for IC/semicon	Production Manager
REMEC Broadband Wireless International Inc.	Carmelray Industrial Park, Laguna	Joint Venture Filipino- American	2005	Microwave/RF units	President
Littelfuse Philippines, Inc.	LIMA Techno Park Batangas	American	1997	Electronics fuse	Human Resource Officer
Fujica Pacific Inc.	Carmona, Cavite	Joint Venture Filipino-Japanese	1995	Molded plastic products for electronics	Assistant General Manager
Exito Electronics Company. Ltd.	Carmona, Cavite	Taiwanese	1992	Extension cord	Production Department Head
Hayakawa Electronics Philippines Corporation	Cavite Export Zone	Japanese	1990	Wire harness	Human Resource Manager
Firm B	Cavite Export Zone	American French	1981 2006	UPS	President

It will be noted in Table 5 that four out of the 10 firms were relatively new as they were established only in the last decade. This is true for most of the locally-owned firms. The foreign firms meanwhile, found their way into the country during the 1990s, confirming the claim that foreign firms find the more liberalized policy environment attractive. In terms of the types of business activities these firms are specifically engaged in, it will be observed that not all of them are directly into electronics production. Some of these firms can be characterized as belonging to allied industries providing support to electronics. Though all of them are classified under the electronics industry, some of them easily fall other categories as well. Five of these firms were interviewed under the auspices of the Semiconductor and Electronics Industries in the Philippines (SEIPI) from their list of regular members. The interviews with the other five firms were made possible by the National Statistics Office (NSO) drawn from the sample firms in the survey conducted in parallel to this study.

Effort was made to cover extensively both lead firms and followers to better explore instances of collaboration for purposes of innovation but at the time of the study, most of the MNCs are too busy to accommodate the interview.[6] Nevertheless, to the extent that was possible, the study was able to trace out links between some of the firms in the case study. Both EMS Components Inc. and Firm C are suppliers of Firm A which is a provider for key original equipment manufacturers (OEMs) in the computing, communications, consumer, industrial, automotive, and medical markets. On the other hand, M2 Fabrication was founded at the instance of Firm B that wanted to develop a local supplier to provide for their casing needs. Meanwhile, Exito Electronics Company Ltd was a former supplier to Hayakawa Electronics and presently, considers Firm B as customer for its products. To reiterate, it was unfortunate that at the time of the interviews, most of these firms declined to provide specific details on the nature of their relationships with both customers and suppliers, citing the highly competitive business environment they are in. Still, there are very useful insights that can be picked up from the results of the interviews. In particular, concrete examples of upgrading activities were elicited from these firms, which are summarized in Table 6.

[6] Inquiries made among Japanese firms were not successful since most of them are being audited by headquarters or there are on-going visits by their principals.

Table 6 Representative Examples of Industrial Upgrading/Innovation by Firms

M2 Fabrication, Inc.	Fastener for steel casing
Firm A	Automotive camera platform
EMS Components Inc.	Reconfiguration of operators' work space
BELL Electronics Corp.	Conversion of equipment for die attach process
REMEC Broadband Wireless International Inc.	Fully integrated product
Littelfuse Inc.	Fuse for specific upgraded end products
Fujica Pacific Inc.	Design of molds
Exito Electronics Company. Ltd.	Handling of assembly process
Hayakawa Electronics Philippines Corporation	Process improvement for ISO certification
Firm B	500 kva UPS

It will be noted that almost all of the firms in the case study were found to have had episodes of innovative activities in various forms and degree of technology involved. As utilized in this study, innovation (interchangeable with industrial upgrading or simply, upgrading here) is broadly viewed as involving the following: product innovation; process innovation; marketing, and organizational innovation. The next section summarizes the results of the interview of each firm in the case study.[7] In each of the cases, a visual representation of the network of linkages will be provided as it exists in CALABARZON, the Philippines (RP) and even across the world. In terms of the lines linking the firm with another, a solid line denotes that there is a strong linkage between the two parties especially when it comes to technology or knowledge transfer; while a broken line represents a weak relationship.

4.1. M2 Fabrication, Inc.

M2 Fabrication is a wholly owned Filipino company built in 2006 to engage in the sheet metal fabrication business that caters to the electronics and semiconductor industry. Their services include powder coating, silk screening, punch press, bending,

[7] It should be noted that the study made use of the common set of questions indicated in the guidelines distributed by the Working Group leader for the project.

and assemblies. M2 Fab for short, is part of Accutech Steel Service Center, a vertically integrated company of the Chan family who is into the steel business in the country for a long time. The mother company, founded in 1981, starts the chain with its importation of raw materials, which it then cut into sheets. These metal sheets are forwarded to the next company in the value-chain, Maxi Metal, which is into the manufacturing of tooling and fabricates the sheets before they can be converted into a box, bracket or frame. M2 Fab is the last stage in the chain bringing the fabricated sheets together and forming server racks.

According to the CEO, he brings in a different business model in the industry in the sense that when one of his company's needs parts, they build a company to fill the gap rather than purchase them from others. In essence, they become self-contained with internal mechanisms already put in place.

4.1.1. Linkages and Innovation

The CEO considers innovation as important in the electronics industry, in general and in his business, in particular since the turn over of electronics products is high. Basically, innovation in the steel business is not dynamic like in the electronics industry where one can create a certain product to fit a certain application. The steel industry is the backbone of the entire module. Though there is not much innovation involved in terms of the product itself, there are processes that have been changed to fit materials or some new part that has been introduced. According to him, these innovations do not really come from them but have been adapted from others. For instance, he mentioned that in the casing or cases that they produce for electronics firms, traditionally, all the screws and bolts are stamped into the metal case. In the last 10 years, one of the latest innovations related to casings came from the Americans. Pre-made fasteners are inserted onto the metal and clinches on it even without molding. These kinds of products are very prevalent in the higher end metal cases. The CEO considers this innovation, albeit incremental, because it is the better solution and provides better reliability. Aside from these, other motivations for upgrading includes improvement in product quality; fulfillment of regulations and standards; improvement in the cycle time; improvement in production flexibility; and to enhance price competitiveness. The CEO himself monitors trends and developments in the industry as he is always on the look out to improve his companies. Along this line, he attends trade fairs locally and abroad.

Related to this, improvements in organizational processes are also being done regularly and in fact, the companies under him have adopted the 5S and have undergone ISO certification. According to the CEO, these are important in order to cope with internationally-accepted standards, norms and best practices. When it comes to internal strategies to achieve upgrading, the acquisition of machinery and equipment in connection with the innovation was mentioned. In fact, in the 80s and the 90s, the CEO said that his company introduced new machines in the industry.

In the particular upgrading example earlier cited, the CEO mentioned the company of his sister as the one that introduced the innovation. He considers his affiliates within his vertically integrated company as partners, and so are his customers. They are all located within the same industrial area in CALABARZON. It is strategic for the company to locate near customers as in the case of M2 Fab which was established in the Cavite Export Zone to be in the proximity of Firm B. It should be noted that it was Firm B that encouraged the CEO to put up a facility to respond to its needs, leading to the establishment of M2 Fab. Although M2 Fab was created for Firm B, the other firms affiliated with the mother company also cater for or supply its needs. Accutech provides the raw materials to Maxi Metal and M2 Fab and even to its competitors to form products intended for Firm B. The latter puts in the electronics in the casing to become an electronics module. When the final products are shipped out, some also finds their way back to the M2 Fab assembly area, which packages the products before shipping out. Thus for the CEO, his companies are able to cater to the needs of Firm B in one full circle. Figure 1 provides a visual representation of the linkages M2 Fab has within its production network.

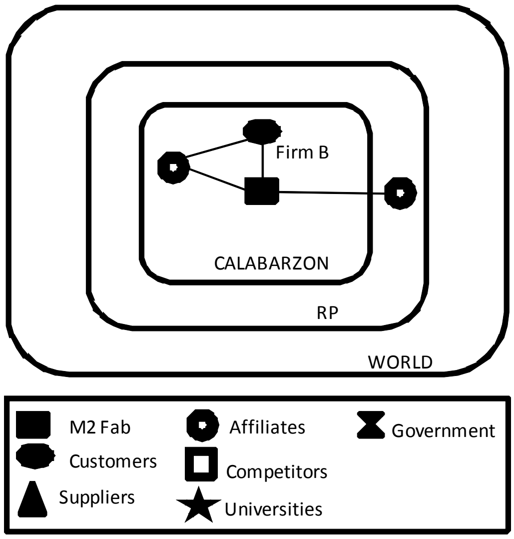


Figure 1 M2 Fabrication Linkages

As partners, the company engages in informal information exchanges with his affiliates and customers, mentioning that the sales people from his sister's company often go around introducing products. As he considers his customers as lifeline, the CEO pointed out that regular communication is important. The nature of collaboration may at first be institutional, but as the relationship becomes more frequent and regular, it becomes more personal. The CEO admitted dispatching engineers to his partners and that his companies also receive engineers from them. This is such a regular occurrence that these engineers have already established good interpersonal relations.

4.1.2. Obstacles to Innovation and Collaboration

In terms of obstacles to collaboration, the CEO mentioned that contractual agreements are difficult to enforce on the part of the customers. He also cited the difference in time horizon, in terms of what he perceives as right timing vis-à-vis his customers and highlighted that time matching is important, especially when upfront investments are involved. When it comes to obstacles to innovation, the CEO cited the high cost of technical manpower. As for the government's role, he mentioned that it creates a lot of road blocks to running businesses efficiently, which is true for both the national and local governments.

4.2.Firm A

Firm A was established in 1980 as a joint venture between one of the largest family-run companies in the Philippines and a small integrated circuits assembler. With almost 30 years of experience in the industry, Firm A has an established expertise in comprehensive manufacturing capabilities and higher value services for storage device, communications, industrial, consumer, and automotive electronics markets. Firm A is substantially Filipino-owned (about 99%), with the employees owning about close to 9%-10% stock ownership. The company's facilities in the Philippines are located in Laguna and Cebu offering a wide range of services such as printed circuit boards assembly (PCBA), Flip chip assembly, Box build, Sub-assembly, and Enclosure system manufacturing.

Firm A originally went into the business to take advantage of the outsourcing trend driven by US firms in the 80s. Specifically, they were outsourcing integrated circuits manufacturing. The company shifted to sub-assembly manufacturing when it was the Japanese firms' turn to outsource this segment of their production chain. In 1998, the company decided to make investments in technology and engineering, and started a small R&D engineering support group. It was in the earlier part of 2000 when the firm charted a new course and to not just try to compete and grow locally, but grow globally.

A lot of internal changes ensued, putting infrastructure both front to back, and standardized and optimized a lot of their operating procedures and systems. It opened up real offices outside of the country to drive sales.

By 2005, when it has become financially strong enough, it started acquiring new companies. It was sort of historical, with a Filipino company buying assets such as a US-based company, setting its footprint in the US and expanding its manufacturing site in the Philippines. This is when the firm truly considered itself a global company. Key to its complete service is flexibility and responsiveness to customer needs, and respect for customers' intellectual property rights. It is claimed that OEMs can leverage the firm's world-class quality and productivity systems. At present, Firm A has a prototyping and engineering center in North America located in Tustin, California. Through this facility, the firm has acquired three US patents for advanced manufacturing. One of these innovative method speeds up the chip assembly process while efficiently maintaining control over flux application. The company has also acquired an established EMS firm in Singapore in 2006 that enabled it to possess additional original design manufacturing (ODM) capabilities in power electronics. This acquisition gave the firm access to additional manufacturing facilities in China, Singapore and the Philippines. In the same year, Firm A acquired a Philippine-based engineering-oriented test systems integrator, developed an engineering support center in Japan and a process management group in Europe to meet the needs of a tier one European automotive original equipment manufacturer (OEM).

The globalization strategy of Firm A has resulted in: (1) Eleven (11) manufacturing plants worldwide, with plans for expansion; (2) Total production area of more than 1.9 million square feet; (3) Capability for both low volume-high mix and high volume-low mix manufacturing; and (4) Over 100 Surface Mount Technology (SMT) lines using the latest equipment.

4.2.1. Linkages and Innovation

In view of rapid technological changes and volatile market conditions intensifying competition among electronics companies, Firm A is compelled to continuously upgrade its skills and diversify its markets. Needless to say, the firm considers upgrading or innovation as important. A recent example of upgrading in the firm was the development of a camera platform to respond to the increasing need for driver assistance systems and electronic content in cars, as well as the growing need for safety regulations in the European Union and the US. This is considered by the CEO as an introduction of a new product/service and in terms of degree, radical innovation as it implies doing something completely new to the firm. The top three motivations for undertaking this upgrading effort are to increase market share, learn about new technology, and for diversification. For this particular example, the firm's strategy was to co-develop it with an imaging technology expert. Contributing to this innovation are external partners- the imaging technology expert; the firm's in-house R&D department and business units within the firm.

The external partner is a foreign owned company engaged in other industries located in California, USA. Needless to say, this particular partner is outside CALABARZON where Firm A's headquarters is located. Their collaboration mode is through technology assistance having been a partner for more than one year. The firm does not dispatch engineers to this partner, and so does the latter.

However, Firm A also considers its customers as important partners for upgrading. The CEO mentioned that his average tenure with customers is seven years. Many of these customers are also locators of the industrial zone where Firm A is. Frequency of collaboration with these partners is regular and occurs through corporate roadmap sharing and development. This interface is considered important because the manufacturing capability of the firm should match the plans and strategies of the customers in the future.

In its official company profile, Firm A claims to also have strategic alliances with other global EMS companies in the US, Europe and in the Philippines. They may be competitors at certain levels but Firm A noted that their collaboration complement the firm's competencies, enabling them to explore subcontracting opportunities and allowing these firms to be its prototyping facilities for foreign markets.

Meanwhile, the President of Firm A said that they also engage local universities for technology dialogues and conduct of symposia. The firm also trains and uses university professors for specific projects. These universities include the University of the Philippines, De La Salle University and Ateneo de Manila University. These are the top three universities in the country with the first two having campuses in CALABARZON. Firm A also collaborates with other schools in the region such as Lyceum University in the South and Technological University of the Philippines. They have institutional cooperation/arrangements including training (both ways) and internships in the firm. If there is one impediment to deepening collaboration with universities, it is lack of technological exposure and practical applications. Firm A also has direct liaison with the Massachusetts Institute of Technology in the US. Figure 2 below represents this extensive web of network by Firm A.

In his personal capacity, the CEO is often invited in consultative panels to discuss the status and future of the industry; sits in various Committees like the Philippines' Competitiveness Council; chairs the ARCDI; a trustee of the SEIPI; and, an adviser to engineering departments of technical universities in the country.

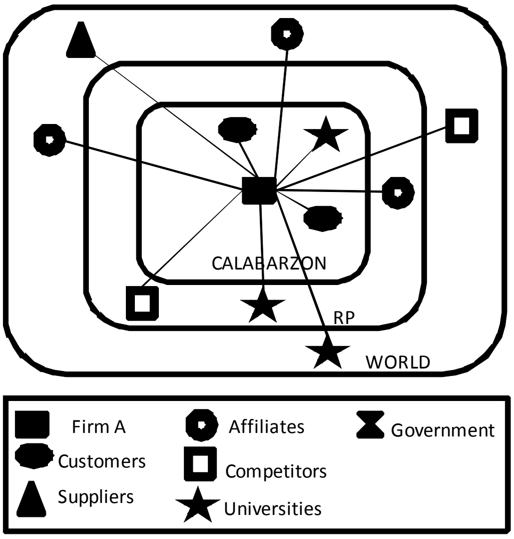


Figure 2 Firm A Linkages

4.2.2. Obstacles to Innovation and Collaboration

In pursuing the particular example of upgrading cited, Firm A did not encounter any obstacles to collaboration. Hence, the firm did not need any public support to facilitate the collaboration. In terms of internal obstacles to upgrading, lack of information on technology was cited. As for the external factor hindering upgrading, the culprit was lack of sources of market information.

4.3.EMS Components Assembly Inc.

EMS Components Assembly, Inc. (EMS-CAI) is a locally-based, 100% Filipino-owned contract manufacturer whose main charter is to provide cost-effective, efficient solutions to the growing global electronic manufacturing subcontracting market. Its goal is to become a market leader geared towards low production cost with the highest quality level. It was established in 2004 by a father and son team whose motivation is less driven by the profit motive but more so by proving a point that a Filipino company can do what a Chinese company can. In order to capture that contract which Firm A is planning to sub-contract to China, EMS was established with only 90 operators and three managers in Sta. Rosa, Laguna. After only five years in the business, EMS has grown and evolved as "the choice manufacturing assembler" of electronics products.

The founder of EMS is Francis Ferrer who is fondly known in the industry as the "Father of Philippine electronics." He was President of Firm A for many years and was head of the SEIPI. When he retired from Firm A, he became board member of PEZA and the BOI. All these stints indicate that EMS was founded on the basis of experience and knowledge of the industry dynamics.

The main business of EMS is electronic assembly for OEMs, ODMs and even other electronics manufacturing services companies. Its array of customers, in addition to Firm A, includes Panasonic, Toshiba, Sanyo, Kisho Sakata Electronics, among others. Although EMS takes on labor-intensive jobs, the company considers itself as high technology, the principle being that manual work can be done in a high-technology way. Through close monitoring of quality and productivity, sophistication is added to manual operations.

4.3.1. Linkages and Innovation

The interviewee was the son of the company's founder who serves as Director for Business Development. He claimed that yes, innovation is important for EMS. This despite the fact that they are on the lower level tier of electronics manufacturing that just accepts the specifications of its OEM-customers in order to assemble intermediate products. For example, EMS does actual assembly of DVD players, while for an mp3 brand, what the company does is limited to a particular electronic component before it gets passed on to another company. Though it does not produce its own products, innovation for EMS is important in order to maintain its leg-up over the competition. It is able to maintain its edge by constantly being better and faster than its customers and its competitors. So far, EMS has been able to deliver 99% good products from the materials consigned to it, which translates to 1% loss rate. This implies materials savings on the part of the customer. The Director mentioned that the company's upgrading efforts are essentially directed towards improving the work space on the floor to make it more operator-friendly and line-friendly. Hence, it does process innovation that is incremental in degree and produces innovations that are new to the firm. The Director said that what they do is a combination of process innovation and improvement of jigs and fixtures, fixing it in such a way that one jig can already do multiple functions. According to the Director, the specifications may come from the customers but that is only half of the equation. The other half involves the company's injection of its own design and innovation, working on what the customer has provided and then improving on it.

With most of its customers and suppliers located in CALABARZON, EMS decided to locate its headquarters and assembly factory in Laguna Technopark. It is in the same industrial zone where customers like Firm A and Panasonic are located.

In terms of motivation for upgrading, the Director points to the need to remain competitive and be better than the company's customers because otherwise, they will just do the assembly themselves. The contributors to upgrading are the company's internal R&D unit composed of six people, its product development team with seven and other internal departments or individual business units that have two engineers on-board to assist in improving the process. In fact, the upgrading example cited by the Director was an idea that came from an operator. Encouraged by the culture prevailing in the company, the operator made a suggestion related to making his/her workspace be more productive. The company's R&D unit then turned the idea into fruition. In this example, the operator suggested modifying the microscope being used by operators in order to have more elbow room and better reach of parts being assembled. This idea turned into reality with the improved workspaces for the operators.

When it comes to partners for upgrading, the Director considers firms in the same business group, customers and the industry association – SEIPI. Except for SEIPI, all of the customers and suppliers of EMS are located within CALABARZON. When it comes to collaboration mode, EMS and its partners have informal information exchange; human resource development and exchange of technical personnel.

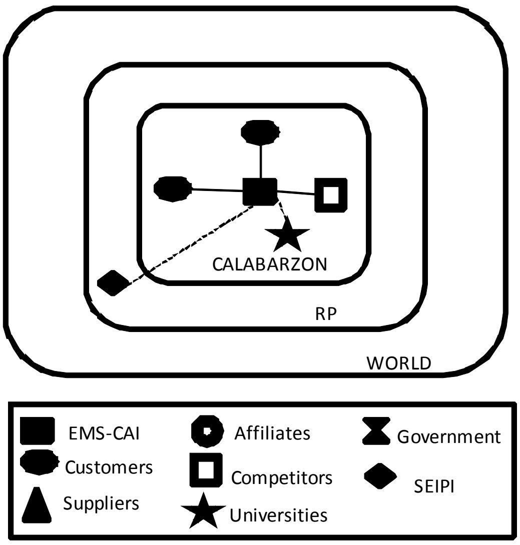


Figure 3 EMS-CAI Linkages

In terms of duration, average length of the relationship is about four years, with EMS in existence only for about five years. In terms of frequency of collaboration, the interface is fairly regular with basis of collaboration bordering on personal already. The Director mentioned that in strategic planning sessions of its customers, EMS is always included in order to find out the directions of the customers and how EMS can respond to them and the types of improvements/upgrading that may be required. Exchanges of engineers also do happen between EMS and its customers. What they do is to exchange technical information as well as on improvements. The EMS engineers inform their counterparts about their business status, while the latter give them information about their company's short term plans or if there is a new product model so EMS could prepare for it. Engineers are also sent to SEIPI to participate in training programs.

4.3.2. Obstacles to Innovation and Collaboration

When it comes to obstacles for collaboration, the Director pointed to intellectual property issues as a concern limiting the extent of technical information that partner firms are willing to share. As for internal factors that impede innovation, the Director pointed to choices such as perceived risks and costs too high; limited financial resources; lack of information on technology and on markets. External factors that hinder innovation are lack of qualified personnel, inadequate support services and lack of government support. Collaborations are able to mitigate some of the obstacles when it comes to alleviating the problem of lack of personnel. In its own terms, EMS tries to develop its own skills requirements through its cadetship program, where it recruits fresh engineering graduates and trains them on the job for six months. Though the company is not able to hire everyone on board, they get easily picked up by other companies.

EMS to some extent collaborates with universities but mainly to speak in classes and to accommodate OJTs. The Director pointed to the problem of matching industry needs with the manpower that comes out from these universities.

As for the government, the Director lauds the incentives given to companies through PEZA but hopes that the government can work on having one common strategy for electronics alone and better equipped facilities that are affordable for the use of industry players.

4.4.Remec Broadband Wireless International Inc.

The President of Remec Broadband Wireless International Inc. (RBWI) and his company is a success story that is highly regarded in the industry. The head of RBWI is an engineer that tried his luck in Silicon Valley in the US, got trained technically and then came back to the Philippines with a desire to build his own company. The first company that he founded together with fellow Asians and Filipino-Americans in 1995 was called Pacific Microwave Corporation that was the country's first and only provider of manufacturing and test services of radio frequency (RF) and microwave devices. In time, the company grew and captured a global market share including customers in the US, Europe and Israel. By 2000, the company was attractive enough to merit an offer from REMEC, Inc. (an American, US-based company) and was acquired to become REMEC Manufacturing Philippines, Inc. Following a change of management, the company's outdoor unit (ODU) and transceiver business was bought by the group of Mr. Bonifacio and was renamed, REMEC Broadband Wireless International (RBWI).

RBWI was formed officially in 2005 and located its manufacturing facility in Carmelray Industrial Park in Laguna. Five years hence, RBWI is a global leader in the wireless broadband revolution. Its ODU is the only commercially successful off-the-shelf ODU product in the market, saving millions of dollars in product, R&D, and manufacturing costs for OEMs, which otherwise would have to develop the product themselves. RBWI also accepts outsource manufacturing of complex components, sub-systems, and systems alongside its own world-class products. The company has presence in San Diego, California and design centers in the US, Canada and soon in the Philippines. Being a global company, it has sales offices in Milan, Italy; Beijing and Shenzhen in China. The President is investing in training people in the US for the eventual establishment of an R&D facility in the country. He admitted that the company does not need another facility like this but it had always been his dream to establish an R&D company in the Philippines as his contribution for jumpstarting the development of technological capabilities in the country. Moreover, having an R&D facility close to manufacturing capabilities has its advantages.

RBWI is a joint venture with majority shares coming from Filipinos and the rest by American investors. The top executive of the company does not consider ownership of RBWI as a joint venture though, insisting that it is one company with groups of investors representing two nationalities. The fully integrated ODU is the company's main product. It is an infrastructure facility that is being put up in towers and cell sites to enable transmittal of RF. Although the company develops and builds the product, they are not considered as an OBM as their customers in the likes of Motorola and Nokia put their own brand into it. However, the company owns a patent to the product being their own design.

4.4.1. Linkages and Innovation

Being a high-technology company, RWBI considers innovation as very important. The President cited two examples of recent innovation that the company has done. One is the development of the ODU itself, a product innovation, and the other, the adoption of the 6-sigma system, a process-innovation. Both are considered incremental innovation since they are both improvements to increasing systems. In particular, the fully integrated ODU was an upgrade from the former product that requires a different unit for every RF, while the 6-sigma system is a value system that aims to improve existing organizational systems. The improved product caused cost reductions, enabling RBWI to quote a substantially lower price to the advantage of its customers. The President considers his ODU as something that is new to the world, while the value system is not.

There is only one motivation for the upgrading and that is, to reduce production costs/materials energy. The company made use of its intramural capabilities to develop the product. Indeed, the firm's in-house R&D department plays the major role in product development and design. It maintains its facility in the US in order to be near the market. Although there are instances when customers change their interface to make use of RBW's products, the company also comes up with products based on the design and specifications of its customers.

As for its partners for upgrading/innovation, RBWI considers its tier one customers as just that. Since they demand high standards for their orders, RBWI has to be responsive and up to par. For example, if the customer demands zero defects but the average in the company is 5%, the company has to work on upgrading its capabilities to be able to respond to customer demands.

RBWI considers their suppliers as partners too. In fact, every January the company holds a Supplier Day- for both local and foreign suppliers. The company confers awards to best suppliers, while it also serves as venue for sharing business outlook. Like their customers as partners, the company also works with their suppliers to ensure good quality inputs. Frequency of collaboration with suppliers is every quarter as RBWI audits them under its supplier quality under RBWI's Engineering group.

These partners for upgrading are not within the proximity of RBWI as the most important customer is in China, while the supplier-partners are both the locally-owned and foreign-based ones. When it comes to modes of collaboration, RBWI engages in joint R&D projects with its suppliers for new devices, while technology assistance is another way. Frequency of collaboration was indicated to be regular for both partners on an institutional basis. Mutual dispatch of engineers is likewise being done. Meanwhile, RBWI has had collaborations with training centers and universities in Laguna for manpower upgrading, on the job training and training of faculty from the University of the Philippines to learn about the manufacturing process in the company.

The firm has also sponsored or has granted scholarship to deserving students through SEIPI's program.

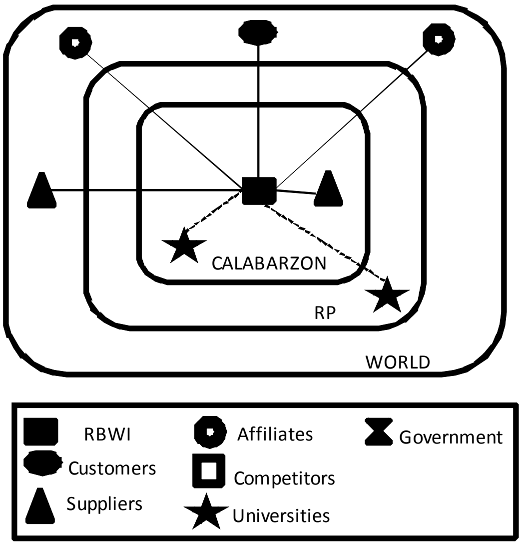


Figure 4 RBWI Linkages

4.4.2. Obstacles to Innovation and Collaboration

The President did not find any obstacles in collaboration indicating that hindering factors are not applicable to RBWI. He did not mention any obstacles to upgrading as well, both internal and external, since the company is able to overcome difficulties. For instance, lack of technical skills at the local level is addressed by the training provided by capable R&D personnel and engineers based in the US. Moreover, Filipino manpower possesses the minimum technical skill requirements, making them trainable and easily adaptable to new technologies.

The President of the company lauds the government for enabling the establishment of industrial zones in the country since business transactions like exportation and importation were simplified.

4.5.BELL Electronics Corporation

BELL Electronics Corporation, a wholly Filipino owned company was established in 2000 as an assembly and test subcontracting house for optoelectronics and sensor devices. It was built by a group of engineers and former employees of a well-established electronics company also located within CALABARZON.

Initially the company focused its resources in metal can packaging for electronics IC. Located in Carmelray Industrial Park in Laguna, BELL is a small firm that indirectly exports to the US, Europe, Singapore, and Taiwan. Its package line started with only three types when it was established, before growing to 20 types of packages. Similar to other Filipino electronics firms engaged in assembly and testing, the main goal guiding the operations of BELL is giving the best possible value for money for its customer/s by providing the highest attainable quality product at the shortest possible time while ensuring the best customer care. Hence, the two main objectives here are quality and speed, implemented on the floor by its team of multitasking operators. The firm boasts of a 2% reject rate in its production, which is an indicator of the quality level the company is able to crunch out. These operators are trained by the company for three months.

4.5.1. Linkages and Innovation

According to the Production Manager, who is well-versed on the operations of the company, BELL considers upgrading or innovation as important. As a subcontracting company, the focus of their upgrading efforts is on the production process and in making sure that the equipment they have would enable them to fulfill customer specifications. It is necessary for the company to have flexibility in their operations in order for them to customize equipment according to their production needs. As an example, the Production Manager cited that the firm had to convert different types of equipment to enable them to do die attach processing. This upgrading in terms of the conversion of equipment for other purposes was undertaken, not by an R&D unit which the firm does not have, but by a team of engineers. In fact, they have instituted the concept of failure analysis to respond to critical problems on the floor. They also have control charts that enable them to monitor their operators and the production process so that they can immediately take action once problems are identified. In the particular upgrading example cited by the Production Manager, incremental innovation was the degree achieved. It was apparently innovative enough that the upgrading was considered not only new to the firm but also new to the market where the firm is operating. Figure 5 traces out the linkages that the firm has for upgrading/innovation.

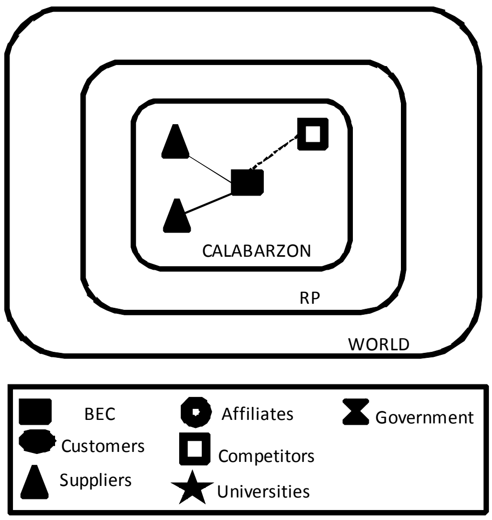


Figure 5 Bell Electronics, Corp. Linkages

The company's upgrading efforts are motivated by the need to improve production flexibility and reduce production costs because the improvements did away with procurement of equipment. The firm's internal strategy is to tap its capabilities within the company, particularly its engineering department. Hence, the Production Manager considers their engineers as the main contributor to the innovation. As regards partners for technological upgrading, the Production Manager points to their vendors or locally owned suppliers. He acknowledged that because they are able to go around places and pick up technological information, the firm is able to generate technical information from these suppliers as well. These local suppliers operate from Laguna, which makes them proximate to the firm. The collaboration mode between and among the partners is technology assistance, and frequency of collaboration is regular, as in once a week. The partnership arrangement is institutional in nature and they dispatch engineers to each other. The main suppliers are required to be ISO certified. It was noted that the technology or technical information acquired is embedded in the equipment provided by the suppliers. Though not really considered as partner for upgrading, the firm has a healthy, informal relationship with its competitors. The Production Manager said that at a certain level, they do have link-ups with their competitors including materials exchange and sharing of information.

4.5.2. Obstacles to Innovation and Collaboration

In terms of hindrances to collaboration, the Production Manager did not cite any, but when it comes to internal factors serving as obstacles for upgrading, he pointed to the limited financial resources that can be set aside for this effort. As for external factors on the same, lack of customer interests in innovation was cited. As assembler of intermediate products, the firm relies on the dynamism of its customers; otherwise, it just performs what is required as per specifications. The Production Manager did not mention any public policy or program that was helpful either for facilitating collaboration or for solving obstacles for innovation.

When it comes to human resources, the Production Manager opined that quantity is a non-issue. Rather, the main concern is the quality of manpower, particularly of engineers.

4.6. Hayakawa Electronics Philippines Corporation

A member of the Hayakawa Group of Companies of Japan, Hayakawa Electronics Philippines Corporation (HEPC) started out in 1990. Founded as a separate entity and located at the Cavite Export Zone, HEPC's main customer is the mother company itself and conducts wire harness assembly for small appliances and automobiles. HEPC is one of the two companies established in the Philippines by the Hayakawa Group, with the other one engaged in the components business. HEPC has undergone upgrading when it comes to the application of assembled wire harnesses, starting out with assembling wire harnesses for small appliances and now, for automobiles and vending machines. It was pointed out that the firm could not just simply upgrade, it has to make sure that it follows adequate standards in production since safety is a major concern when it comes to product applications.

4.6.1. Linkages and Innovation

In fact, the upgrading in relation to wire harness assembly for automobile was the example provided by HEPC. The Human Resource Manager interviewed mentioned that special care and attention has to be given in this venture since the safety of passengers is the primordial concern. Needless to say, the company has to upgrade its capabilities to be able to fulfill the stringent requirements equivalent to an ISO or TS. Since HEPC's production is labor intensive, it goes to show that innovation has to be directed towards skills upgrading. For this particular example, the Manager cited adoption of new production method and substantial organizational change as the types of upgrading in relation to the company's venture towards wire harness assembly for automobile. It can be regarded as incremental innovation that was new to the firm. She cited several stimulants for the innovation namely, replacement of products or model changes, improvement of product quality, opening up of new markets, compliance with regulations and standards, improvement of cycle time, decrease delivery lead time, improvement of production flexibility, reduction of production cost, improve work conditions for employees, learn about new technology, enhance price competitiveness, and reduce environment effects such as lead free materials.

When it comes to the firm's strategies to realize the upgrading effort, the following were indicated: acquisition of machinery and equipment in connection with process modification; training and market introduction of innovations. For the particular example cited, the firm considers its in-house department, in particular Design and Development (D&D), and other internal departments as contributors to the upgrading. The D&D unit has to check the applicability or manufacturability of the proposed upgrade as well as check if it is suited to customer requirements.

As to who the firm considers as partners for upgrading, the Manager cited two particular examples – customer and supplier. The former pertains to the Hayakawa mother company. It is considered to be both located within the agglomeration and across or outside the industrial area where HEPC is; while its partner-supplier is not located within the agglomeration. The collaboration modes adopted for both partners were said to be informal information exchange, joint D&D projects, contract research, technology assistance, and exchange of technical personnel including engineers. The duration of collaboration for both is 19 years and frequency of collaboration that is both institutional and personal, is regular. HEPC also has linkages with foreign-owned suppliers; firms in the same business group particularly its Mother Company and affiliates, other customers, and also, competitors at certain levels. It also has links with universities but only in terms of sending a list of students studying in related programs.

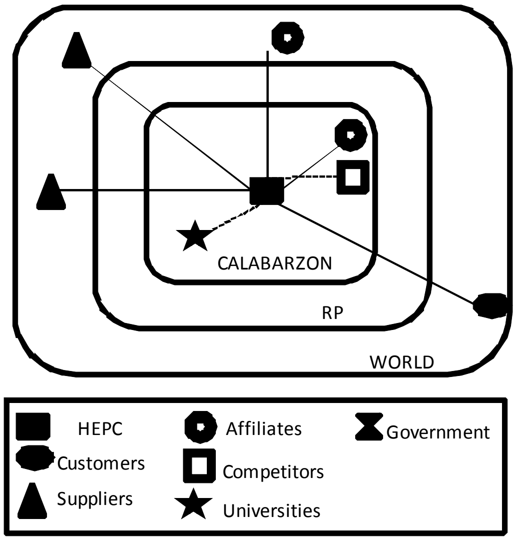


Figure 6 Hayakawa Electronics Philippines, Corp. Linkages

4.6.2. Obstacles to Innovation and Upgrading

Obstacles to collaboration that was mentioned by the Manager were difference in time horizon in the literal sense and limitations caused by intellectual policy issues. As for hindrances to innovation, internal factors such as perceived risk too high and perceived cost too high as the major ones. However, collaboration can mitigate such obstacles through mutual testing and liability sharing. Meanwhile, an external turn off factor to innovation is lack of customer interests in innovation especially since the specifications and requirements of the work required come from them.

4.7. Firm B

Firm B, an American company, provides protection against many of the primary causes of data loss, hardware damage and downtime. Founded in 1981, Firm B is a leading provider of global, end-to-end AC and DC-based back-up power products and services, which include surge suppressors, uninterruptible power supplies (UPS), power conditioning equipment, power management software, and DC power systems as well as precision cooling equipment. Firm B's corporate offices are located in West Kingston, Rhode Island. The company has sales offices throughout the world and manufacturing facilities in the U.S., Ireland, Switzerland, Denmark, Philippines, China, India, and Brazil.

The interview was granted by the President of Firm B, an American. The facility in the Philippines is the largest manufacturing center of Firm B in the world. Initially, the company does not have offshore manufacturing in Asia not until it decided to establish its presence here in Manila. Instead of acquiring another company, it was decided to set up its own.

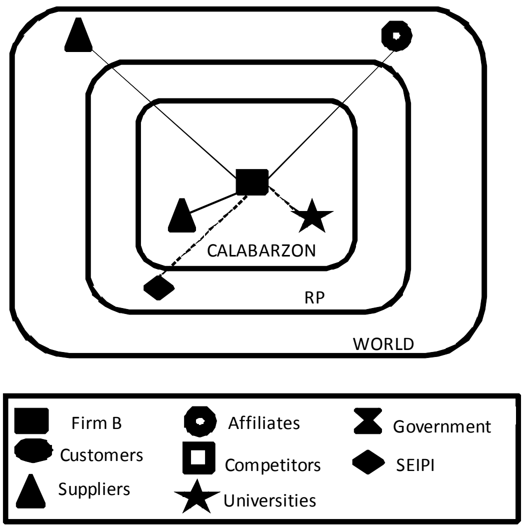


Figure 7 Firm B Linkages

4.7.1. Linkages and Innovation

Firm B's President admitted that upgrading/innovation is important to the company and cited the introduction of the 500kva UPS as example of this. As innovation type, this upgrading effort enables them to introduce new product or service; adopt a new production method; secure new supplier/new materials; and, substantial organizational change. The firm considered their recent effort as neither incremental or substantive and opted to provide for so called, disruptive technologies. The motivations for upgrading were improved product quality and opening up of new markets. This enabled Firm B to adopt internal strategies in implementing the innovation utilizing intramural/in-house R&D; training and, reverse engineering. In the upgrading example earlier citer, Firm B considers vendors as one of those who gave substantial contribution to Firm B. Also added were the firm's internal departments.

4.7.2. Obstacles to Innovation and Collaboration

As for obstacles for collaboration and innovation, the President cited the firm's capability to innovate on its own and the difficulties in looking at the difference in time horizon.

Meanwhile, among the many obstacles to innovation, two were identified namely, perceived cost too high and others. Among the external factors, lack of qualified personnel was pinpointed as a hindrance to upgrading.

4.8. LITTELFUSE PHILIPPINES, INC.

Littelfuse Philippines, Inc. is a manufacturing facility of Littelfuse, an American company with headquarters in Chicago. The Philippine facility is located in LIMA Industrial Park in Batangas and manufactures products, i.e. fuse, for application in the electronics industry like in cellphones, teleconferencing equipment, laptops, among others. Littelfuse is the worldwide leader in circuit protection products and solutions, with a comprehensive portfolio backed by industry leading technical support, design, and manufacturing expertise and having significant investments in R&D and distribution. The products of Littelfuse are vital components in virtually every product that uses critical energy, including automobiles, computers, consumer electronics, handheld devices, industrial equipment, and telecom/datacom circuits.

Representing the company was the Human Resource Officer who proved to be very knowledgeable about the operations of the company. She acknowledged that upgrading/innovation is very important for the company. Product innovation is meant to align with customer needs and requirements, while process innovation is done in a backdrop of being a lean company, to be able to shorten production without sacrificing quality. In fact, the firm has ISO certifications and has been practicing the 6-sigma value system for a long time.

4.8.1. Linkages and Innovation

As representative example of upgrading efforts, the Officer cited the need to customize the firm's fuse as a response to the introduction of new cellphone models by its client. It was mentioned that each model sometimes requires a different kind of circuit protection. This type of upgrading was related to the introduction of new product but an incremental innovation since there is only a need to improve the same product but customized to the pressing needs of the customer. Since the upgraded product can be considered new, it is a novelty in the market where the firms are operating in that regard. The motivation for the upgrade is to replace the product being phased out or being upgraded, to improve product quality, extend the product range, and open up new markets. Meanwhile, additional information was provided like when it comes to the aim of getting certification, the motivation for upgrading is the fulfillment of regulations and standards, while there is another set of rationale when it comes to process innovation. As for the firm's strategy in relation to its upgrading efforts, the company relies upon its intramural/in-house R&D efforts; acquisition of other external knowledge such as licenses to use intellectual property; training; and basic design. The contributors to this type of upgrading were its in-house R&D unit as well as other departments like process engineers and even from the operators.

Littelfuse's partners for innovation are its customers and suppliers, both local and foreign owned. However, these customers and suppliers are mostly outside of the agglomeration. In addition to informal information exchange where the customer shares market information, exchange of technical personnel was also mentioned. The frequency of collaboration to its partners are regular and on an institutional basis. While the firm dispatches engineers to its partner customers and suppliers, the firm does not receive engineers from them.

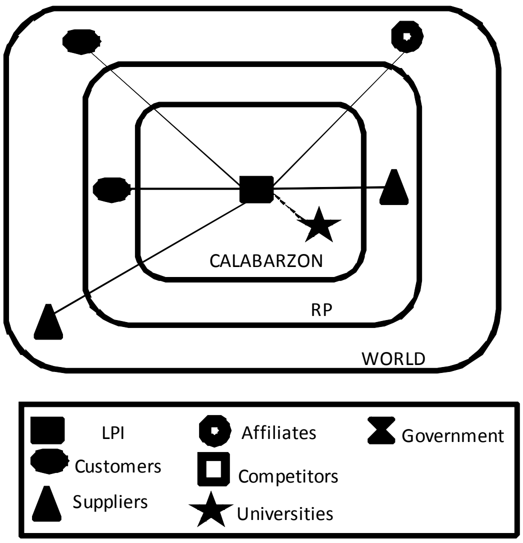


Figure 8 Littelfuse Philippines, Inc Linkages

The firm likewise engages other parties in various types of activities, not necessarily related to innovation pursuits. For one, Littelfuse has a two-way relationship with universities located in CALABARZON such as Batangas State University, among others. The firm accommodates on-the-job-trainees from universities and employees from the firm serve as resource speakers in their classes. In a similar manner, the firm also engages consultants to become technical resource persons for them.

4.8.2. Obstacles to Innovation and Collaboration

The main obstacle to collaboration as pointed out by the Officer is the so called, intellectual property issues, hindering further exchange of technical information. As for obstacles for upgrading, the Officer did not identify any since the firm is able to cope with both internal and external factors. She added that they regularly set aside a budget for R&D and the firm is aware of the possible risks.

4.9. Firm C

Firm C is a joint venture company between a large family-owned Filipino company, and a Japanese company for the manufacture of high precision injected molded plastic products for electronics. It was incorporated in 1995 and started commercial operation in 1996. Located outside of PEZA zones, Firm C is registered with the BOI. It is claimed that the company was founded to respond to the needs of Toshiba for plastic frame/products. Though it was unfortunate that the DVD-rom operation of the latter closed down, Fujica was able to pick up other customers like Firm A and Japanese firms as subcontractor.

The company acquired additional units of injection molding machines in order to increase its capability and capacity for a total of 16 injection molding machines complete with accessories three years after it was founded. By 2008, the company can already count twenty (20) machines.

4.9.1. Linkages and Innovation

The interviewee was the Assistant General Manager of the company. According to him, since they are engaged in plastics processing or hi-precision injection molding in support of electronics firms and their products, and they are dependent on the molds designed and supplied by their customers, upgrading is not really that important to them. The company's upgrading if any, is limited to fixing their equipment to adapt to the needs of their customers. However, during the course of the interview and further exploration into the plant yielded the observation that some of the firm's employees are venturing into mold design. The fact that they are into mold or product development as well as into equipment upgrading or adaptation, then it can be considered that the firm is also into innovative activities. These are however, not a priority at the moment and largely informal. Due to this, collaboration is also not present when it comes to upgrading/innovation concerns. Nevertheless, engagement with local universities was traced although their interaction is limited to the accommodation of on-the-job trainees in the firm.

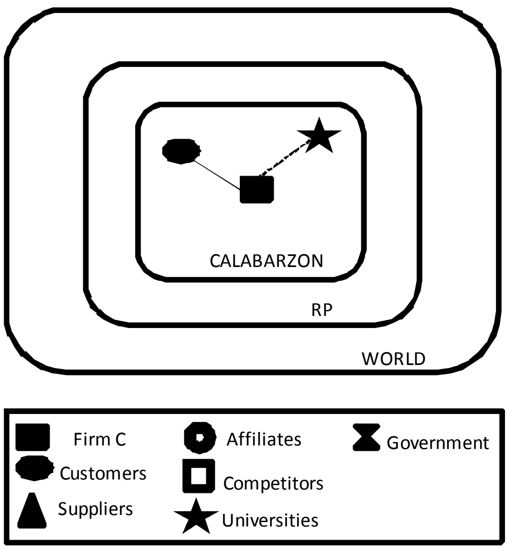


Figure 9 Firm C Linkages

The inclusion of this firm in the case study was continued to be able to provide a counter-example to the others and in order to derive insights into why there are firms in the electronics industry that do not do R&D.

4.10. EXITO ELECTRONICS COMPANY PHILIPPINES, INC.

Exito Electronics Company Philippines, Inc. is a foreign investment corporation set up in 1991 as a manufacturing firm, which is wholly Taiwanese in ownership.[8] The company's products are export-bound comprising of indoors and outdoors- use extension cord, electrical wires and cables, communication and audio/video cables. Its operations are highly automated in keeping with the high standards of precision required for such products as the finished products are subjected to rigid testing and analysis in accordance with the Underwriters Laboratories, Inc (UL) of USA and Canadian Standard Association, which safeguard market quality standards. From 123 workers in 1992 when it started operations, the company now has 425 workers in line with the expansion of its manufacturing capabilities. The company typically sources its materials from Taiwan but also locally when available. About 90% of its products go directly to hardware stores abroad particularly in the US, Mexico and Taiwan, while the residual goes to OEMs.

4.10.1. Linkages and Innovation

The company was represented by its Production Head during the interview. He clarified that there are two companies in the Philippines under the Exito banner. One is Exito Philippines that handles indoor cords, while the other is Tai-Fini Copper and Conductors which take care of the outdoor cords and provide the copper requirements. While formal R&D is being conducted in Taiwan, the Philippine plant has engineering capability and can make samples of products. By virtue of the set-up of this company alone, it can be inferred that innovation is considered important.

---

[8] In the written profile of the company given to the interviewer during the dialogue, it was indicated that the firm has both Filipino and Taiwanese incorporators. However, during the interview, the Production Head mentioned that the company is wholly Taiwanese. The latter was adopted in this paper.

As a representative example of upgrading efforts, the Production Head shared their experience in upgrading the handling of their production. The process used to be segregated by stations and takes four hours to complete production. With the innovation introduced being the conveyor type process, production time was reduced to one hour. As this has helped improve the production flow, this type of upgrading is considered as adoption of new production method. It is incremental innovation as the present way of doing things was improved and considered new to the firm. As explained by the Production Head, product innovation is handled by the R&D facility in Taiwan, while the Production Department in the Philippines which houses its engineering capabilities does production improvements like the type described above. Whenever new products are developed, representatives from the Taiwan R&D unit visit to introduce the product. Since the firm started, five additional products were introduced. The Production Head emphasized that it is also convenient for the Taiwanese facility to conduct the R&D since they have an existing relationship with UL already.

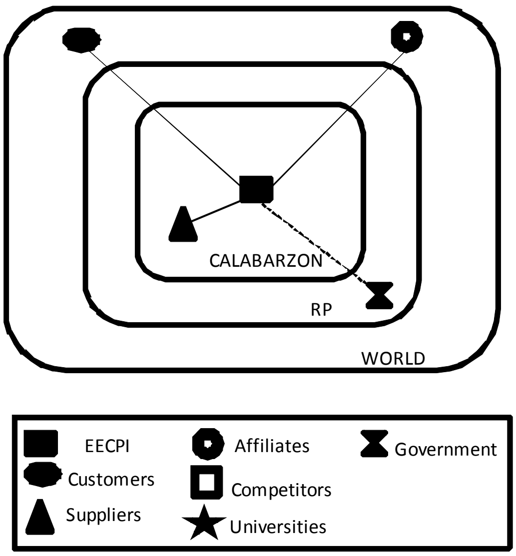


Figure 10 Exito Electronics Company Philippines, Inc. Linkages

Upgrading efforts in this company are motivated by the desire to increase market share, improve cycle time, decrease production lead time, and reduce production cost. For the particular affiliate in the Philippines, the firm's strategy for innovation is through intramural efforts by its Production Department. As for its partner in innovative pursuits, the Production Head considered its local supplier as one, which is located also in Cavite. As they also do packaging of their products, the supplier is able to provide them with state-of-the-art packaging technology while the design comes from their customers. He candidly admitted that the company does not have university linkages or membership in industry associations. As for extent of engagement with public agencies, he mentioned that they attend training programs offered by the Department of Trade and Industry (DTI) on productivity enhancements. In terms of obstacles to innovation, the Production Head indicated that their firm's capability is enough to innovate which explains why he could not cite any other partners for upgrading except particular suppliers of packaging materials.

Most of the company representatives interviewed shared their thoughts and opinions on the state of the electronics industry in the Philippines. Some relate to the need for R&D capabilities in the country, while others to the role of government in developing the industry. Their insights will be cited in the concluding chapter.

5. ANALYSIS

5.1. Summary of Survey Results[9]

A survey of firms in CALABARZON completed at the end of 2009 was intended to

---

[9] The survey was commissioned to the National Statistics Office (NSO) by the Philippine Institute for Development Studies and the Bangkok Research Institute/JETRO under the supporting study to the ERIA overall project on Asian Comprehensive Development Plan. This case study is intended to supplement the econometric analyses that will be undertaken by the Japanese team under said project.

generate information on production and science and technology linkages and their impacts on technological upgrading and innovation in the last three years (from 2007). The same sample of firms that participated in the 2008 survey conducted in relation to a firm-level study under the auspices of ERIA was revisited to be part of the latest survey. Selected results from this survey are presented in this section to provide a backdrop of the general situation in the region, zeroing in on electronics firms covered by the survey, before venturing into an analysis of the information gathered from the interviews of the 10 firms.

Table 7 Profile of Surveyed Firms

	Levels	% Share
Number of Surveyed Firms	203	100.00
By Sector		
Food, beverages, tobacco	34	16.75
Textiles	2	0.99
Apparel, leather	22	10.84
Wood, wood products	11	5.42
Paper, paper products, printing	5	2.46
Chemicals, chemical products	11	5.42
Plastic, rubber products	15	7.39
Other non-metallic mineral products	8	3.94
Iron, steel	13	6.40
Non-ferrous metals	1	0.49
Metal products	15	7.39
Machinery, equipment, tools	5	2.46
Computers and computer parts	7	3.45
Other electronics and components	22	10.84
Precision instruments	2	0.99
Automobile, auto parts	14	6.90
Other transportation equipment and parts	2	0.99
Other, specify:	10	4.93
NR	4	1.97
Electronics:	31	15.27
Computers and computer parts	7	3.45
Other electronics and components	22	10.84
Precision instruments	2	0.99

A total of 203 firms participated in the survey, of which, the top three manufacturing sectors in terms of number are food, beverages and tobacco; apparel and leather; and, other electronics and components. These sectors represent the agglomerated industries in CALABARZON. When lumped together, the total number of electronics firms covered a total of 31 comprised of the following: computers and computer parts, other electronics and components, and precision instruments. As expected, the sector on other electronics and components which include semiconductors is represented the most (Table 7).

In terms of ownership of the firms surveyed, almost half are wholly Filipino-owned, a little more than 25% is wholly foreign, while the residual is rounded up by joint ventures. It should be noted that the region is dotted with numerous industrial and economic zones, preferred location of exporting and foreign firms due to the incentives offered, the facilities and the simplified process of exportation and importation. It is thus, no wonder that one half of the total samples surveyed are foreign-owned and joint ventures (Table 8).

Table 8 Ownership

By Capital Structure		
100% Filipino-owned	101	49.75
100% Foreign-owned	54	26.60
Joint Venture	48	23.65

Except for electronics and automobile and auto parts, all of the firms surveyed consider NCR and CALABARZON as their most important sources of inputs. Electronics look to Japan as its main source of supplies, followed by a wide margin by Korea and CALABARZON. This implies that Philippine electronics firms continue to be part of the production web of Japanese firms, while they have connections with Korea, China and Taiwan (Table 9).

Table 9 Most Important Source/Origin of Inputs

	Philippines (NCR)	Philippines (CALABARZON)	Philippines (Other Regions)	China (Mainland & HK)	Japan	S. Korea	Taiwan	US	Total
Food, beverages, tobacco	13	15	4					1	34
Textiles/Apparel	4	3	1	4	1	3	2	6	24
Wood/Paper	5	4	2	1	2	0	1	1	16
Chemicals, chemical products	2	1	1		2	2	1		11
Plastic, rubber products	4	6	2		3				15
Iron, steel, non-metallic products	10	6	3	1	0	0	0	1	22
Metal products	3	6		1	1				15
Machinery, equipment, tools	1			1	2				5
Electronics	**1**	**4**	**0**	**3**	**15**	**4**	**2**	**1**	**31**
Automobile, auto parts		1			12				14
Other transportation equipment and parts					2				2
Others/NR	2	3	1	2	0	0	0	3	14
Grand Total	45	49	14	13	40	9	6	13	203

In terms of affiliated firms in other countries which could indicate the industry's participation in the regional or global production network, survey results show that among all the sectors, it is the firms in the electronics industry that have the most number of affiliates outside of the Philippines. The table below shows that the electronics firms are affiliated with Singapore-, Malaysia-, China-, Japan-, US-, Europe-, Taiwan-, and South Korea-based firms. The linkage is found to be highest in Japan, China and the US. Meanwhile, the number of firms with affiliates within CALABARZON is likewise high compared to the others, denoting the agglomeration of electronics firms in the region more than in any other regions in the country (Table 10).

When it comes to the location of the most important customers, nearly half of the total electronics firms indicated CALABARZON. This indicates that their partners are proximate to their own location denoting its importance for critical production linkages and transactions (Table 11).

Table 10 Do you have affiliates in the ff countries?

	Philippines (NCR)	Philippines (CALABARZON)	Philippines (Other Regions)	Singapore	Malaysia	China (Mainland & HK)	Japan	US	Europe	Taiwan	S. Korea
Food, beverages, tobacco	6	10	10	1	2	4	2	2	2	1	0
Textiles/Apparel	1	1	3	0	0	3	2	4	2	2	4
Wood/Paper	3	5	3	0	1	0	2	0	1	1	0
Chemicals, chemical products	2	1	3	2	2	1	1	2	3	2	2
Plastic, rubber products	5	8	5	1	1	2	2	1	1	2	0
Iron, steel, non-metallic products	6	7	3	1	1	1	2	2	1	0	0
Metal products	1	2	1	4	2	3	5	3	2	2	2
Machinery, equipment, tools	2	1	1	1	0	0	3	1	2	0	1
Electronics	**2**	**12**	**3**	**11**	**8**	**17**	**18**	**12**	**11**	**5**	**6**
Automobile, auto parts	3	6	3	1	2	2	8	5	4	2	0
Other transportation equipment and parts	0	1	0	0	0	0	2	0	0	0	0
Others/NR	3	1	2	3	3	4	2	5	4	3	2
Grand Total	34	55	37	25	22	37	49	37	33	20	17

Table 11 Location of Most Important Customer

	Philippines (NCR)	Philippines (CALABARZON)	Japan	US	Philippines (Other Regions)	Grand Total
Food, beverages, tobacco	15	12	1	1	3	34
Textiles/Apparel	4	3	1	12	1	24
Wood/Paper	5	5	3	0	2	16
Chemicals, chemical products	9			1		11
Plastic, rubber products	5	6	3		1	15
Iron, steel, non-metallic products	16	4	0	1	0	22
Metal products	4	6	3	1		15
Machinery, equipment, tools	2	1	2			5
Electronics	**1**	**12**	**8**	**2**	**0**	**31**
Automobile, auto parts	3	4	6			14
Other transportation equipment and parts	1		1			2
Others/NR	3	1	1	6	1	14
Grand Total	68	54	29	24	8	203

Activities for upgrading and innovation done in the last three years were also asked and where survey results indicate that in the aggregate (all sectors), significant improvement of an existing product or service was the most common followed by the development of a totally new product based on existing technology. The same pattern was found for electronics firms alone though the latter was tied with the development of a totally new product based on new technologies. In both cases, the new products developed were mainly shopped to existing customers. When it comes to process upgrading, improvement of existing machines, equipment and facilities for both aggreggate sectors and electronics only came up as the most common mechanism. This was followed by buying new machines or facilities with new functions in the case of electronics firms. As for substantial organizational changes undertaken, the top three among all sectors are production control and management; quality control; and cost control and management. For electronics firms, the main mechanisms are adoption of international standards, enviornmental management, human resource management, quality control, and production control and management.

The top major sources of knowledge and new technologies among the surveyed firms in all the industries covered, those considered to be important, are the following:

internal sources of information and own R&D efforts; recruitment of mid-ranking personnel; participation in conferences and trade fairs; and, foreign-made equipment and software. Firms that are more internally driven have their sources in the same area where they are located or to their affiliates in other ASEAN countries; to those located in other regions in the country; and to their affiliates in Europe or the US. Presumably, these sources are their headquarters, R&D units or departments of the company or other internal departments. It is interesting that recruitment of mid-ranking personnel ranked so high relative to the others which point to the importance of getting highly-skilled and educated people on board to handle technical and management matters. The fact that these personnel are sourced mainly within CALABARZON validates previous findings that industrial agglomerations are able to gather pool of specialists, which attracts more firms wanting to tap this pool to locate in the same area. This finding also points to the possible homogeneity of production pursuits in such an agglomeration, thus enabling the mobility of labor. That foreign made equipment and software figured high in this survey is no surprise as technologies are embedded in machines and other inputs. The fact that they are foreign-made implies that these are state-of-the-art hardware. Findings by the ADB show that new machinery and equipment is the most important source of technological innovation among Asian firms, followed by internal sources and those arising from cooperation with client firms (ADB, 2009).

Participation in conferences, trade fairs and exhibit remain to be an important source of knowledge since it is expected that knowledge do get around in a gathering of industry players and technical resource persons, if any. As the government typically organizers and sponsors such events, this finding validates the need for them to continue conducting these activities or to facilitate participation of industry players in these fora, particularly to those held abroad which lends the possibility for good and wider exposure for them.

Table 12 Major Source of Knowledge and New Technologies: ALL INDUSTRIES

	No. of Respondents	Not important source	Important source	Locations of Partners/Sources: In CALABARZON	Other regions in the Philippines	In Other ASEAN	In East Asia	In Europe or US	In other countries
Q12.1. Internal sources of information and own R&D efforts	**203**	**91**	**112**	**47**	**25**	**29**	**5**	**19**	**13**
Q12.2. Cooperation with (technology transfer from) local firms (100% Filipino capital)	203	134	69	34	29	8	1	3	6
Q12.3. Cooperation with (technology transfer from) MNCs (100% non-Filipino capital)	203	132	71	14	10	23	6	13	17
Q12.4. Cooperation with (technology transfer from) from Joint Ventures (JVs)	203	151	52	12	5	18	5	5	9
Q12.5. Technical assistance financed/provided by support organizations such as seminar, lecture, training, technical advice, or consultant /expert dispatched or hired by them									
a. Technical assistance financed/provided by government/public agency	203	131	72	44	27	3	2	0	1
b. Technical assistance financed/provided by industrial/trade organizations	203	131	72	29	27	11	3	2	5
c. Technical assistance financed/provided by community organizations (NGOs or NPOs)	203	166	37	26	11	0	1	0	0
d. Technical assistance financed/provided by government owned financial institutions	203	163	40	25	14	0	0	0	0
Q12.6. Linkages with Universities and R&D Institutes									
a. Cooperation with (assistance from) universities/higher educational institutions	203	153	50	39	16	1	0	1	0
b. Cooperation with (assistance from) government or public research institutes	203	151	52	29	24	1	0	0	0
c. University professors or researchers individually contracted by this establishment	203	166	37	23	15	0	0	0	0
d. Dispatch your engineers to universities/higher educational institutions	203	163	40	19	21	1	0	0	0
e. Dispatch your engineers to government or public institutions	203	160	43	21	24	1	0	0	0
Q12.7. Human Resources									
a. Recruitment of middle-ranking personnel or mid-career engineers	**203**	**92**	**111**	**87**	**42**	**2**	**0**	**0**	**2**
b. Recruitment of senior engineers retired from MNCs, JVs or large firms	203	148	55	42	20	2	0	1	1
c. Headhunt of top management from MNCs, JVs or large firms	203	158	45	25	18	5	1	2	2
Q12.8. Other sources of new technologies and information									
a. Technical information obtainable from academic publication	203	134	69	35	30	11	1	7	5
b. Technical information obtainable from patents	203	149	54	20	16	14	1	5	6
c. Introduction of 'foreign-made' equipments and software	**203**	**103**	**100**	**18**	**20**	**36**	**10**	**23**	**18**
d. Reverse engineering	203	164	39	17	11	9	0	4	3
e. Participation in conferences, trade fairs, exhibitions	**203**	**83**	**120**	**51**	**56**	**28**	**6**	**11**	**13**
f. Licensing technologies from other firms	203	153	50	23	18	10	0	2	10

Zeroing in on firms in the electronics industry, it is noted that they mirror the pattern of the aggregated firms from other industries. However, cooperation with MNCs is slightly higher than internal strategies which denote that this sector is oriented more outside of the country and is entrenched in the regional/global production networks. These firms depend more on MNCs in other ASEAN countries than in any other locations. This is also where foreign equipment embedded with technology is mainly sourced.

Table 13 Major Source of Knowledge and New Technologies: ELECTRONICS

	No. of Respondents	Not important source	Important source	Locations of Partners/Sources					
				In CALABARZON	Other regions in the Philippines	In Other ASEAN	In East Asia	In Europe or US	In other countries
Q12.1. Internal sources of information and own R&D efforts	31	16	15	5	0	6	1	4	3
Q12.2. Cooperation with (technology transfer from) local firms (100% Filipino capital)	31	22	9	6	1	2	0	0	1
Q12.3. Cooperation with (technology transfer from) MNCs (100% non-Filipino capital)	**31**	**13**	**18**	**4**	**1**	**6**	**3**	**3**	**3**
Q12.4. Cooperation with (technology transfer from) from Joint Ventures (JVs)	31	17	14	3	0	7	2	2	1
Q12.5. Technical assistance financed/provided by support organizations such as seminar, lecture, training, technical advice, or consultant /expert dispatched or hired by them									
a. Technical assistance financed/provided by government/public agency	31	18	13	9	2	1	0	0	1
b. Technical assistance financed/provided by industrial/trade organizations	31	16	15	5	4	4	0	0	2
c. Technical assistance financed/provided by community organizations (NGOs or NPOs)	31	22	9	8	2	0	0	0	0
d. Technical assistance financed/provided by government owned financial institutions	31	21	10	9	1	0	0	0	0
Q12.6. Linkages with Universities and R&D Institutes									
a. Cooperation with (assistance from) universities/higher educational institutions	31	20	11	8	3	1	0	1	0
b. Cooperation with (assistance from) government or public research institutes	31	23	8	4	3	1	0	0	0
c. University professors or researchers individually contracted by this establishment	31	25	6	4	2	0	0	0	0
d. Dispatch your engineers to universities/higher educational institutions	31	23	8	5	3	0	0	0	0
e. Dispatch your engineers to government or public institutions	31	24	7	4	3	0	0	0	0
Q12.7. Human Resources									
a. Recruitment of middle-ranking personnel or mid-career engineers	**31**	**6**	**25**	**21**	**9**	**0**	**0**	**0**	**0**
b. Recruitment of senior engineers retired from MNCs, JVs or large firms	31	15	16	15	4	0	0	0	0
c. Headhunt of top management from MNCs, JVs or large firms	31	16	15	11	5	2	0	0	0
Q12.8. Other sources of new technologies and information									
a. Technical information obtainable from academic publication	31	16	15	8	5	3	0	1	1
b. Technical information obtainable from patents	31	19	12	4	3	6	0	0	0
c. Introduction of 'foreign-made' equipments and software	**31**	**8**	**23**	**4**	**2**	**12**	**3**	**2**	**3**
d. Reverse engineering	31	18	13	4	2	5	0	1	1
e. Participation in conferences, trade fairs, exhibitions	**31**	**11**	**20**	**11**	**7**	**5**	**1**	**1**	**0**
f. Licensing technologies from other firms	31	17	14	6	3	6	0	1	0

5.2. Summary of Interview Results

Most of the 10 firms regard firm-level upgrading/innovation as important. Each of the firms explained their position in detail and in the context of their firm's history and recent developments. However, one firm, which is engaged in plastic molding for electronics products do not regard innovation as that important in the context of their company's limited production line and activities, citing their dependence on the customer for specifications and mold designs. Still evidences were found that, albeit informally, the personnel of this particular firm develop some degree of innovation in relation to mold designing on their own.

Table 14 Importance of Upgrading/Innovation

	Yes	No	Total
Local	4	-	4
MNC/FO	4	-	4
JV	1	1	2
Total	9	1	10

The upgrading activities by the case study firms are mostly related to adoption of new production method (46%), followed by introduction of new products (33%). Almost all of these innovations are incremental in nature and half are new to the firm.

Table 15 Type of Upgrading/Innovation

	Local	MNC/FO	JV	Total
Introduction of new product/service	1	2	2	5
Adoption of new production method	3	3	1	7
Creation of a new market	-	-	-	-
Secure new supplier/materials	-	1	-	1
Substantial organizational change	-	2	-	2

Firms A and B considered their work as radical innovations. Firm A, a locally owned firm that considers itself global is predominantly into high level assembly manufacturing but offers turn-key and customized manufacturing as well. Looking at its history, it will be noted that the firm has evolved from assembly to sub-assembly to production of end-products though still not its own. Still, Firm A has already evolved from simple manufacturing to doing radical innovation which tells something about the internal capabilities that now exists in the company. The company is also into original design manufacturing that started with its establishment of an R&D facility in Manila and mainly through its acquisition of companies outside of the country – the US, Japan and Singapore -- with design and development capabilities. Firm A's strategy is reminiscent of MNCs in the sense that it has fragmented operations with locations chosen based on functional niches. For instance, manufacturing is done in the Philippines and China, design in Singapore, the US and Japan, and sales in all of these countries plus in Europe.

Meanwhile, Firm B is foreign-owned whose President described the upgrading that they have done as disruptive technology – cutting edge technology that seems to be a step up from radical innovation. Aptly new to the world and new to the market, this firm has reached the point where it is able to push the envelope, so to speak, in product development. The fact that it considers an external partner, i.e. vendor that gives inputs, in upgrading efforts in tandem with its internal capabilities highlights the importance placed by firms to their networks for fostering innovation.

Another firm that is into product development is RBWI. Similar with Firm A, RBWI has design capabilities abroad when it acquired the R&D unit of its former mother company, Remec. It has also opened its design center in Canada in addition to the one in the US, which according to RBWI's President enables the company to be close to its market. Though its presence in the Philippines is largely for manufacturing, aside from being its headquarters, the President has plans to establish an R&D facility in the country as well as earlier mentioned.

Table 16 Degree of upgrading/innovation

	Local	MNC/FO	JV	Total
Incremental innovation	3	3	1	7
Radical innovation	1	1		2

Table 17 Direction of innovation

	Local	MNC/FO	JV	Total
New to the world	1	1	1	3
New to the market	1	2		3
New to the firm	3	2		6

In terms of motivations for upgrading, the top 3 are: reduction of production cost, improvement of product quality and for compliance or fulfillment of regulations and standards. The factors that induced locally-owned firms in the case study to conduct upgrading were diverse, but the improvement of production flexibility got the more responses. Most of them indicated that their edge over competitors, especially those from China, is the quality of their final outputs and the speed that they are able to crunch them out. It is also important that the reject rate is very low to generate cost efficiency on the part of their customers. According to them, this capacity is what sets them apart with their competitors in other countries. For MNCs, their rationale is much more diverse than their local counterparts and considered all of the options presented as applicable to them, except the option on enhancing non–price competitiveness. Meanwhile, only one joint venture firm provided a response to this question since it is the only one among the two joint ventures that actually undertakes upgrading.

Table 18 Motivations of the Upgrading/Innovation Effort

	Local	MNC/FO	JV
Replace products being phased out	-	2	-
Improved product quality	1	3	-
Extend the product range	-	1	-
Open up new markets	-	3	-
Increase market share	1	1	-
Fulfill regulations & standards	1	3	-
Improve cycle time	1	2	-
Decrease R&D lead time	-	1	-
Decrease production lead time	-	2	-
Decrease delivery lead time	-	2	-
Improve production flexibility	2	1	-
Reduce production cost/ materials energy	1	3	1
Reduce environment effects	-	2	-
Improve work conditions for employees	-	2	-
Learn about new technology	1	2	-
Enhance price competitiveness	1	2	-
Enhance non-price competitiveness	1	-	-
Others	1	-	-

As for the firms' internal strategies to foster innovative activities: intramural or in-house R&D and engineering garnered the top spot, followed closely by training related to innovation activity and then acquisition of machinery and equipment in connection with product or process innovation. For locally-owned firms, internal capabilities to undertake upgrading is evident, while the others get the technological information embedded in machinery and equipment acquired. Training their manpower is also considered a strategy for upgrading efforts. Among the MNCs, training is their go-to strategy to enable them to do innovation, followed by their internal capacities.

Also captured during the interview was the high-regard some of the interviewed firms give to their manpower, in general, and the operators, in particular. Many of these firms have mechanisms in place to capture ideas for upgrading that their employees might have. One of the firms even mentioned that to get good ideas about improving production processes, go to the floor and ask the operators who are in the thick of the action, so to speak. This does not imply though that it is no longer necessary to have a formal R&D or product/process development unit since ideas would have to be translated to operational or implementable activities to be able to be really useful. Still, this goes to show that a management that is open to ideas percolating on the floor or in any of the business units is able to accumulate useful information for upgrading and innovation and such information need not always be high technology-based especially in relation to improvements in production processes.

Table 19 Ownership

	Local	MNC/FO	JV	Total
Intramural/In-house R&D/engineering	2	2	1	5
Acquisition of R&D (extramural/external R&D)				0
Acquisition of machinery and equipment in connection with product or process innovation	1	1		2
Acquisition of other external knowledge such as licenses to use intellectual property or specialized services		1		1
Training related to innovation activity	1	3		4
Reverse engineering		1		1
Basic design to change main features of products		1		1
Detailed design after the main features of products have been set				0
Market introduction of innovations		1		1
Others	1	1		2

Given that the firms relied more on their internal capabilities for the upgrading efforts, the specific contributors to these were their in-house R&D department, among those who have, and to those that do not have formal R&D units, other internal departments.

Table 20 Contributors to Upgrading/Innovation

	Local	MNC/FO	JV	Total
External Partners	2	1	-	3
In-house R&D department	2	2	1	5
Other internal departments	3	4	-	7
Own affiliates	1	-	-	1

Meanwhile, the top 3 partners for innovation are customers, foreign-owned suppliers and local-owned suppliers. This highlights the notion that production linkages are the main pathways toward upgrading in the cases of these firms. As with the previous study, linkages with knowledge stakeholders like universities and research institutions were found to be less of a driver in fostering innovation. Most of the partners for upgrading and innovation are located within the same industrial area (CALABARZON) and for many, even in the same economic zone. This finding denotes that knowledge do circulate in an agglomeration setting, particularly when involving an industry where the lead firm-follower firm theory is found in practice. Though technology now enables virtual collaboration among participants located in various parts of the world, “face to face” interaction, though more institutional in arrangement than personal, enables more regular interface perhaps due to proximity and convenience to get together. Of course, it should also be considered that quite a number of electronics firms are dependent on the customers for design and specifications in relation to assembly work, which make them important partners for upgrading. Thus, if the customer would have limited product range, then it follows that the firm would also have limited chances for diversification and product innovation. However, this does not preclude the possibility that the firm itself can undertake other types of innovation, not least of which is process innovation to strengthen its competitive edge among other providers of low-cost manufacturing. This has been observed in the cases of some of the firms in this current study. Meanwhile, there are also partners that are located across agglomerations, which are in other regions of the country or in another country (Table 21)

The typical mode of collaboration between the firms and their partners is informal information exchange and technology assistance. The exchange of technical personnel is also being done. Some of the information exchanges occur during personal interactions, as in the case of one firm whose engineers already established personal rapport with their counterparts through regular meetings. In fact, the electronics firms in the case study do dispatch engineers to their partners and vice versa (Table 22).

Table 21 Partners for the Upgrading/Innovation

	Local	MNC/FO	JV	Total
Locally-owned suppliers	1	2	1	4
Foreign-owned suppliers	-	3	1	4
Firms in the same business group (parent companies/affiliated companies/other subsidiaries	1	1		2
Customers	3	3	1	7
Competitors	-	1	-	1
Firms in other industries	1		-	1
Universities or other higher education institutes	-	1	-	1
Public research institutes	-	-	-	0
Financial institutions	-	-	-	0
Consultants who belong to universities or other higher education institutes as faculty or researcher	-	1	-	1
Other independent consultants or consulting firms	-	-	-	0
Other business service providers (private R&D institutes, market research company, etc)	-	-	-	0
Community organizations (NGOs/NPOs)	-	-	-	0
Others	-	-	-	0

Table 22 Collaboration Mode

	Local	MNC/FO	JV	Total
Informal information exchange	2	2	-	4
Joint R&D projects	-	1	1	2
Contract research	-	1	-	1
Licensing technology	-	-	-	0
Technology assistance	2	1	1	4
Human resource development	1	-	-	1
Exchange of technical personnel	1	2	-	3
Financing innovations	-	-	-	0
Others	-	-	-	0

Internal obstacles for innovation are quite spread out among the choices given but these two garnered the top responses: perceived costs too high and limited financial resources. On the other hand, external barriers include inadequate support services and lack of customers' interest in innovation. It is worth noting that although many of the firms considered this particular question on innovation as obstacles, it was observed that such challenges could not have seriously impaired the capabilities of the firms to upgrade in various ways and degrees. Based on the firms' responses, policy supports or public programs were rarely tapped, if any, in their upgrading or collaboration efforts. This could be because firms tend to rely on their own, internal capabilities and to partner with their customers and suppliers/vendors. This implies that perhaps, there are other roles for government that they could perform more substantially to matter to these firms.

One firm highlighted the fact that collaboration could indeed mitigate particular obstacles through mutual testing and sharing of liability. Still, there are perceived obstacles to collaboration with the top 3 responses as follows: difference in time horizon (both literally and in terms of strategic thinking); intellectual property issues; and the perception that the firm's capability is enough to enable it to innovate. Based on his experience, one CEO mentioned that differences in viewing time horizon is costly as well. He was asked by a major customer to put up a facility with a promise that it will be utilized once he has fulfilled all its specifications and requirements. Although he has already invested substantially to the facility, the tactical delays on the part of the customer frustrated him and delayed as well the returns on his investment. The CEO is now looking at the short term horizon to be able to recoup his investments but apparently the customer has a longer time frame. Hence, if partners do not agree on a common time frame and do not commit on it, the collaboration would not push through.

Table 23 Obstacles of Upgrading/Innovation: Internal Factors

	Local	MNC/FO	JV	Total
Perceived risks too high	1	1	-	2
Perceived costs too high	1	2	-	3
Limited financial resources	3	-	-	3
Internal resistance to innovate	-	-	-	0
Lack of information on technology	2	-	-	2
Lack of information on markets	1	-	-	1
Others	1	1	-	2
Obstacles of Upgrading/Innovation: External Factors				
	Local	MNC/FO	JV	Total
Lack of qualified personnel	1	-	-	1
Inadequate support services	2	-	-	2
Lack of government support	1	-	-	1
Lack of customer interests in innovation	1	1	-	2
Lack of competition in the market	-	-	-	0
Others	1	-	-	1

6. CONCLUSION AND RECOMMENDATIONS

The case study began with a more macro view on upgrading. Since the Philippine electronics industry is concentrated on the low value added segment of the value chain, any upgrading is thought to lead to the higher segment that is, design and own brand, own product manufacturing. When the case study went into the micro, a slightly different perspective emerged. That while the Philippine electronics industry is mainly concentrated in the assembly and test segment of the value chain in the past three decades, this does not mean that innovation has been stagnant. Indeed, even in the lowest segment of the value chain, upgrading is possible and being undertaken. With both of the macro and micro perspectives in mind, a summary of insights derived from the case study is enumerated, together with some policy suggestions at the national and regional (ASEAN+6 level).

1. Firms in CALABARZON do indeed innovate. This has been proven based on the three firm-level surveys already undertaken in this area since 2007 across various industries and firm characteristics.[10] The survey results are consistent that these activities tend to be limited to the first stage of innovation, that is, development of new product based on existing technologies for existing markets. Process innovation meanwhile is primarily through equipment and facilities improvement to increase productivity and to respond to customer specifications. It is quite possible that manufacturing in the Philippines, in general and in CALABARZON, in particular is limited to the lower stage of innovation because of the types of activities involved. For instance, the electronics industry in CALABARZON is mainly engaged in

[10] The first survey included manufacturing firms in Metro Manila as the geographical locus of the study then was Greater Manila Area composed of Metro Manila, Cavite and Laguna.

manufacturing and specifically, in assembly and testing. This already denotes a dependence on the customer and the jobs assigned by MNC affiliates or mother companies.

This is also evident in the types of technology assistance some electronics firms ask from knowledge stakeholders like ERDT for instance, i.e. on manufacturability and failure analysis. Dean Guevarra of the ERDT was of the view that manufacturing companies in CALABARZON should not be expected to do R&D since these firms are mainly recipients of R&D outputs from elsewhere. She added that R&D activities happen mostly in Metro Manila where the infrastructure and facilities are relatively stable and where the top universities with more advanced amenities are located. It is also in Metro Manila where government research institutions and private knowledge providers are located. Though these considerations are important given that high value knowledge spillovers may indeed occur where the knowledge stakeholders are, the fact that CALABARZON is the manufacturing center of the country should not deter it from undertaking R&D or mechanisms for upgrading and innovation where it is at. Universities have already established branches in the region and there are regional government offices as well. The issue here is how to encourage closer interaction and collaboration among actors in this agglomeration for knowledge flows to happen and be utilized for innovative purposes.

On the other hand, there are firms that take a different route in terms of the conduct of R&D activities. Firm A and RBWI acquired R&D companies or at least have R&D facilities in other countries where their manufacturing operations become recipient of their outputs. Aside from product introduction, these manufacturing firms which also have internal engineering units have capability to make use of these R&D outputs and adapt them to customer specifications or local conditions. Thus, it is important to also have the absorptive capacity for technology available in the recipient firms or branches, regardless of where the technology came from.

2. In the past 30 years, the electronics industry in the Philippines has hardly moved up the high value segment of the supply chain. Aside from the above cited reasons it is also opined that the industry might have rested on its laurels or has adapted a mindset that it is “too successful to fail.” The reason given was that, even in the face of tough competition, investments continue to come in and the industry remains to be the top export earner for the country. Another compelling reason is the fact that the industry is also a top employment generator in the country, the bulk of which is in the lower skills level. Should electronics firms shift to design and other advanced operations and start limiting their production in favor of the former, then employment would suffer. In fact, this is one of the motivations of EMS-CAI for its establishment, that is, to provide employment to Filipinos.

However, if the building up of skills could happen with the industry, the firms and its people together, then the latter could still be employed and possibly, with an even higher pay scale should the companies be successful in their new ventures. Admittedly, this process would take time and has to start somewhere.

3. Increasingly, there is recognition that the electronics industry has to start transforming and move up the value chain. All the players, whatever the time frame, have the view that this should happen in order to buttress the competition. The SEIPI, which boasts of a membership bordering to about 200 comprised of the MNCs and medium to large local firms, is of the view that despite 30 years in the electronics industry, the Philippines may not yet be ready to take on the high value segment of the production chain as the critical factors are not yet adequately in place. For one, technological capabilities are not yet on a level to take on the high tech challenge, which

is the reason why the association is venturing into programs like helping improve the curricula of engineering programs and providing scholarships to generate Masters and PhD graduates. On the other hand, the Electronics Industry Association of the Philippines, Inc. (EIAPI) which brings together small local companies venturing into IC design, embedded systems and other high technology ventures in the industry is already pushing for government and private sector support for venturing into design and other frontiers in the electronics industry.

There is legislation pending for the establishment of an institution akin to the Industrial Technology and Research Institute of Taiwan, which will focus on conducting research and generating technology on an industry one at a time, starting with electronics, if possible. This effort has garnered a critical mass of support with COMSTE, ARCDI, EIAPI, and the DOST pushing for its realization. As Dr. Tangonan (2008) pointed out, this industry-led institution would conduct applied R&D, prototype development and commercialization of high value added electronic products. It will also help focus S&T investments of government, industry and academe to achieving specific milestones. ITRI-Philippines would grow new business in chip design, green engineering and biomedical electronics and would represent the electronics industry in capturing new investments for the electronics sector. In effect, this industry-led but government-supported endeavor would be the intermediary between the stakeholders and players in the electronics sector. Eventually, this Institute could establish a branch in CALABARZON akin to the Penang Skills Development Corporation that is dedicated to catering to the needs of the firms in the Penang cluster. Such an institution is sorely needed in CALABARZON that would serve to integrate all programs offered for all the industry within it and be the bridge that would pave the way for stronger linkages for innovation. These ideas are consistent with efforts on FilipINNOVATION to engender a culture of innovation among Filipino firms and the people, in general.

4. It is inspiring to note that companies that are willing to develop themselves further into world-class level are able to do that by continuously beefing up their toolkits with the appropriate technological capabilities and networks. Firm A has evolved from sub-assembly to assembly and into turnkey, customized manufacturing, without necessarily producing their very own products. Acquisition of technology was not limited to the outputs of their R&D and engineering units but also, by acquiring other firms that already have the capabilities for designing and high-technology production. Both Firm A and RBWI have done this, and both are majority owned Filipino companies, if not wholly owned. Indeed, all the firms in the case study have internal strategies and mechanisms for capturing technological information and adopting them into useful endeavors for productivity improvement and skills enhancement.

The inflection point for Firm A was the decision to adopt a "global" mind-set and had this inculcated within the organizational dynamics. This enabled them to build up a strong and credible reputation and has become a strategic partner of MNCs and local firms alike. On the other hand, RBWI is benefiting from its "technopreneur" President who followed the example of Taiwanese engineers from the US who went back to their country to successfully build up electronics firms. While a "Balik Scientist" (Returning Scientists) program is being implemented by the DOST, it would also augur well for the industry if the Department of Trade and Industry (DTI) could establish a similar program for returning or retired engineers in other countries and entice them to transfer in the country knowledge and technology acquired from their years of experience in other countries. As "technopreneurs," the government, in collaboration with industry associations, can offer incentives and financing support to those who would be interested to set up their own companies in the country.

5. This study has shown that production linkages are the main pathways to industrial upgrading and innovation among firms in the Philippine electronics industry. These business links are not limited to those within the agglomeration where they are located but extend outward, to their affiliates in other countries. In other words, being entrenched in a production network enables information exchange and fosters innovation. The appropriate direction therefore, is to continue efforts to attract investments into the country, in any of the components of the electronics industry, whether on semi-conductors still or electronics manufacturing services, whether in the low value added segment of the value chain or on the higher level. What is important is that knowledge is generated, gets shared and captured for productive and innovative purposes.

In contrast, public policies and programs purportedly targeted at the industry did not figure prominently in the study as viable sources of technological information. Linkages with universities exist but modes of collaboration are limited to employment sourcing, on-the-job-training and plant visits. Nevertheless, there are already seeds planted in terms of the potential for better modes of collaboration between firms and universities. For some firms, joint projects have been done and underway as well as facilities for mutual learning, i.e. engineering faculty and students visiting the plant and learning about production processes and personnel of firms serving as resource persons in classes are being built. According to ERDT, academe-industry linkages are evident in the donations and contributions coming from the latter such as laboratories and equipment. It was asserted that companies with well defined technologies and R&D activities find ways of connecting and linking up with universities. The experiences of Firm A and RBWI in this regard can serve as examples.

As for the role of industry associations, SEIPI already has the structures, institutions and mechanisms in place for information exchange and networking. In fact, several networks on different business units are in place where it is hoped that exchanges on the ‘best known methods’ are already underway.

6. As for the national government, its emerging role seems to be the provision of the strategic vision for the electronics industry. Although there are roadmaps here and there, an integrated strategy solely focused on the industry and where it should be heading is amiss. It is in this area that the industry associations and the firms themselves agree on. Having such a framework would enable prioritization of policies, programs and allocation of resources. This industrial framework should be linked with the medium-term regional development plan for consistency and to establish a timeframe or milestones for these plans and strategies. These should of course be accompanied by funding support for programs where the industry players themselves and the association can buy in. A critical area needing such support is curriculum development as it has been pointed out many times that the engineering curriculum in the country is no longer responsive given the current milieu.

On the other hand, the local government, particularly the provincial governments encompassed by the CALABARZON configuration should start asserting themselves more strongly for the sake of local economic development. A local innovation system following the FilipINNOVATION framework should be put in place at the provincial and then in an integrative manner, at the regional level. These local governments can pool their resources and contribute in various endeavors such as the establishment of a CALABARZON Skills Development Center; common facilities for the use of the industries located within their jurisdictions which can be done in cooperation with PEZA and administrators of economic zones in the region; and the improvement of the overall business environment in the region. The latter is critical as the region’s infrastructure still leaves much to be desired particularly in its internal road network, flood and drainage system, among others. Taxes and fees should likewise be rationalized in order not to put undue burden on existing business locators and in order to attract new investments to come in. Since there are no regional governments in the Philippines, this consortium of local government leaders should take up this role in close coordination with the regional office of the NEDA and their respective local development councils with various stakeholders as members including industry players.

7. One missing link in this linkages-innovation nexus and that is the link with the local supporting industry. The content of electronics production in the country is significantly foreign, making it dependent on imported inputs. The Filipino firms covered in this case study already have systems in place, however limited, in developing local suppliers. For instance, RBWI has facilitated the upgrading of capabilities of one local supplier that is now able to supply materials for its ODU – after starting out with supplying motorcycle manufacturers! On the other hand, developing local suppliers is also limited by the type of production electronics firms are engaged in. Assembly manufacturing depends mainly on materials and inputs coming from their customers that more often than not are sourced outside of the country.

The potential diversification efforts of firms or their evolution towards turn-key manufacturing may augur well for the local supporting industry. Government has to contribute to this effort by developing capabilities of the local supplier base – tying it up with its SME development programs. In other countries, local content was a requirement asked of investors, but tied up with the incentive structures available. These are worth considering in order to bridge the missing link in the electronics supply chain. For their part, local suppliers should reset their mindset that they are supplying to companies that are well entrenched regionally and globally. This implies that they themselves would have to upgrade and be world-class firms.

8. Being entrenched in the regional production network, there are cooperative mechanisms that can be instituted that relate to and go beyond production linkages. For one, there is a need to determine the niches of each country in the region on various industries many of them are commonly engaged in. While it is more or less clear that Malaysia and Thailand are into components assembly, Indonesia into lighting electronics, and the Philippines into semiconductors, it would augur well for the electronics industry at the regional level to find out the specializations of new entrants like Vietnam, China and others. Such specifications would signal to the MNCs/lead firms that indeed, the Asian region is the best destination for electronics production with specific countries having expertise in particular segments or sub-sectors.

One of the obstacles to innovation that was identified by the case study firms was the lack of information when it comes to technology and on markets. While this should also be pursued at the national level, creating a database of currently available technology, suppliers and information on buyers' needs could be an important regional effort, not only for electronics but for other industries as well.

In terms of the upgrading of technological capabilities of researchers, scientists and engineers, a possible collaborative effort can be an exchange program that would enable them to learn various technical aspects of operations in different countries. This would expand their knowledge as well as allow them to experience the organizational dynamics in a different setting. In addition, a Washington accord-type of accreditation or equal mutual recognition of engineers, scientists and researchers would facilitate further the exchange of experts and the engagement of technology consultants.

Still in relation to the exchange of manpower, it would be instructive for local and regional government officials, planners and industry experts to visit industrial agglomerations considered best practice models namely the Penang Cluster in Malaysia and Bangkok's automotive cluster. The PSDC is a good model to study for local government officials from CALABARZON for the possibility of establishing a similar institution in the area.

The electronics industry in the Philippines is one of its most important industries, top export earner and employment generator. Its concentration in CALABARZON was instrumental in transforming the region into an advanced industrial cluster that attracted other industries and increased the revenue base of the local governments within its jurisdiction. Top universities and other educational institutions have established branches and affiliates and have increasingly been linking with firms in the region albeit limited mostly to internships and plant tours. After 30 years of existence, time is ripe for the industry to start moving up the value chain, boosted by an innovative and entrepreneurial culture that would have to be strengthened among Filipinos. This transformation of the industry should be supported by stronger linkages with sources of technological information and the government, both national and local. This is one of the more important initiatives to ensure that the industry, CALABARZON and the country could withstand competitive pressures and be on its way to progress and development.[11]

---

[11] Thanks to the following interviewees who provided valuable inputs to this case study: Mr. Lito Gruet, Vice President of the Electronics Industry Association of the Philippines, Inc. (EAPI); Mr. Ernie Santiago, President of the SEIPI; Mr. Cesar Quiaison, Executive Director of the ARCDI; Ms. Lita Arcellana, Director and Business Development Head for Electronics at the Board of Investments; officers and staff of the Congressional Committee on Science & Technology and Engineering (COMSTE); and Dean Rowena Cristina Guevarra of the UP College of Engineering and ERDT Executive Director. Special thanks go to the officers and staff of the 10 electronics firms that are all part of this case study and information from their websites, when available, and news articles were utilized in this study.

REFERENCES

Asian Development Bank (2009) "Key Indicators for Asia and the Pacific 2009," Manila, Philippines.

Austria, Myrna S. (2008) "Recent Developments in the Electronics Production Networks in Southeast Asia," De La Salle University: Angelo King Institute Working Paper Series 2008-05. Manila, Philippines.

Board of Investments (2009) "Philippine Electronics Industry: Detailed Industry Profile as of 30 October 2009," Makati City, Philippines.

Congressional Planning and Budget Department (2009) "Electronics Industry: Surviving the Global Financial Crisis and Attaining Competitiveness," Policy Advisory no. 2009-07. Quezon City: CPBD.

Macasaquit, Mari-Len R. (2008) "Sources of Innovation of Philippine Firms: Production, Logistics and Knowledge Networks," Economic Research Institute for ASEAN and East Asia Project Report 2008 No. 4-1 edited by Kitti Limskul. Jakarta, Indonesia.

Morisawa, Keiko (2000) "The Philippine Electronics Industry and Local Suppliers: Developing Supporting Industries through Foreign Capital-led Industrialization," UP School of Economics Discussion Paper No. 0011.

National Economic and Development Authority Regional Office IV-A (2004) "Region IV-A: CALABARZON Development Plan 2004-2010," NEDA Regional IV-A (2010).

National Economic and Development Authority Regional Office IV-A (2008) "Updated Chapters of Region IV-A: CALABARZON Development Plan 2004-2010," NEDA Regional IV-A (2010).

Semiconductor and Electronics Industries in the Philippines. http://www.seipi.org.ph/seipi/content2.asp?type=aboutindustry (accessed 20 November 2009).

Tangonan, Gred (2008) "COMSTE Electronics Panel Report on New Partnerships to Create High Value Added Electronics," Paper presented during the Filipinnovation seminar held on 26 November 2008 at the Sofitel Hotel, Manila, Philippines.

Tecson, Gwendolyn R. (1999) “The Hard Disk Drive Industry in the Philippines,” UC San Diego: Information Storage Industry Center. Retrieved from: http://escholarship.org/uc/item/0sh085cn.

U, Peter Lee (2005) “A Tale of Two (Philippine) Industries,” Nagoya University: Economic Research Center Discussion Paper No. 152.

5

Thai Automotive Industry: Opportunities and Challenges

Somrote Komolavanij, Chawalit Jeenanunta and Veeris Ammarapala

Abstract

The automotive industry started in Thailand more than 50 years ago. This paper seeks to trace the developments within the industry since then, that is, in terms of technology transfer, research and development (R&D) as well as innovations involving the automotive manufacturers and their suppliers, especially the local (Thai) ones who supply automotive parts. Technology transfer and innovations among local companies are among the indicators of sustainable growth within the Thai automotive industry. In this study, ten companies in the automotive industry were selected for interviews, which focused on the kinds of relationships existing among the companies comprising the automotive cluster of Thailand. Two of these companies were automotive manufacturers and eight were auto parts makers (first, second and third tiers). Based on the interviews, it was found that there were strong relationships between the automotive makers and the suppliers. However, the relationships were in terms of support for and technology transfer in the manufacturing process aimed at reducing manufacturing costs and improving the quality of the auto parts rather than achieving product innovation. The innovation of process improvement was done via the auditing process between the automotive manufacturers and the suppliers, as is required by ISO/TS 16949. The automotive maker and automotive supplier relationship was partly defined by joint product innovations or technology transfer in product innovations.

1. INTRODUCTION

The automotive business in Thailand evolved from importing cars and trucks from overseas to meeting the country's vehicle demand. Today Thailand is one of the major automotive manufacturers in the world. The automotive industry is now an important component of the Thai economy, accounting for about 10.5% of the country's total Thailand's GDP in 2008 belonging to automotive sectors. Thailand has a very strong and successful automotive cluster. Thailand was originally an agricultural country and thus had no technology of its own in automotive manufacturing. Thus it is interesting to understand the development of the automotive cluster in Thailand.

The successful automotive cluster of Thailand began with investments from foreign automotive manufacturers, resulting in the formation of groups among automotive suppliers, which in turn became clusters later. After almost sixty years since the 1950s, the automotive industry has been firmly established in Thailand. But what does the future hold for the industry?

R&D is one of the key factors that ensures the success and sustainability of the automotive industry. It facilitates the innovation of both products and the manufacturing process. Product innovation can keep customers' interest while manufacturing innovation can reduce the costs of manufacturing. R&D is key to understanding the evolution of the industry, especially in terms technology transfer from automotive manufacturers to their suppliers at all tiers.

The following section provides an overview of the Thai automotive industry. Section 3 presents the results of interviews with ten Thai cases within the automotive industry. The last section explains the policy implications of the state of the supporting technology transfer, R&D and innovations within the industry.

2. AUTOMOTIVE INDUSTRY IN THAILAND

2.1 Thai Automotive Industry Exports and Growth

The automobile and automobile parts industry is one of Thailand's most important industries. At present, Thailand is the center of large manufacturers all over the world. Thailand, which is already the largest automotive manufacturer in Asia-Pacific, can potentially become the world's small car hub. Thailand is the largest producer in Southeast Asia and the world's second largest producer of and market for pickup trucks. It was also the world's 12th largest automobile producer in 2008 (up from 15th in 2007). It is also a production hub and exports motorcycles to manufacturers in Japan.

Table 1 Total Export Value of Automotives from Thailand (in millions USD)

	2006	2007	2008	January-October 2008	January-October 2009
Total exporting value of automotives	15,073	17,812	20,846	17,955	12,817

Source: TAI (2009).

In 2009, there were 16 assemblers in Thailand's automobile industry with a combined production of 1.4 million units. About 50.76% of production comprised pick-up trucks and 43.72% passenger cars. Thailand's car industry is already a global export hub for one-ton pickup truck. Of its total production, Thailand exports 40% one-ton pickup trucks. Based on the report of the Thailand Automotive Institute (TAI) in 2009 (Jan-Oct), the automobile and auto parts industry exported units valued at 435,154 million baht (US$12,817 million), up from 28.72% in 2008 as shown in Table 1 (TAI, 2009).

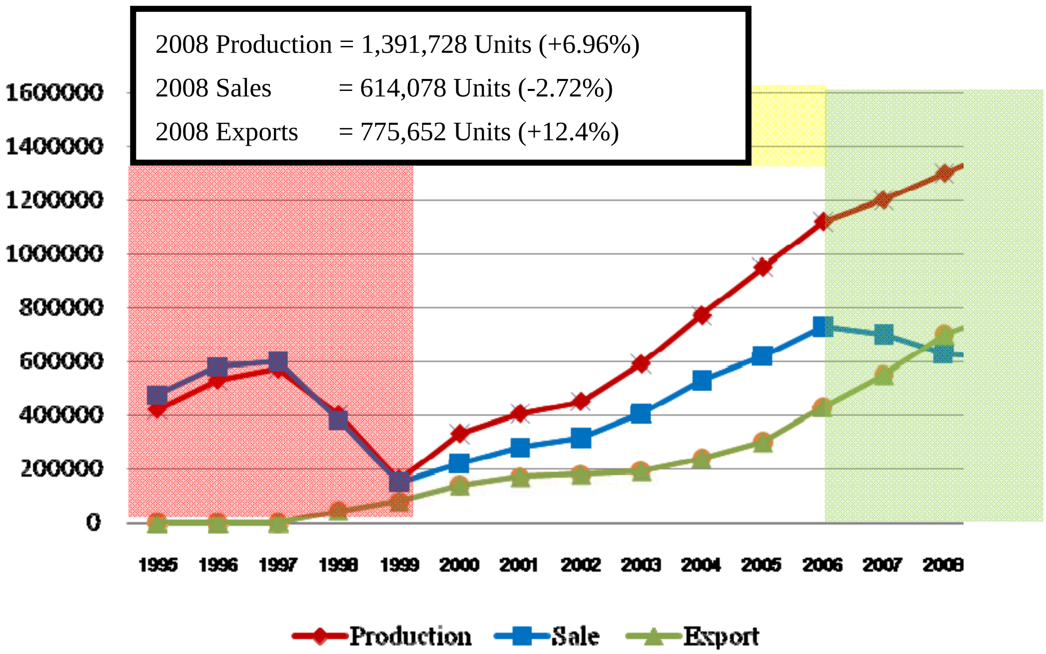


Figure 1 Thai Automotive Growth

Source: Thailand Automotive Institute, as February 12, 2009 (Asawachintachit , 2009).

As shown in Figure 1, the Thai automotive industry's growth came in three phases. The first phase was marked by the Tom Yam Kung crisis during the period 1997 to 1998, when the global economy decelerated and the value of Thai baht fluctuated, which in turn led to a significant decline in automotive production at 30% (Amano, 2009). Between 1999 and 2005 – the second phase – the economy started to recover. Also, major automotive maker Toyota selected Thailand as its largest manufacturing base for pick-up trucks in Asia (Amano, 2009). The Japanese firm also launched its Innovative International Multi-purpose Vehicle project as part of its efforts to increase its export of complete pick-up trucks and its parts and beef up sales and production for the domestic market in Thailand, which grew to an average of 35% per year from 1999 to 2005 (Praisuwan, 2006). The last phase, beginning in 2006, was marked by the breakout of the Hamburger crisis, which manifested in high gasoline prices, high inflation rate, and a fluctuating economy that adversely affected automotive sales (TAI, 2009). In 2008, the Thai government enforced a policy granting reduced taxes to automobile makers using substitute energy. However, this policy led only to a marginal industry growth of 6.96% (Asawachintachit, 2009).

The Thai government is setting its sights on turning the country's automotive industry into the major production base of eco cars in Asia and making it the 10th largest automotive hub in the world by 2011 (Hart-rawung, 2008). At present, Thailand is called the "Detroit of Asia," after one of the US's largest manufacturing hubs.

As seen in Figure 2, original equipment manufacturer (OEM) parts as Thailand's major exports were continuously increasing from 2002 to 2008. Spare parts and engines, among others, made a small amount of exports. Most parts and accessories of motor vehicles are exported to Japan, Indonesia, Malaysia, and the United States, where the world's major automobile manufacturers are based.

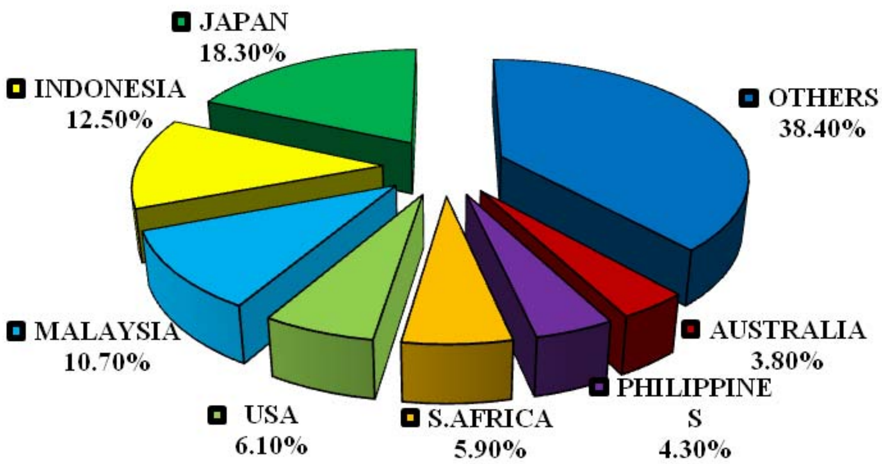


Figure 2 Export Market for Part and Accessories of Motor Vehicle in Year 2008

Source: Ministry of Commerce Thailand, as of March 2009 (MOC, 2009).

2.2 Automotives Manufacturers and Their Suppliers

As shown in Figure 3, Thailand's suppliers are located in – listed in order of number of their suppliers – Bangkok, Samutprakarn, Chonburi, Rayong, and Pathumthani. Most of automotive assemblers are located in Samutprakarn province, for instance, Toyota, Isuzu, Nissan, Hino, and etc. Many auto firms are located on Thailand's Eastern seaboard where most of its suppliers are in Bangkok, next is Samutprakarn, Chonburi, Rayong, and etc.

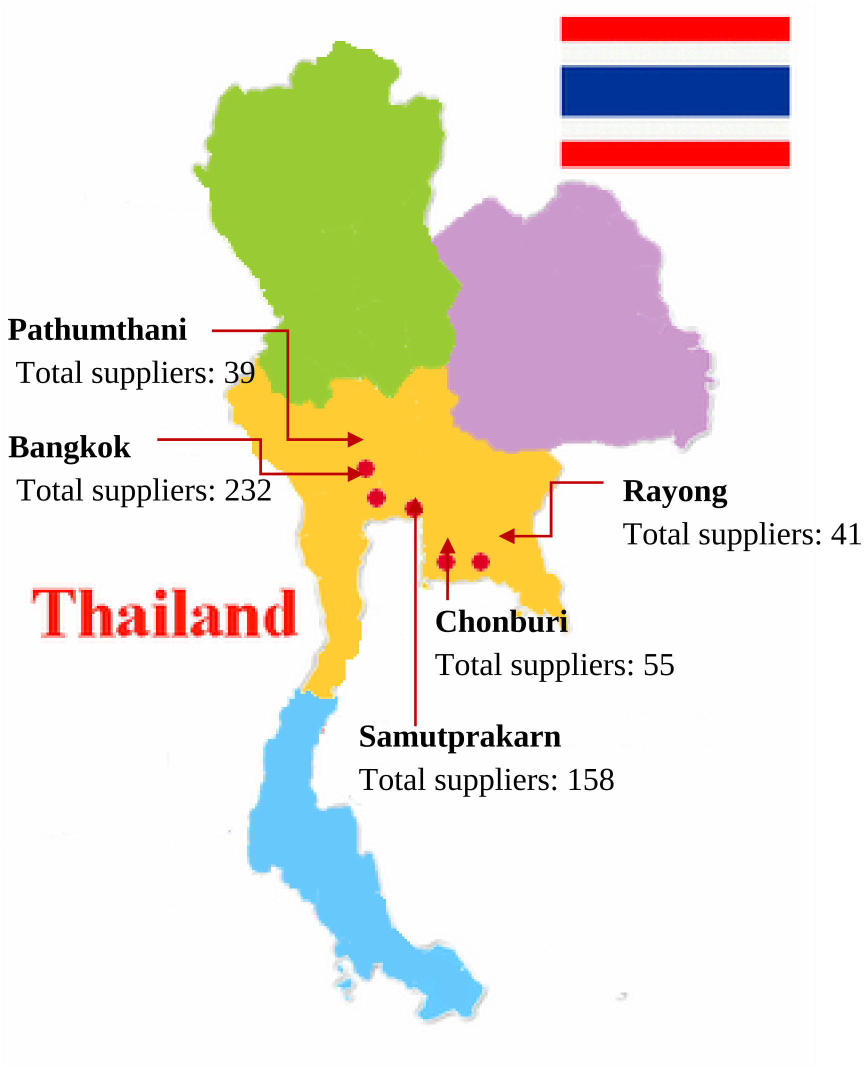


Figure 3 Principal Auto Parts Production Sites in Thailand

Source: Thailand Board of Investment (Praisuwan, 2006).

Thai auto parts industry is composed of approximately 16 auto assemblers, 648 first-tier or **OEMs**, and 1,641 of 2^{nd}- and 3^{rd}-tier manufacturers, as show in Figure 4. The country's first-tier suppliers mostly consist of global auto parts makers and their partners and a few Thai companies. Thailand has managed to turn its auto parts industry into a world-class base due to its economies of scale growth strategy and export-oriented approach. This has led automakers from all over the world to establish their manufacturing bases in Thailand.

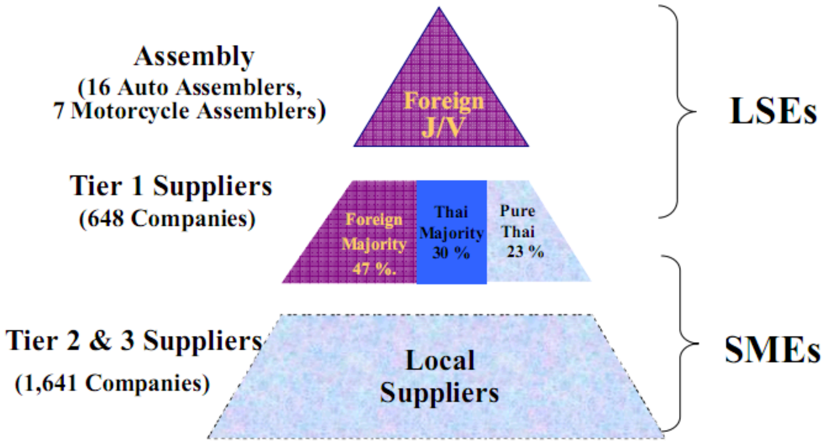


Figure 4 Structure of Thai Automotive Industry

Source: Thai Automotive Institution, 2009 (Asawachintachit, 2009).

Table 2 Total Production of Automobile Industry in 2007

Manufacturer	Passenger Cars	Pickup Trucks	Heavy Trucks	Total
Toyota Motor	200,000	350,000	-	550,000
Isuzu Motors	-	200,000	20,000	220,000
Mitsubishi	50,000	150,000	6,000	206,000
General Motors	40,000	120,000	-	160,000
Auto Alliance	-	155,000	-	155,000
Nissan	36,000	98,400	5000	139400
Honda	120,000	-	-	120,000
Hino Motors	-	-	28,800	28,800
Thonburi	16,300	-	-	16,300
Yontrakij	12,000	-	-	12,000
BMW	10,000	-	-	10,000
Thai Swedish	10,000	-	-	10,000
TATA	-	35,000	-	35,000
Total	494,300	1,108,400	59,800	1,662,500

Source: Thai Automotive Institution, adapted from the Office of Small and Medium Enterprise Promotion (OSMEP, 2008).

Toyota Motor Thailand Co., Ltd has the most production capability in the automobile industry, which is estimated at 550,000 units per year or about 33% of total industry production. The second-ranked manufacturers are Isuzu (Thailand) Co., Ltd. and MMC Sittipol Co., Ltd., which is the manufacturer of Mitsubishi. These firms can produce 220,000 units and 206,000 units per year, respectively, or about 13% of total production, as seen in Table 2.

2.3 Automotive Associations and Organizations in Thailand

There are four main associations and organizations in Thailand that support and collaborate with the automotive industry, namely:

The Thai Automotive Industry Association (TAIA)

TAIA was established in 1981 as the central organization of automobile members, which comprise automobile assemblies, motorcycle assemblies, auto parts and automobile engine industries. TAIA’s objective is to gather news and information among automobile members, thus playing a key role in the exchange of information among and facilitating meetings among industries and with relevant association in and outside Thailand. Moreover, TAIA coordinates with the government by providing advice, among others, related to the automobile industry.

Thai Auto Parts Manufacturers Association (TAPMA)

TAPMA, which was created in 1987, is a union of auto parts manufacturing companies from the private sector to serve as the central agency for automobile parts makers in the country, tasked to protect, support and develop Thai industries. The 578-strong TAPMA coordinates with the government in drafting and implementing policies vital to the industry. As the representative of the private-sector auto parts industry, it identifies problems and obstacles facing the industry to the government. It also represents the Thai auto parts industry in relevant negotiations on the international stage.

Moreover, TAPMA defends the legal rights of members and serves as a venue for members to exchange view. Lastly, it serves as an auto industry information and news clearinghouse for both domestic and international members.

Thailand Automotive Institute (TAI)

Organized in 1998, TAI is responsible for researching and proposing appropriate policies to the government. It also facilitates coordination among Thai automotive industries and helps set the standards for auto parts. Moreover, the institute extends testing services required for auto parts certification, gathers and disseminates information on the auto business among its members. The 652-strong institute also further ensures the industry's global competitiveness through human resource development and R&D undertakings.

Automotive Industry Club (AIC)

Established in 1976 under the Federation of Thai Industries, AIC consists of manufacturers, distributors, importers and exporters of cars and motorcycles. As the focal point for members and relevant agencies, notably government and private agencies, the Club's activities are aimed to promote information sharing as well as facilitate joint solutions to industry concerns, thus enhancing its competitiveness and its growth (Thaibestjob, 2006).

3. FINDINGS FROM CASE STUDIES

Case studies focusing on several companies yielded the following results.

3.1 Toyota Motor Corporation

Toyota Motor Corp. was established in Japan in 1937 by prominent Japanese industrialist Kiichiro Toyoda (Monden 1993). In 1956 the Toyota Motor Sales was set up in Thailand to sell the Japanese car maker’s units. In less than a decade, in 1964, Toyota built an automobile assembly factory at North Samrong in 1964 under a new name, Toyota Motor Thailand.

Today, Toyota runs four plants in Thailand, namely, the Samrong plant, Thai Auto Works, Gateway plant, and Ban Pho plant in Chachoengsao (Surasak 2005). The head office is located in Samutprakarn.

There are currently 135,000 associates, 119 dealers, and 312 showrooms for Toyota cars in Thailand. Suppliers to auto parts manufacturers (Tier 1) total 151. Approximately, 70% of Toyota supplier firms are joint ventures between Japanese firms while the rest involve Thai companies. Of the total production, 40% are sold locally while the rest are exported to other countries.

Supply chain of Toyota Motor Thailand

The Toyota Production System (TPS) undertakes the supply chain of the Japanese car firm. To meet the market demand, TPS constantly seeks to have a short lead time in production processes and to keep the lowest inventory possible. To reach these objectives, applies methods called Just-In-Time and ‘Jidoka’, which means “the decision to stop and fix problems as they occur rather than pushing them down the line to be resolved later.”

Factors for choosing suppliers

Toyota’s choice of suppliers is based mostly on three factors: quality, cost and culture. In determining the quality of suppliers, the firm considers all the production processes to check whether they meet the established standards. In assessing costs, suppliers are expected to offer the least costs possible. Reliability and trust are prime components of the culture factor.

Since Toyota is a Japanese company, its suppliers are mainly Japanese. The choice of Japanese suppliers rather than local (Thai) suppliers is based on the idea that they have passed the standard test of production from the head company in Japan, making them more reliable than the latter. Engaging Japanese suppliers also enables Toyota to save significant lead time and costs, among others, by avoiding the need to find new suppliers in Thailand, which need to be subjected to the requisite tests.

Performance measurement of suppliers

In order to measure the performance of each supplier, Toyota follows the "Reward strategy," whereby each supplier is assigned a total score of 100 at the beginning of the year. This score is correspondingly reduced in case of, say, failed quality or delayed shipments.

At the end of the year, Toyota releases the suppliers' individual scores, which will correspondingly affect the volume of orders suppliers will get in the following year.

Collaboration with Toyota (Thailand)

Prior to achieving an effective system of collaboration, Toyota had to deal with many problems, notably those involving defects in the working process. It soon embarked on reducing such defects to achieve shorter lead times. Until then Toyota had been experiencing difficulty in forecasting the release of new products. For example, popular models, which were in high demand in the market, were met with production delays and longer lead times.

To address the situation and meet market demand, Toyota decided to apply the collaboration technique in its production processes where it helps suppliers produce the right amount of auto parts for Toyota. Toyota divided its departments into two sections based on functionality. One works with suppliers and the other with dealers. For instance, the purchasing, quality control, and parts logistic department takes care of suppliers. The marketing, sales, and vehicle logistics collaborates with dealers.

For new products, Toyota applies the assured quality method by testing the trial parts in terms of quality and capacity of production three months before launching a new product model. In addition, collaboration between the marketing and production planning departments makes production forecasting more accurate.

The major collaborative activities in Toyota involve information sharing, joint decision-making, and resource and skills sharing. Part of information sharing is dealers showing its monthly orders to Toyota Motor Thailand to facilitate efficient production planning and balance the workload of suppliers. Then the production plan is sent to suppliers in three forms. The first one is a three-year plan, which allows suppliers to project future market demands so it can anticipate production needs. The second is a yearly plan, which forecasts the production within one year. It provides the number of units be produced for each model during the year. The last, a monthly plan, is more specific than the yearly plan as it allows suppliers to determine the particular number of auto parts that are actually needed.

Toyota has an inventory-checking center run by the marketing department that checks the inventory level of dealers. The center keeps track of all products by using a barcode. Once the dealer sells the product, Toyota knows which model to produce for that dealer. Once Toyota uses the auto parts in an assembly, the checking center also knows which auto parts have been used.

Toyota also follows the cross-functional management principle. This means it assigns individuals in one department to work with different departments within the company so that they will how other departments work. This helps employees become more effective as they learn the ropes running other departments.

For resource and skills sharing, Toyota allows its specialists to train its suppliers in specific aspects of its manufacturing process. Each supplier is required to attend the training at least once a year in order to maintain the required production quality.

As part of its collaborative efforts, Toyota also enables its suppliers to learn about the Toyota Production System (TPS). Occasionally, the TPS team also randomly evaluates the system and the production processes of its suppliers.

Toyota is the only automobile company in Thailand that undertakes such an initiative for its suppliers.

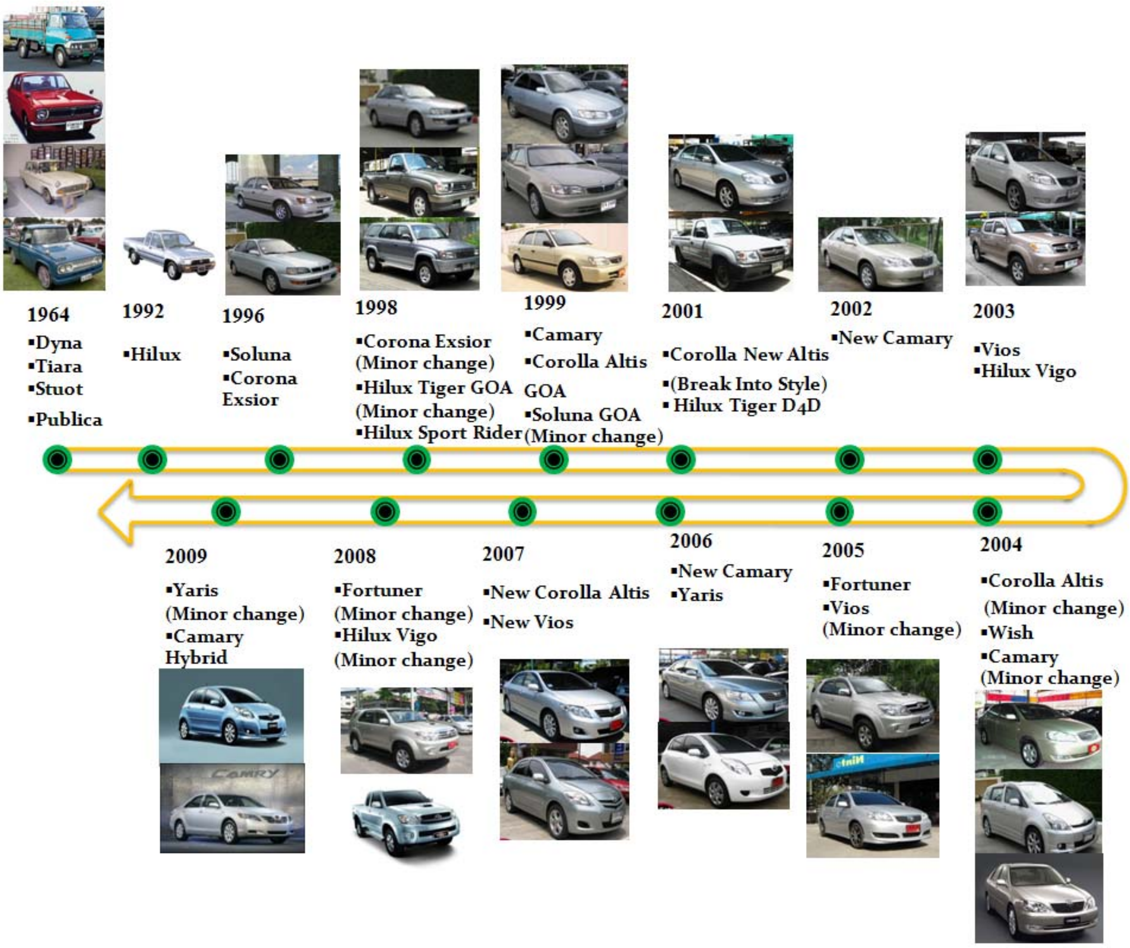


Figure 5 The Innovation of Toyota (Thailand)

This time phase graph shows how innovations in the product development of

Toyota automobiles have evolved in Thailand since 1964. In the earlier stage, Toyota assembled automobiles using the complete knocked-down or CKD method, that is, each auto part was imported and assembled with other parts in Thailand. Afterwards, Toyota set up an assembly plant in Thailand, which now is the most modern and the most efficient automobile assembly plant in the Southeast Asian region.

R&D center of Toyota (Thailand)

The Toyota Technical Center Asia Pacific (Thailand) Co. Ltd. (TTCAP-TH), a research and development base for Toyota in the Asia-Pacific region, officially opened on May 11, 2005. The center was established in response to the needs of the region's automotive market, which was increasingly becoming complex. This R&D center plays an important role in enabling the Toyota Motor Corporation to design and modify vehicles and component parts that have been developed from Japan to meet the demands of the Asian market.

The center cost a total of 2.7 billion baht and was built on an area measuring 320,000 square meters on Bang-na Trad Road KM. 29.5 in Samutprakan province. Currently, it has a total of 290 employees. The TTCAP-TH's ultimate objective is to become a true R&D center, providing design, research and development services as well as producing prototype vehicles and component parts for the region.

Obstacles amid collaboration between Toyota and its suppliers

Notwithstanding its close communication with its suppliers, Toyota's forecast volumes will not always be as accurate as expected. Uncertainties over Thai economy contribute to uncertainties over actual and projected demands, which in turn will have an impact on suppliers' production. Sometimes Toyota has to adjust its production to meet in order to balance orders to suppliers. Occasionally, such adjustment may not achieve the desired results, resulting in a production peak. This in turn affects suppliers in terms of excess safety stock, which means additional costs. Toyota also faces many problems on the logistics side, including government requirements, traffic congestion and suppliers' strike.

Benefits of collaboration with Toyota (Thailand)

By collaborating with Toyota, suppliers are able to determine the volume of auto parts that needs to be produced. It also facilitates a significant reduction of the total supply chain processes in Toyota as well as of the costs of automobiles produced. Thus without collaboration, the suppliers will not know the amount of production needed, resulting in higher stock and inventory costs.

Collaboration also allows for a shorter lead time and faster response time to customers, and consequently, higher customer satisfaction alongside more effective management system. Due to the close relationship between Toyota and its suppliers, production capability becomes more flexible even amid fluctuations in market demand. Moreover, inventory turnover and asset turnover of Toyota are high, which can be seen as a reflection of corporate efficiency. Figure 6 summarizes Toyota's networks and its activities.

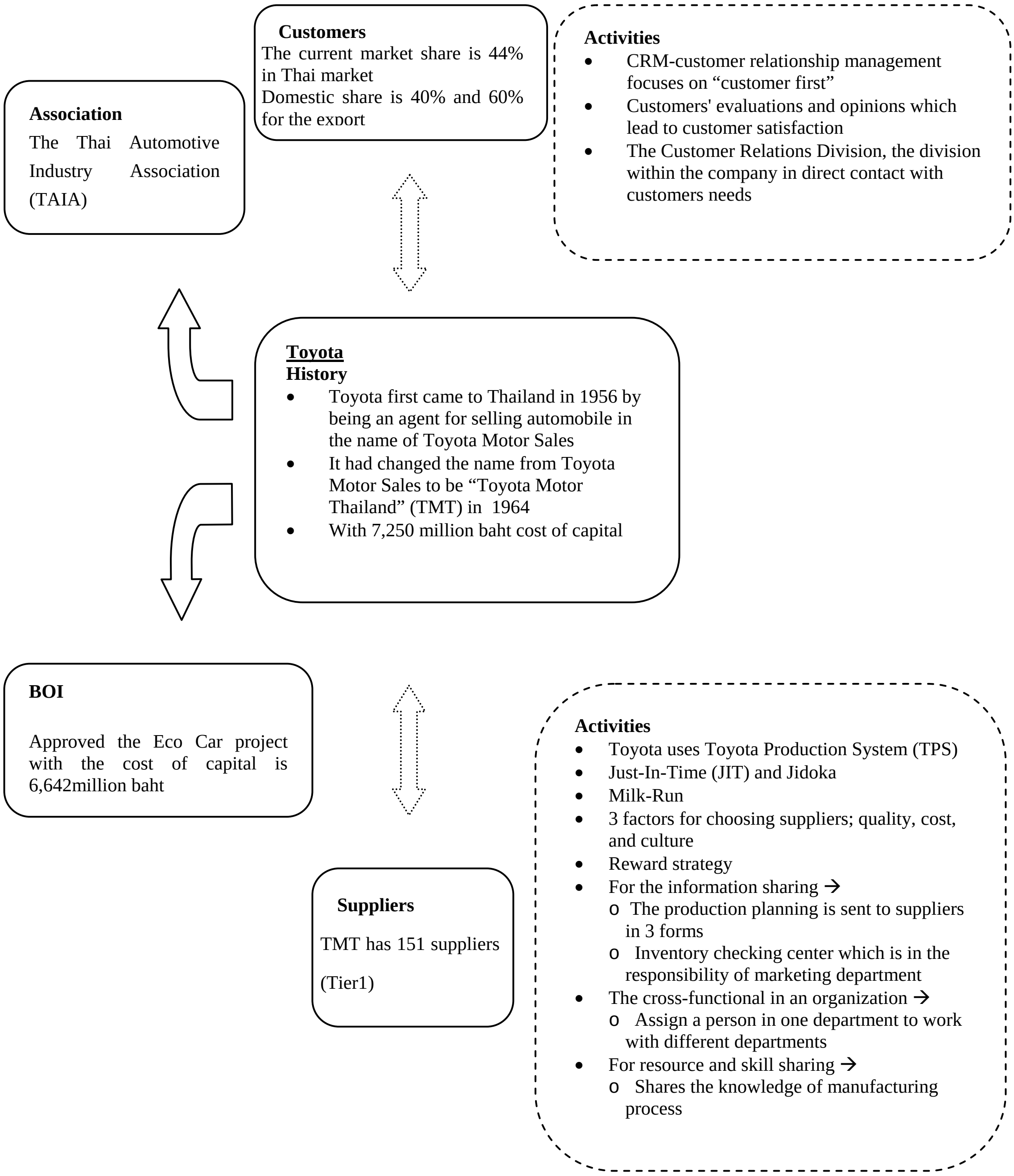


Figure 6 The Linkages between Toyota and Partners

3.2 Nissan Motor (Thailand) Co., Ltd.

Nissan's profile

Established in 1933, Nissan currently manufactures vehicles in 16 countries around the world, including Japan. The Japanese car maker has produced an extensive range of mainstream cars and trucks, initially for domestic consumption and later, beginning in the 1950s, for the international market.

In 1960 the company's first assembly plant was set up under the name Siam Motors & Nissan Co., Ltd. On April 21, 2009, it changed its name to Nissan Motor (Thailand) Co., Ltd. The ratios of major shareholders are as follows: a) Nissan Motor (Thailand) Co., Ltd. – 75%; and b) Siam Motors Co., Ltd. – 25%. Nissan's share of the capital investment is 1,900 million baht in capital. It has 92 dealers and around 164 service centers in Thailand. Its total workforce is 2,920. As of 2009, Siam Nissan had 5.6% share of the market.

Supply chain of Siam Nissan

The main production of Siam Nissan is divided into two components: the completed unit (a car) and automobile parts. Its supply chain process consists of three departments, namely, sales, and production and logistics departments, which work in tandem.

The supply chain for a complete build-up unit begins with dealers doing the initial estimate forecast for Siam Nissan. The sales department plans and discusses the capacities that suppliers have to produce to meet orders. After that, all completed production will be sent to the supply chain department. The products are then delivered to dealers by using third-party logistics providers.

For the production line of automobile parts, the Nissan center sends the orders through the export vehicle operation, which serves as the operation center gathering orders from other countries and sending them to the nearest manufacturers in each area. The supply chain department of Siam Nissan receives the orders and brings them through the production process. All automobile parts are delivered to supply chain department, which then takes care of exporting them to other countries.

Factors for choosing suppliers

The Siam Nissan has 248 suppliers, which are mainly 1st-tier suppliers that provide automobile parts to the company. Almost 80% of its suppliers are Japanese while 20% are Thai.

The main factors for choosing Nissan suppliers are best expressed in the acronym "QCDT," which stands for *quality*, *cost*, *development*, and *time*. Suppliers have to meet the qualified standard at the lowest cost possible. Moreover, the company also focuses on the development potential of each supplier. The last factor is the shortest time within which suppliers can meet the order.

All potential suppliers are subjected to a bidding process, where the standards or requirements stipulated are the same across all countries where Nissan operates. These are part of Nissan's global policy. Each department of Siam Nissan scores each bidder or potential supplier according to QCDT. The scores are then tallied so that the supplier with the highest score is finally selected and wins the bid. In terms of the ratio of suppliers, 80% of them are Japanese companies operating in Thailand.

Performance audit

Siam Nissan's purchasing department audits the quality and performance of its suppliers every year. Latest scores are compared with the previous year's. Audit scores are ranked A, B, C, D, and F, that is, arranged from highest to lowest. Suppliers who get F undergo retraining under the auspices of Nissan so they can meet the company's standards.

Collaboration activities in Siam Nissan

Collaboration activities between Siam Nissan and its suppliers involve joint decision making and sharing of resources and skills.

As part of its formation activities, Siam Nissan conducts monthly meetings with its suppliers to exchange information and discuss problems faced by the latter and which are relevant to the former. The marketing department shares certain information such as sales production data with its dealers. The firm also uses its information technology (IT) system to connect with suppliers and dealers.

Synchronized decision making involves production planning, production process development, training activities and efficient work procedures within the organization. Using the milk run system in the logistics process, Siam Nissan has classified logistics companies into zones. It makes decision alongside suppliers and logistics providers in order to deliver the products from suppliers' manufactures to Nissan's plant.

To facilitate sharing of resources and skills, Siam Nissan assigns a team that conducts training and knowledge sharing for suppliers that fall below the standards of Nissan. Knowledge sharing specifically revolves around models and designs, and is aimed at ensuring suppliers meet Nissan's quality standards as stipulated in the contract. It must be pointed out that only the Nissan headquarters in Japan shares R&D information with its suppliers**.**

Nissan's R&D center in Thailand

The Nissan Technical Center South East Asia Co., Ltd (NTCSEA) is the R&D base for Nissan in the Southeast Asian region and other counties. It was established in 2003 at a cost of 224.5 million baht. The center, which has 114 employees, was set up on

Bangna-Trad Highway Km.22 in Samuthprakarn province. Nissan Motor (Thailand) Co., Ltd. held 100% of shares in NTCSEA, which is tasked to develop vehicles for the region and other countries and ensure that all specifications meet local market requirements and Nissan's standards. The main activity of NTCSEA is to create performance innovations.

Obstacles in collaboration between Siam Nissan and suppliers

Despite enjoying the benefits of collaboration with its suppliers such as shorter lead times and reduced production costs, which translate to higher customer satisfaction, Nissan is still faced with some obstacles.

The first problem involves differences in policies or business strategies between Siam Nissan and suppliers. Suppliers generally rely on the policies of Toyota Motor Thailand, which has the highest market share in the automotive industry. Another problem is the lack of a budget to support R&D undertakings. Weak management support for collaborations within Nissan is also cause for concern because each department has its own way of doing things and rarely coordinates with other departments within the organization. Figure 7 summarizes all the activities of Nissan's partners.

Customers
Market share 5.6% Domestic 40%, Export 60%

Associations

The Thai Automotive Industry Association (TAIA)

Activities

- Marketing department analyst the market trends in the current market.
- R&D survey the information of user and customer need

<u>Nissan</u>

History

- In 1960 the first assembly plant was established under the name of Siam Motors & Nissan Co., Ltd.
- Nissan Motor (Thailand) is hold by Nissan (Thailand) is 25% shares & Nissan (Japan) hold 75% shares
- Nissan invested 1.900 million baht cost of capital

BOI
Approved the Eco Car project with the cost of capital is 5,550 million baht

Suppliers
Siam Nissan has 248 suppliers

Activities

- Nissan consider is “QCDT” for choosing suppliers
- Milk-Run
  - The company has 5 steps of scores which are A, B, C, D, and F for evaluating suppliers
  - The formation activities →
    - has monthly meeting with suppliers
    - Nissan uses its IT system to connect with suppliers and dealers in types of the Internet
  - The decision synchronization →
    - Nissan makes the decision with suppliers and logistics providers
    - Nissan (Thailand) uses Keisen in order to improve the manufacturing process

Figure 7 The Linkages between Nissan and Partners

3.3 Michelin (Thailand) Co. Ltd.

First Michelin, which was established in 1898, has constantly developed its product and creates innovations for highly reliable products and services. The firm has over 117,500 employees worldwide and operates in six geographical zones, namely, Europe, North America, South America, Africa and Middle East, and Asia-Pacific, particularly China. Moreover, it has a global sale network covering 170 countries.

In Thailand Michelin set up its operations in 1987, comprising three tire manufacturing factories and one wire-manufacturing factory. It operates under Siam Michelin Co., Ltd., Siam Tyre Phra Pradang Co., Ltd., and Michelin Research Asia (Thailand) Co., Ltd. The Michelin products consist of tires for passenger cars, motorcycles, aircraft, trucks, and civil engineering vehicles. Sixty percent of production line consists of passenger car/light truck tires.

The company has over 3,600 workers and a registered capital of USD 12 million. Its customers are partly foreign and mainly local manufacturers of vehicles. As an automotive parts supplier, Michelin's market share as of 2007 was 17.1%.

Supply chain of Siam Michelin

The stage preceding production is to forecast product demand by the marketing and sale department. In the forecasting process, the department discusses with the supply chain department the volume of production that needs to be produced. The purchasing department then allocates the orders to its suppliers and seeks confirmation of delivery date.

The marketing and sale department forecasts the quantity of product every eight months and reforecasts four months before production starts. Using the make-to-stock manufacturing process, the firm produces all products based on sales forecasts and are stocked in the warehouse. Michelin (Thailand) uses a third-party logistics provider.

Factors for choosing suppliers

The main supplier of Michelin has two sections: material and non-material. The first consists of rubbers, wires, etc., the second machinery, maintenance, among others. Michelin chooses suppliers based on the quality of their products and ability to meet the former’s specifications. The company then examines the risks, if any, of engaging the services of a potential supplier. Almost 80% of its suppliers are local manufacturers while the rest are foreign ones. Michelin’s suppliers number approximately 3,500.

Performance measurement of suppliers

Michelin evaluates its suppliers yearly or as the need arises. It mainly focuses on the production sale and product quality. If suppliers have failed in terms of production sale two to three consecutive times, they are subjected to an evaluation by Michelin. Consistent with its fair business policy, Michelin supports its suppliers over the long term to achieve business objectives. The company specifically helps its suppliers by undertaking certain activities such as transferring, shipping, warehousing, packaging and related services. It also follows the supplier relationship management approach to further improve its relationship with its suppliers. Michelin sends a team to suppliers to teach the needed specific knowledge and skills on the production process and machinery with the end in view of gaining high production sale and reducing lead times in working processes.

Obstacles confronting Michelin and its suppliers

The main obstacle facing Michelin lies in delayed product transfers. This is followed by the substandard quality of products, which the company promptly brings to the suppliers' attention. Beyond that Michelin also lends its support to its suppliers to enable them to improve their products and continue meeting the requirements of Michelin.

R&D center of Michelin (Thailand)

Michelin Research Asia (Thailand) Co., Ltd. serves as the company's R&D center in Asia-Pacific. Based in Bangkok (located on the 16th Floor, SPE Tower, Phaholyothin Road), the center is instrumental. The firm is the world's major innovator in tire manufacturing, especially radial tires. The R&D center has been instrumental in this regard, as it constantly pursues innovations, R&D and product tests to meet demands in the Asian market. Michelin also develops its production system for its manufactures and its product specifications**.**

Innovations in Michelin (Thailand)

Michelin's innovations are based on two factors: customer needs and competitor analysis. Product innovation strategic planning consists of three levels: the long-term plan, which covers 5 to 10 years; the medium-term plan, which extends to a period of three to five years, during which market trends in the near future are studied; and the short-term plan, which consists of projected market and customer needs over a period of one year.

The production design team checks the raw materials used by potential suppliers alongside their potentials in terms of quality, cost, and time. The firm's software used in marketing, sale, logistics, etc. in Thailand is based on the systems and applications developed by IBM, a multinational computer, technology and IT consulting company. The software used in the logistics and supply chain department is developed by the Michelin team in France.

The obstacles to product innovations in Michelin are delays in coming up with product designs consistent with customer needs, limited time for research, delays in inventing new products, the high costs of investing in new projects, limited R&D budget, and product imitation by competitors. Figure 8 shows the linkage of Michelin and partners.

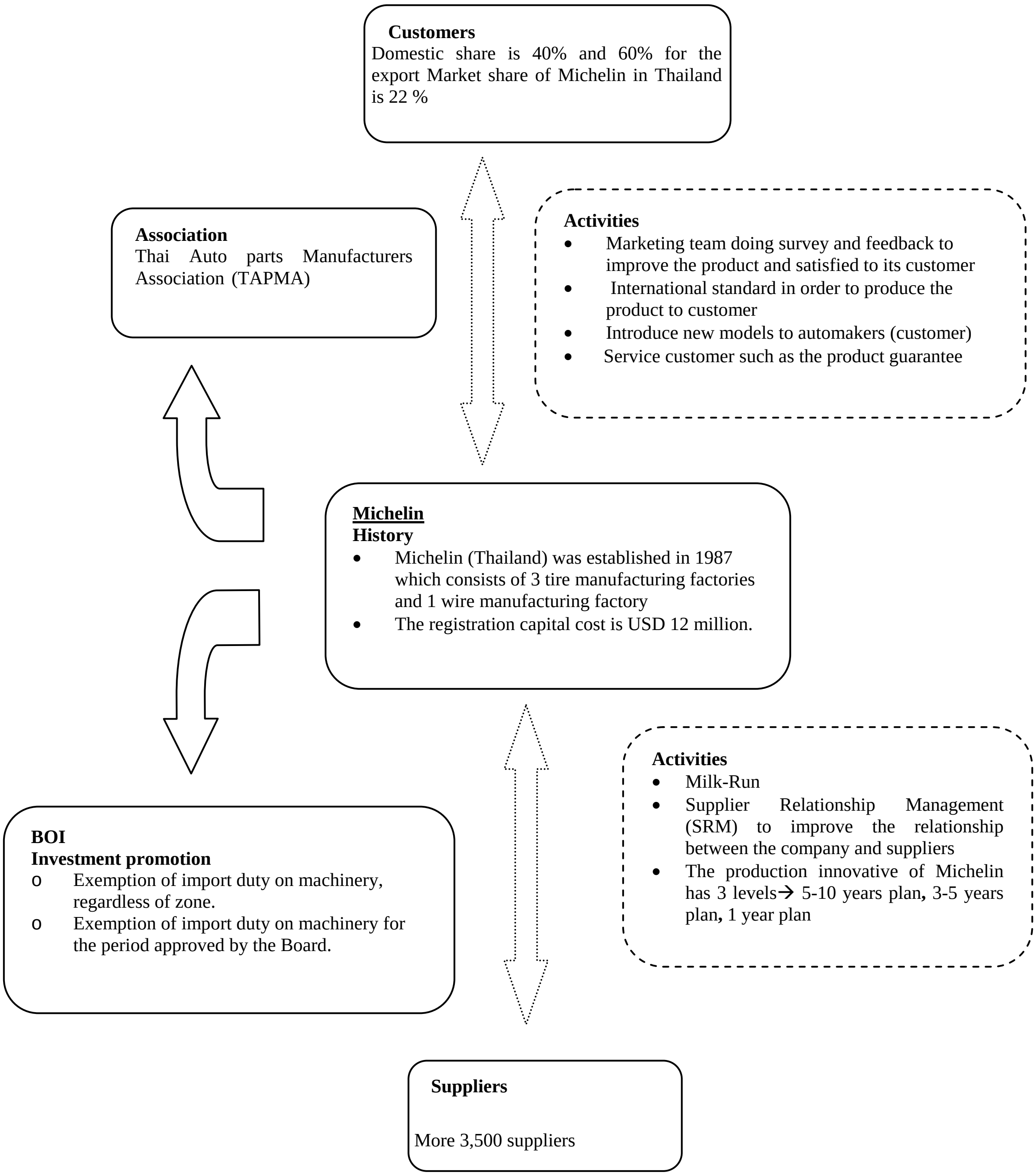
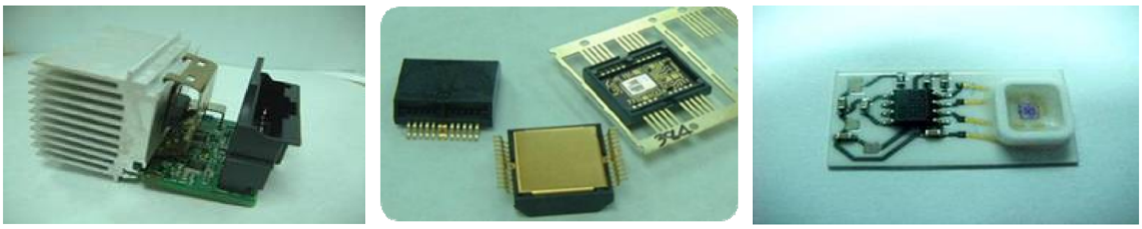


Figure 8 The Linkages between Michelin and Partners

3.4 Fabrinet Co. Ltd.

Fabrinet was founded in January 2000 in Thailand by acquired the Thailand Seagate Facility. It is a manufacturing services company specializing in the engineering and manufacture of complex optical, mechanical, and electronic components, modules, and subassemblies for a wide range of industries, including the automotive industry.

The following figure shows some of its automotive products. Fabrinet is a second-tier supplier in the automotive industry. Its customers are based around the world, namely, those in the US, EU countries and China. One of them is Systron Donner Automotive Division, which belongs to BEI Technologies, Inc. It manufactures inertial sensors for the automotive market. Originating in Thailand in 2000, Fabrinet has expanded its operations to include offices in China and the US and now boasts more than 5,000 employees.



Power Module   Positional Sensor   Differential Pressure Sensor

Figure 9 Automotive products of Fabrinet

Factors for choosing suppliers

The operations of Fabrinet focus on cost, quality and service. These are the same factors that the firm considers when choosing its suppliers. By applying the concept of "Asia Low-Cost Vendor Base," Fabrinet puts a premium on high quality, excellent service and low production cost.

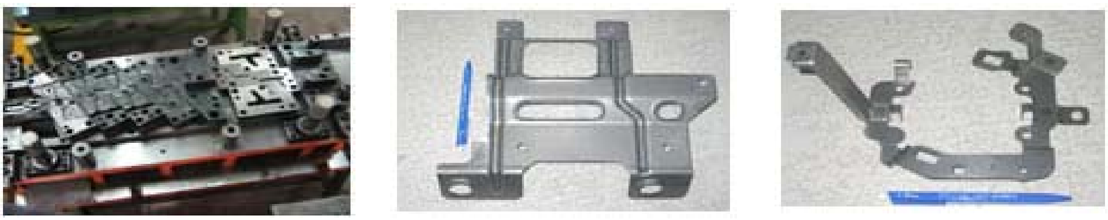
R&D and innovations

Since Fabrinet acquired facility and employees for Seagate (Thailand), all the technology, knowhow, skill and customers were transferred from Seagate as well. Fabrinet has its own R&D team that focuses on the improvement of the manufacturing process. Notwithstanding the many innovations and patents in the manufacturing process, cooperation is lacking between the company and client firms for product innovations. Fabrinet usually makes products based on customer designs. The relationship between Frabrinet and its customers lies mainly in quality audit as required by TS16949 (ISO16949).

3.5 Brother Auto Parts and Engineering Co. Ltd.

This company's products are metal stamping parts. It is a first-tier supplier for Mitsubishi and second-tier supplier for Honda.

Figure 10 shows examples of the company's products while Figure 11 shows examples of basic machines used in the factory.



Stamping Die — Stamping Part — Assembly Jig

Figure 10 Examples of Products

Milling — CNC — Robot Welding

Figure 11 Examples of Machines

R&D and innovations

There is no innovation involving the automotive manufacturers. Brother Auto Parts makes parts according to its clients' specifications. Mitsubishi and Honda audit the company once a year based on the requirements of ISO/TS 16949. Since there is no innovation, all processes of the company are quite simple. There are several basic manufacturing machines such as milling machines, CNC mills, and robot welding equipment. The labor-intensive manufacturing process depends on the skills of workers.

3.6 Wisdom Autoparts Co. LTD.

This company's main product is the metal structure of the car seats. It is the second tier of many Japanese automotive manufacturers and one of the suppliers for the Big Three, namely, General Motors, and Chrysler.

Figure 12 Example of Car Seat Structure

R&D and innovations

There is no innovation involving to the automotive manufacturers. The company makes parts based on the design of first-tier suppliers. The latter audits this company once a year based on the requirements of ISO/TS 16949. This company has around 30-40 third-tier suppliers. There is no technology transfer between the company and its suppliers. Every year, the company audits its third-tier suppliers based on the ISO requirements.

3.7 Mahle Co., Ltd.

The development and production of pistons and piston systems is the core business of Mahle, which was established about 90 years ago. In Thailand, Mahle took over Isumi Piston Company five years ago. Today the company supplies pistons to pick-up (truck) car manufacturers in Thailand (e.g., Isuzu, Nissan, Mitsubishi). Thailand being the world's largest manufacturer of pick-up trucks, Mahle's role as a major supplier of main engine parts is very important. Figure 13 shows examples of pistons.

Figure 13 Examples of Pistons

R&D and innovations

As pistons are the major parts of auto engines, the piston designs normally come together with engine designs. As part of standard practice, automotive manufacturers complete the engine designs and select the first-tier suppliers of pistons based on the cost and quality of the latter's manufacturing processes. Once a supplier is selected, sample engines are made and tested. At this stage, if the engines do not perform as expected owing to the poor design quality of the piston used, the piston supplier will undertake the necessary design adjustment.

In the past, all engine designs and adjustments were done in Japan. Today, all designs are still performed in Japan, but the adjustments mostly happen in Thailand, which is now one of the world's main pick-up car manufacturers. Mahle and Isumi Piston (in Thailand) have recently completed production of pistons based on the design of their client automotive manufacturers.

Mahle has a long history of manufacturing and design technology. As a firm believer in the importance of R&D and innovation, it has invested millions of US dollars in research centers in many cities across the globe such as Stuttgart, Northampton, Detroit (Farmington Hills, Novi), Tokyo (Kawagoe, Okegawa), Shanghai and São Paulo (Jundiaí). Unfortunately, it has yet no research center in Thailand. Be that as it may, research would do well to focus on finding new solutions to increasing the efficiency of the piston system such as reduction of fuel consumption and exhaust gas emissions as well as extended engine lives.

Mahle has expanded its business in Thailand by going into a joint venture with Siam Tennex, a manufacturer of filter systems for automotive engines.

Relationships with suppliers

The most important aspect of Mahle's relationship with its suppliers, which number several hundreds, lies in ensuring product quality, reducing lead times and keeping costs at a reasonable level. Mahle sees to it that its suppliers are duly informed about its specific requirements so the latter can plan its production well.

3.8 Summit Auto Seat Co., Ltd.

The company was established in 1972 as a manufacturer of seating and interior trim parts.

R&D and innovations

The automotive parts produced by the company can be classified into two:

1. Those that are made specifically for cars already in production. The parts follow the existing design of the car model.
2. Those that are intended for cars that are not yet in the market and in production elsewhere. The company designs the product, which must be approved by the OEM company.

For each new production order, the OEM will provide only specifications and drawings alongside other product requirements. The material and some aspects of the design are assumed by the supplier, which in turn is expected to have its own R&D.

Summit Auto Seat (SAS) has to focus on R&D to ensure efficient product design and production process, not to mention cost reduction.

Here are some important facts about SAS:

- 30% of SAS's suppliers were chosen by an OEM group, and the remaining 70% by SAS.
- The growth of China's auto part industries has adversely affected Thai suppliers. Yet some of the latter may source some auto parts from China.
- The global sourcing strategy was set up by an OEM, particularly NISSAN.
- The signed agreement between SAS and its suppliers stipulates protection of trade secrets. The former also registers patent to protect any novelty or

innovation.

3.9 DENSO (Thailand) Co., Ltd.

NipponDenso was established in Japan in 1949 after being separated from Toyota Motor Co., Ltd. Currently, DENSO operates in 32 countries in four regions, namely, Japan; North, Central and South America; Australia, and Asia. It first came to Thailand in 1972 and was registered as DENSO (Thailand) Co., Ltd. The 7,800-strong company has eight subsidiaries in Thailand, collectively known as Thai DENSO Group. They are as follows:

- DENSO (Thailand) Co., Ltd.
- DENSO Tool & Die (Thailand) Co., Ltd.
- Sian DENSO Manufacturing Co., Ltd.
- Toyota Boshoku Filtration System (Thailand) Co., Ltd.
- Anden (Thailand) Co., Ltd.
- DENSO Sales (Thailand) Co., Ltd.
- Siam KYOSAN DENSO Co., Ltd.
- DENSO International Asia Co., Ltd.

The products that Denso produces are car air conditioning systems, power-train control systems, engine-related components for motorcycles and construction machinery, and meters

Factors for choosing suppliers

DENSO consider its suppliers based on the concept of QCDS:

- Quality: meet the product quality standards
- Cost: provide the lowest product cost possible

- Delivery: deliver products to DENSO on time
- Safety: ensure product safety during delivery and prior to assembly

Eighty percent of DENSO's suppliers are Japanese and the rest are Thai.

Performance measurement of suppliers

DENSO assesses its suppliers' performance, on the basis of which they are given scores ranging from A to D (A being the highest and D the lowest). In its yearly performance audit of its suppliers, the company puts a premium on time, quality, and safety. Every month, suppliers have to report about safety prior to delivery of products to DENSO.

DENSO's customers can audit DENSO in case of failed car parts to improve the quality of their working processes.

Collaboration obstacles between DENSO and suppliers

Although DENSO's suppliers do not offer the lowest price compared to other suppliers, some of them have been in business with DENSO for a long time. DENSO has difficulty finding new suppliers that can offer it the lowest price of products. Toyota's parts ordering system is considered more advanced and complex than DENSO's, which has an effect on the old system used by its suppliers, who still need to learn about the Toyota Production System (TPS).

3.10 Murakami Ampas (Thailand) Co., Ltd. (MATCO)

Murakami Ampas (Thailand) Co., Ltd. (MATCO) is a joint venture established in 1996 at a cost of 100 million baht. Located in Bangpoo Industrial Estate, the company's main business is manufacturing of automobile rear view mirrors. It is composed of

Murakami Manufacturing (Thailand) Co., Ltd., which produces inner mirrors; Murakami Saikyo (Thailand) Co., Ltd., which makes molds; and Ampas Industries Co., Ltd. The Murakami group has plants located in Japan, specifically in Fujida, Yaizu, Oigawa and Kyusyu. Moreover, it has plants in China and the US.

With the advent of the global economic crisis in October 2008 to June 2009, the demand for the company's products was reduced by 70% of the total production. From June 2009 to December 2009 the demand declined by around 30%. This year’s market forecasts for MATCO indicate a production increase of about 25% compared with 2008.

MATCO is the first-tier supplier of Toyota, for whom it delivers about 80% of its product requirements. As a Toyota supplier, MATCO applies the TPS. MATCO produces parts suited to the requirements of its major customer, Toyota. MATCO also uses the Kan-ban system to reduce the inventory cost and shorten lead times.

MATCO is part of Toyota’s milk run system, which refers to procurement logistics and material flow planning to deliver products according to demand both within and between production plants.

Based on this system, MATCO’s trucks pick up the exact amount of products to deliver to designated plants. Toyota provides order volume forecasts, on the basis of which MATCO estimates the raw materials that will be needed for its production. A six-month forecast has about 50% accuracy, a four-month forecast 70% and a two-month forecast 90%.

MATCO chooses its suppliers on based on QCDS: quality, cost, delivery, and safety. The quality of the product must meet the standard requirements while ensuring the lowest cost possible. The supplier must be able to deliver on time in keeping with the TPS system. Lastly, suppliers are expected to have a safe environment for their production processes.

MATCO’s audit team from the purchasing, production and quality assurance department assesses the suppliers' performance yearly. The firm assigns scores ranging from A to D based on the performance audit results. Suppliers who get a score of D undergo a retraining under the MATCO team so they can improve and develop further their production processes.

MATCO shares information with its suppliers and customers such as those on demand forecasts, production plans, cost reduction, stock level and point of sale. Moreover, it shares competition information such as those on blueprints, marketing, business, and new product development. MATCO jointly makes business decisions with both customers and suppliers such as those pertaining to daily production plan, and operations problem solving. Strategic decisions are also shared with its partners such as those dealing with project plans, marketing plans and standard operations. In addition, MATCO jointly develops business plans with its suppliers and customers.

MATCO sends its development team to suppliers to teach and evaluate their respective capacities. The firm has its own training center, which it shares with its suppliers.

Despite anticipated annual increases of material and labor costs, selling prices must remain stable, or reduced if possible. Customers always ask for a 2-3% price reduction every two year. Production innovations are focused on productivity and quality. The inventory level must be gradually reduced. Using milk run delivery system, MATCO's process improvements, which were initiated by Toyota, should lead to a gradual reduction of competition cost. Every month the top management measures innovations and graph them accordingly. The results are announced and disseminated in the form of posters displayed in conspicuous places within MATCO's departments.

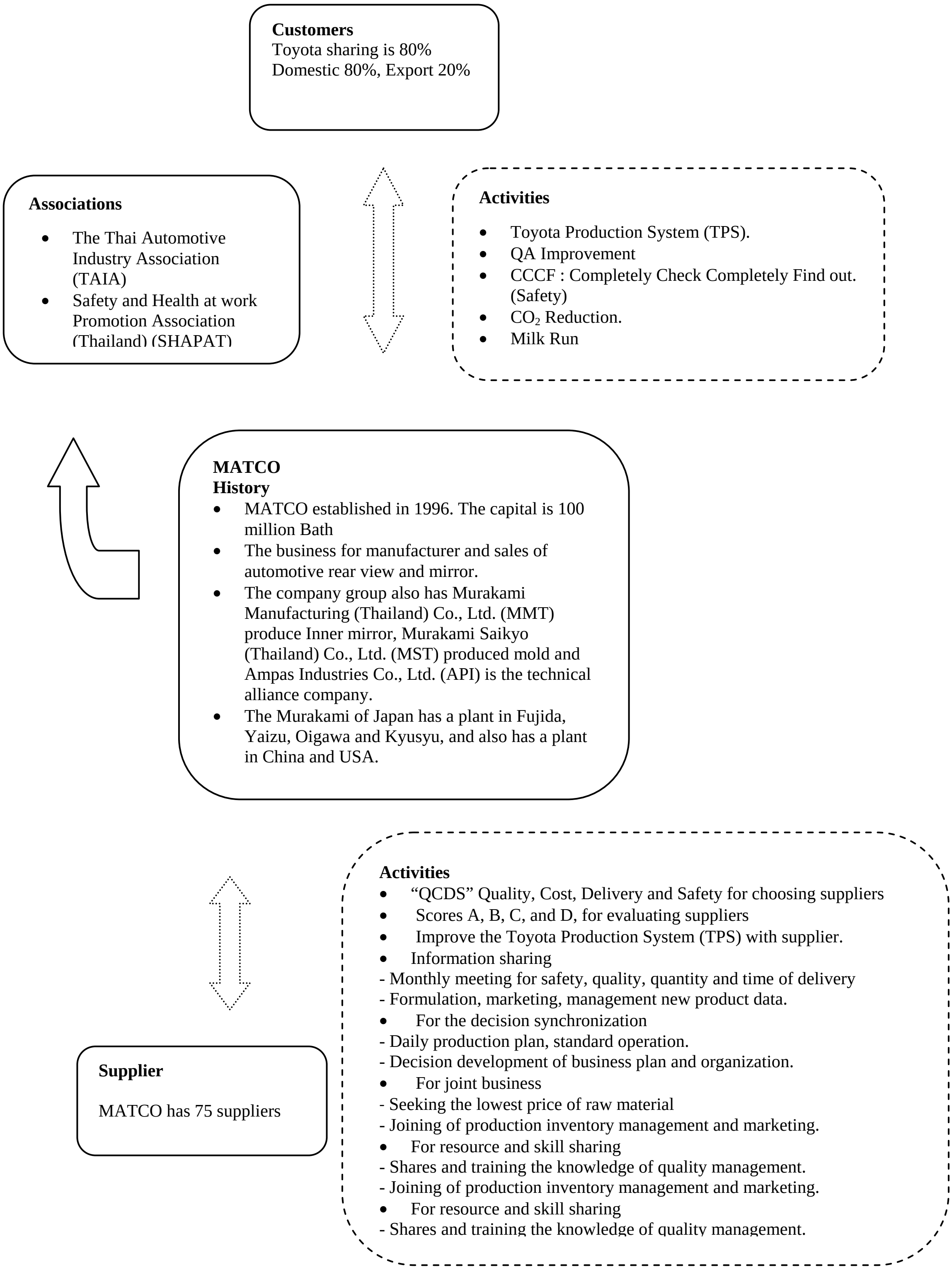


Figure 14 The Linkages between MATCO and Partners

Among the obstacles to innovations are lack of information, high installation costs for new equipment, high costs of testing machines, the need to modify machines to improve quality. Where collaboration between supplier and client firms is concerned, lack of trust and lack of suitable supporting organization are among the innovation hurdles. Information sharing between customers and suppliers suffers from inaccuracy and mistrust. Figure 14 represents the linkage of the company to its partners.

4. SUMMARY OF FINDINDS AND POLICY IMPLICATIONS

Following are the main findings based on the foregoing case studies:

- There are few Thai companies among first-tier auto parts suppliers, most of whom are foreign companies or joint ventures between Thai and foreign companies.
- Thai suppliers mainly found among second-tier groups, which supply secondary auto parts such as stamping tools and accessories. These auto parts do not require high production technology.
- Technology transfers normally involve improvements of production processes to meet quality assurance or quality control and cost reduction targets. Another apparent focus of technology transfer is the management system such as what Toyota has done by initiating the TPS for its suppliers. As a result, innovations are confined to processes at the expense of product innovation.
- Automotive manufacturers and foreign first-tier suppliers confine product innovations within the companies. Local companies produces parts based according to the automotive makers' specifications.
- Most Thai companies acquire equipment and knowhow from abroad, which they then adapt to their needs.

- Although some Board of Investment policies were enforced to persuade industries to conduct more R&D, most of the resulting researches were patterned after existing innovations, with few attempts toward originality.
- Despite the Thai government's efforts to promote innovations and R&D, there have not been any major impacts on industries and society alike.
- There has been no research collaboration between companies and universities or local experts toward product development. Collaborations between these sectors were largely focused on improving management systems.

Policy Recommendations

- The government could set up a more effective strategy that encourages technology transfer.
- Government could enforce a strategy that will encourage the research community in Thailand to focus more on commercially viable researches rather than simply publishable ones.
- Government could reshape the educational system to make Thai people more interested in conducting research and development.
- The academic community should aim to produce more students that will support the local automotive industry, among others, by enabling to develop an innovative mindset.
- More industry people should be involved in designing and developing university curricula for such as areas as engineering, sciences and technology.
- University should serve as the linkage between industry and education.

REFERENCES

Advanced Research Group (ARIP) (2003) “Automobile and Auto Parts Business,” *Business News*. http://www.arip.co.th/businessnews.php?id=406819 (accessed November 13, 2009).

Amano, T. (2009) “Learning the Way of Capability Building from the Case of Toyota Motor Thailand.” http://www.jbic.go.jp/en/about/topics/2009/0423-02/3amano.pdf (accessed August 25, 2009).

Asawachintachit, D. (2009) “Opportunity Thailand.” http://www.boi.go.th/english/download/news/1426/DJ_seminars_in_Brisbane_29%20April%202009_final.pdf (accessed November 2, 2009).

The Board of Investment of Thailand (BOI) (2004a) “Investment Policies and Criteria.” http://www.boi.go.th/english/about/investment_policies_criteria.asp (accessed December 26, 2009).

__ (2004b) “Basic Incentive.” http://www.boi.go.th/english/about/basic_incentive.asp (accessed December 26, 2009).

__ (2004c) “Granting Tax and Duty Privileges.” http://www.boi.go.th/english/about/boi_incentives.pdf (accessed December 24, 2009).

__ (2004d) “BOI Privileges by Location.” http://www.boi.go.th/english/about/boi_privileges_by_location.asp (accessed December 26, 2009).

Hart-rawung, C. (2008) “Building Competitiveness with Manufacturing Automation, Automotive Parts Manufacturing.” http://www.tgi.or.th/content/filemanager/files/Automotive%20Parts%20Manufacturing.pdf (accessed October 5, 2009).

Manprasert, S. (2002) “Overview of Thai Economy.” http://pioneer.netserv.chula.ac.th/~msompraw/Overview.pdf (accessed October 11, 2009).

Ministry of Commerce (MOC) (2009) “The Value of Total Export of Thailand.” http://pcoc.moc.go.th/pcocsys/view_news.aspx?data_id=2751&control_id=9&pv=77&view=1 (accessed November 2, 2009).

Ministry of Finance (MOF) (2009) “Import/Export Statistics.” http://dwfoc.mof.go.th/foc_eng/menu6.htm (accessed November 15, 2009).

Office of Small and Medium Enterprises Promotion (OSMEP) (2008) “Thailand’s Automotive Industry.” http://cms.sme.go.th/cms/c/portal/layout?p_l_id=25.683 (accessed July 13, 2009).

Praisuwan,V. (2006) “Investment Opportunities in Thailand: Automotives.” http://www.boi.go.th/english/download/business_speeches/282/Automotive%20Sector%20presentation%20India%20mission.pdf (accessed August 25, 2009).

RedPrairie (2007) “Automotive Supply Chain Diagram.” http://www.redprairie.com/articles/template2.aspx?contentid=82a08095-7206-424a-8d00-21067e7facc5&lid=1&nomenu=true (accessed August 20, 2009).

Runckel, C. (2007) “Thailand Key Information.” http://www.business-in-asia.com/countries/thailand1.html (accessed September 10, 2009).

Thailand Automotive Institute, Automotive Industry Analyze Division (TAI) (2009) “Automotive Industry and Auto Parts Situation.” http://www.thaiauto.or.th/research/document/status09/status0910.pdf (accessed August 22, 2009).

Thaibestjob (2006) “Automotive Industry Club.” http://www.thaibestjobs.com/employer_search/empr.php/id_comp/0001269/. (accessed February 28, 2010).

6

The Process of Improving Technology and the Perspective of Domestic Suppliers in the Motorbike Industry in Hanoi

Truong Chi Binh

Abstract

In the manufacturing scene in Vietnam, the motorbike industry is assessed as the most developed one in recent years. Japan, Taiwan and China are the main sources of foreign direct investments (FDI) in the industry with Hanoi and neighboring areas as the main focus. The development of the motorbike industry has significantly contributed to the establishment of domestic enterprises involved in manufacturing and supply. Enterprises with 100-percent Vietnamese capital have been able to manufacture and supply technology-demanding components to multinational corporations (MNCs) such as Honda, Yamaha, Piaggio, and VMEP in Vietnam and also export these to their parent companies. However, there are only a few enterprises that can satisfy the standards of multinational assemblers to be able join their production network. The research of these enterprises is a practical lesson for developing the motorbike industry as well as considering the development perspective of supporting industries in Vietnam.

1. INTRODUCTION

In the manufacturing scene in Vietnam, the motorbike industry is assessed as the most developed one in the last years. Japan, Taiwan, and China are the main sources of FDI with Hanoi and neighboring areas as the main focus. The development of the motorbike industry has significantly contributed to the establishment of domestic enterprises involved in the manufacturing and supply aspects. Enterprises with 100-percent Vietnamese capital have been able to manufacture technology-demanding components needed by MNCs such as Honda, Yamaha, Piaggio, VMEP in Vietnam and also export these to their parent companies. However, there are only a few enterprises that can satisfy the standards of multinational assemblers to be able to join their production network. The research of these enterprises is a practical lesson for developing the motorbike industry as well as for considering the development perspective of supporting industries in Vietnam.

Based on the results of the research of ERIA in 2007 and 2008, this research focuses on finding some key points of firm innovation in the motorbike industry in Hanoi. In particular, it attempts to determine and analyze: (1) the objectives and motivation for innovation and upgrading of firms, including the technical requirement aspect such as quality, delivery time, environmental issue, and design, and the economic requirement aspects such as cost reduction, new client, new market, and new product; (2) the level of innovation (either incremental or radical manner) in terms of the international or domestic market and within the firm or outside the firm level; (3) the strategies of firms that will create efforts for innovation activities such as investments for manpower, new technology and machines, and R&D cost, business linkages, utilization of internal sources, and external support; and (4) the key factors for the success of firm innovation activities.

Research Question

1. How do domestic enterprises that are successfully supplying for MNCs develop? What are their obstacles and successes?
2. What is the role of FDI suppliers in the motorbike industry?
3. What is the development perspective of domestic suppliers in the motorbike industry?

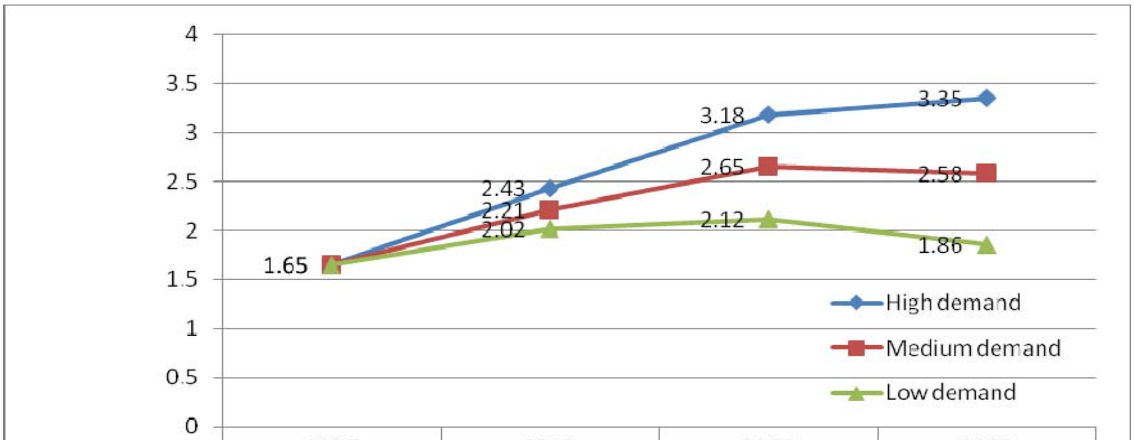
Hypothesis

It is hypothesized in the study that the backward machines and the lack of investment capital of many industries hamper their ability to supply to MNCs. In this regard, several questions are also worth answering. Is the problem about upgrading product quality a technological issue? How do enterprises gain success in this field? What are the implications of problems that relate to improving manpower? Whenever enterprises that have achieved success in this field continuously upgrade their technology and the quality of their products, can they supply for higher technology industries such as electronics, home appliance and automotive.

2. BACKGROUND: AGGLOMERATION AND PRODUCTION NETWORKS FOR UPGRADING AND INNOVATION

2.1. Current Conditions of Production Network for Upgrading and Innovation

Motorbike is a popular means of transportation in Vietnam. Vietnam is considered one of the biggest countries all over the world that manufacture and use motorbike. Having a large domestic market, it is expected that this market has a high level of growth in Vietnam.



	2005	2010	2015	2020
High demand	1.65	2.43	3.18	3.35
Medium demand	1.65	2.21	2.65	2.58
Low demand	1.65	2.02	2.12	1.86

Figure 1 Estimate Interior Demand according to Three Levels: High, Medium and Low

Source: The Motorbike Joint Working Group (2007).

Due to the characteristics of growth and the regulations of the Vietnamese goverment about localization and the large capacity of supply in the downstream market, the supporting industry for the motorbike industry has rapidly grown in Vietnam. Products of Honda, Yamaha, and VMEP, including most of the component details, are manufactured locally. Because of the market capacity, assembly enterprises are encouraged to invest in Vietnam. According to the Ministry of Industry and Trade, the rate of localization has reached 95 percent. Technology transfer is taking place between foreign companies and Vietnamese companies that supply components. The machinery and plastic industries supply for the motorbike industry so they have strong growth steps in the technical, management and labour skills levels. Examples of sucessful supplying enterprises include Tan Hoa mechanics, Dong Anh mechanics, Hanoi mechanics, metallic tool for export, and Ha Noi Plastic. However, many important components and details with high value are still manufactured by foreign suppliers.

Table 1 Number of Enterprises Manufacturing Component and Assembling Motorbike in Hanoi

Unit: enterprise

Order	Type	Year 2004	Year 2006
	Total	**69**	**79**
1	Enterprises having 100% foreign capital	12	18
2	Enterprises jointing venture with foreign companies	4	5
3	Central state enterprises	3	1
4	Local state enterprises	1	1
5	Joint-stock companies having more than 50% state capital	1	3
6	Joint-stock companies having less than 50% state capital	0	1
7	Limited companies having less than 50% state capital	39	37
8	Private joint-stock companies	3	5
9	Private enterprises	3	6
10	Industrial co-operatives	1	2

Source: Statistics yearbook of Hanoi Department of industry.

In terms of specialization level, there are enterprises specializing in the manufacture of one kind of spare parts in Hanoi. However, there are still many enterprises that manufacture motorbike components and spare parts as their secondary products besides other main products. Big enterprises specializing in manufacturing motorbike spare parts and components in Hanoi are Machino Motorbike Car Company that specializes in manufacturing buffer, clutch and brake, and Thang Long Goshi and Thang Long Machinery that specialize in manufacturing body, rim, and outlet. Beside these enterprises, there are about 100 household-level manufacturers producing the simplest motorbike components and details such as stabilizer, basket, and protection parts.

Table 2 Procurement of Japanese Motorbike Assemblers in Vietnam

	Inside firm	Local procurement				Import						
		Japan	Taiwan	Vietnam	other	Japan	Thailand	Indonesia	Malaysia	Taiwan	other	Total (%)
Quantity of Parts and component	2.6	28.1	28.4	10.6	4	2.3	19.5	2.3	0.7	0.7	1	100
Engine	6.3	14.3	16.1	5.4	0	2.7	47.3	4.5	1.8	0.9	0.9	100
Exhaust pipe	0	50	50	0	0	0	0	0	0	0	0	100
Frame/body	0.8	32	44.3	9	9	0	3.3	0	0	0.8	0.8	100
Electrical	0	75	7.1	10.7	3.6	0	0	3.6	0	0	0	100
Others	0	15.2	24.2	36.4	0	12.1	6.1	3	0	0	3	100

Source: The Motorbike Joint Working Group (2007).

With a combined production capacity of 30 percent, Hanoi and Dongnai are considered the two biggest centers of motorbike assembly in the whole Vietnam. Due to stiff competition and low quality, the consumption of low-priced motorbikes made from spare parts from China has experienced a downward trend in demand. This has quickly reduced the number of local assembling enterprises.

In general, the technical level of enterprises in the motorbike industry in Hanoi is at the medium level. A few are in the advanced level of technology. In general, two kinds of technology levels exist simultaneously.

(1) *Advanced modern technology*: This is typical of enterprises having foreign capital, equipped with modern lines from Japan, use a lot of specialized machines and robot technology, have a production line with a high level of automation and have a strict system for checking and controlling quality. These enterprises have manufactured some difficult product lines requiring a high level of precision such as transmission gears. These products have a large capacity and output, and a high level of quality is maintained.

(2) *Medium technology*: This is typical of local enterprises that mostly use single, backward, asynchronous equipment belonging to many different sources and generations. Most equipment and machines have a medium level of technology from Asian countries such as Taiwan and China. They are processed in many different small equipments that are mainly general purpose machines and lack specialized parts. Their accessories are simple; testers are backward and have a low level of accuracy. The procedure of controlling product quality is weak. Thus, they are only able to manufacture components and details that are uncomplicated. The degree of accuracy is low. Durability is also low and quality is unstable.

The number of machines and technologies used for manufacturing and assembly of motorbikes is large but they are asynchronous. Many enterprises generally invest in some equipment and machines such as assembly belt, normal processing machine for cutting, and plastic detail extrusion machine. This leads to capacity redundancy but low quality. However, equipment for processing, manufacturing patterns, heat treatment, and surface treatment are lacking in quantity. Equipments like these also have a low technology level.

The total labor force of the motorbike industry in Hanoi as of 2006 is 16,971. It accounts for five percent of the total labor force in the industrial enterprises in Hanoi, which is also bigger by 1.4 times compared with the figures in 2004. On the average, one motorbike enterprise attracts 214 workers, 1.8 times larger than the average level in the Hanoi industrial enterprises. This proves that the motorbike industry has a strong ability to attract more workers than other industries can. The labor force of the motorbike industry in Hanoi, however, lacks experts who are adequately trained in managing enterprise and controlling production process. As production procedures become stricter in terms of requirements in design, adjustment, and operation, the workforce also has to enhance its technical ability, be proficient in multiskilling, and should have a thorough grasp of production processes to satisfy work requirements.

2.2. Government Policy for Upgrading and Innovation

Vietnam’s science and technology system is dominated by public agencies of research institutes. Only few of state-owned enterprises (SOEs) have their own laboratories because of the legacies of the planned economy. In the past, the government took the responsibilities for technical change and industrial modernization. About 85 percent of the total R&D budget came from the state budget (UNIDO, 2000). The share of government budget has decreased to around 70 percent of total R&D investment. Government R&D investment has decreased dramatically in the 1990s since the *Doimoi* reform but recovered from between USD 50 and 60 million in 1997 to USD 270 million in 2005.The small government R&D fund has been fragmented among the various research projects in each research institute and university.

The government research institutes consist of the Vietnamese Academy of Science and Technology (VAST), Vietnam Academy of Social Sciences (VASS), ministry-line research institutes, and local government research centers. Vietnam's direction for these institutes is to enhance their contribution to economic development and to promote the commercialization of research results. Accordingly, Decree 115 declared that government research institutes should be self-financed and should be S&T-based enterprises. As of 2004, there are 40,000 researchers in Vietnam, 14,000 of whom are PhD degree holders and 16,000 have MSc degree.

As one of the two biggest education centers, Hanoi has more than 50 universities and several colleges. However, the R&D activities in the universities have not been paid much attention. The educational system also requires further development to support the S&T system and this can be realized by producing qualified researchers and engineers.

In 2006, the technology priorities identified consist of information and communication technology, biotechnology, new and advanced materials, automation and machinery, energy, food and foodstuff, and aero plane. However, the national priority program is ineffective because of limited involvement of R&D institutes and high-technology firms from overseas and private/public enterprises. Moreover, the weak linkage among ministerial laboratories, national institutes, local laboratories, and universities results in poor performance in R&D.

This weak linkage is a major problem in Vietnam. There is a weak vertical and horizontal coordination between local government and central government in strategy building and priority setting.

Overall, the S&T system has many shortcomings that need to be fixed. FDIs are not strategically and efficiently utilized for technology capacity building of local industries.

SOEs also need to take a leadership role in promoting strategic industries. Additionally, the government does not play a guiding role in S&T for industrialization due to lack of strategies, coordination and sufficient funds. The educational system also does not provide appropriately trained workers for the industry and qualified researchers and engineers for the S&T system.

To transfer from a labor-intensive economy to a capital, knowledge and technology-based economy, it is urgent for Vietnam to develop a proper S&T system to support and promote the industrial sectors. Vietnam should design a comprehensive policy framework for industry targeting, prioritized S&T, focused human resource development, and strategic technology transfer. The key point in strategy setting is to select and focus. The success of building and maintaining a strategy will mostly depend on how determined the government is about its strategy and not so much on the technological aspect.

3. CASE STUDIES

Ten firms were interviewed: two MNCs (Honda Vietnam, VMEP Vietnam), three FDI firms (Taiwan, China, Malaysia) and five local firms (Tan Hoa, Toan Luc, Freewheel and Chain Dong Anh, Export Mechanical Tool Stock Company, Hop Phuong). Most of Vietnamese suppliers are in the metal component manufacturing aspect.

3.1. Honda Vietnam (HVN)

HVN is a motorbike supplier and manufacturer. It has the largest market share in Vietnam. The total capacity of its two factories is 1.5 million motorbikes a year. HVN is one of the biggest factories that manufacture motorbikes in the world. Along with the development of the motorbike industry, HVN continuously increases its rate of localization and it has now reached a localization rate of 90 percent with 78 of its suppliers coming from Vietnam. Among them, there are 19 enterprises that have officially become suppliers of HVN and are directly taking part in the first supplier class. Examples of these companies include Hanoi Plastic Company and Dong Anh Chain Company. Their number, however, is not high and account only for 24 percent of the total number of suppliers of HVN in Vietnam compared with 59 FDI suppliers. While the number of FDI suppliers has been increasingly rapidly, the number of Vietnamese suppliers has only gradually increased in the last three years.

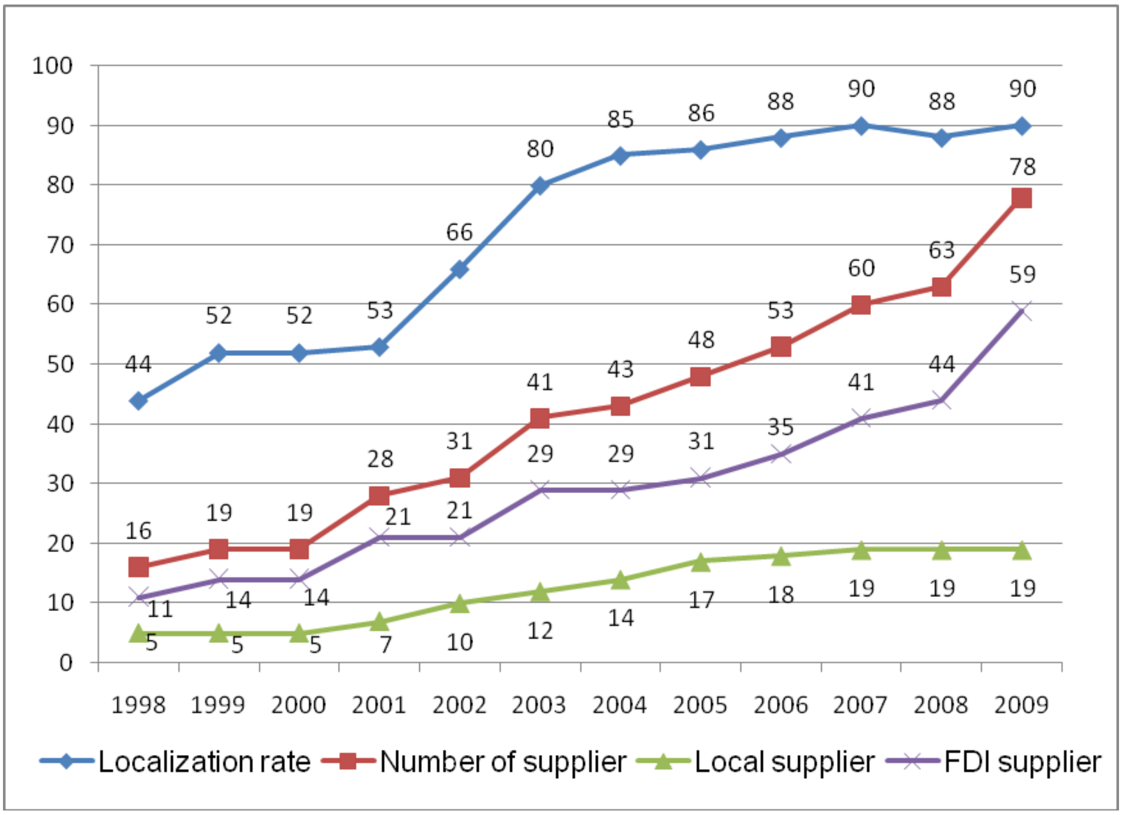
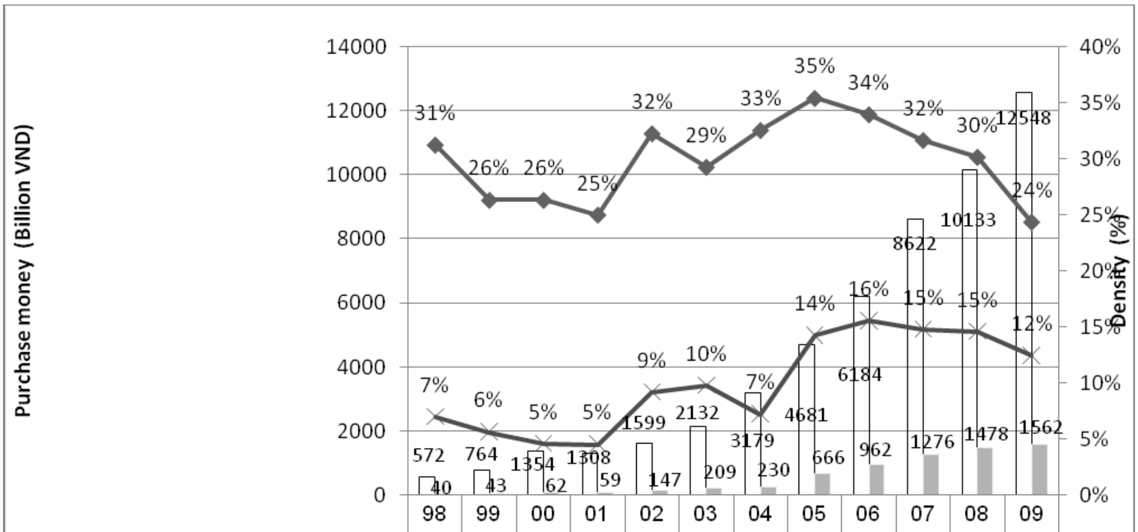


Figure 2 Rate of localization and number of suppliers of HVN

For motor components, the products require a high a degree of accuracy. They are mainly imported from Thailand, while the interior part is mainly from Japanese and

Thailand FDI enterprises. For electric components, 75 percent are supplied by Japanese FDI enterprises. Motorbike body and outlet are mainly supplied by Japanese and Taiwanese FDI enterprises. Vietnamese enterprises mostly supply components that have low technology content. This explains why components manufactured by local suppliers do not have a high value and only account for 15 percent of the total volume of procurement purchased by HVN.



	98	99	00	01	02	03	04	05	06	07	08	09
Total purchase money	572	764	1354	1308	1599	2132	3179	4681	6184	8622	10133	12548
Purchase of local supplier	40	43	62	59	147	209	230	666	962	1276	1478	1562
Purchase density of local supplier	7%	6%	5%	5%	9%	10%	7%	14%	16%	15%	15%	12%
Local supplier density	31%	26%	26%	25%	32%	29%	33%	35%	34%	32%	30%	24%

Figure 3 Total purchase money of HVN and rate of interior suppliers

Source: HVN

HVN’s rate of localization of 90 percent is considered ideal and increasing this rate is not necessary. However, HVN still wants to diversify its local suppliers for each kind of component to eliminate the risk of depending on just one supplier for each kind of component or finding other suppliers that are more capable and can supply higher quality components at a cheaper price. In addition, the company continuously changes its design, provides new motorbike types so the demand of developing new components is very high. According to the assessment of HVN, Vietnamese enterprises are still weak in terms of quality, cost and delivery (QCD) and they have not considered improving in these aspects.

Item	Japanese suppliers	Suppliers having foreign capital (Taiwan)	Vietnamese suppliers	Chinese suppliers
Quality	Good	Good – moderately good	Moderately good-medium	Moderately – Medium
Price(Mold)	1	0.9	0.85	0,60
Good delivery	Good	Good	Good – moderately good	Good – Moderately good
・Development ・Management	・Have ability to develop highly ・Self control in improving quality ・The system for ensuring quality is complete ・New structure/new technology	・Need to improve quality ・Have ability to develop more highly ・Management is better ・Quality system is sufficient	・According to assessment level of customer ・Have a large difference between management ranks and people directly manufacturing ・Analyze the reasons of weak matters ・Management aspect is not complete ・Need large supports if bring the products into the use.	・According to assessment level of customer ・Checking quality in each stage is not strict, so errors still exist ・Management is not complete ・Dependence on the level of leader ・Development ability is not stable

Figure 4 Assess QCD Quality of HVN.

Source: HVN.

3.2. VMEP Vietnam

Vietnamese VMEP Company now has 1,881 workers, which include 40 Taiwanese staff and 1,841 Vietnamese staff. The main products of VMEP are Enjoy (2% of revenue), Attila (54%), Excel II (2%), Angle EZ(14%), Elegant 100 (6%), and Sanda (22%). VMEP takes the lead in the market share for scooter motorbike manufacturing in Vietnam.

In 1994, when VMEP started to invest in the Vietnamese market, only 12 Taiwanese supporters were investing in Vietnam. Today, there are now 59 FDI enterprises and more than 10 local enterprises supplying body details. Most Vietnamese suppliers are private enterprises. Local Vietnamese suppliers contribute to reducing the production cost which means savings for the company. VMEP usually signs a yearly contract with these enterprises.

VMEP faces many difficulties in looking for good local auxiliary enterprises in Vietnam. The number of auxiliary enterprises for manufacturing components is limited. Importing normal cast iron materials from overseas impacts negatively on the working time. Auxiliary enterprises have a low engineering level, which affects production time. Resources of suppliers are insufficient. VMEP resolves these issues by consulting other companies for suggestions of auxiliary enterprises to tap. The company sometimes finds out auxiliary suppliers via the internet or telephone directory, enterprise associations, locals or fairs, exhibitions, and promotional trade fairs. When choosing suppliers, VEMP considers factors such as product quality, production ability (size), self-design and innovation, delivery on time, reasonable price, level of leaders, and long-term cooperative relationship. In addition, the company also considers factors related to homogeneous product quality, standards about production management, and environmental management. The company focuses on the support for auxiliary suppliers via supporting activities, designs, models, patterns, information support, and introduction about customers. Besides, the company sometimes appoints technical officers to guide, control, train workers for auxiliary enterprises and supply, lend machines and equipment, or support investment capital for auxiliary suppliers. It is expected that in 2010, the company will expand its supplying capacity for the local market with the supply of input materials (3.4%), metal components (52.6%), electric and electronic components (15.1%), plastic components (20.6%), packaging, cellular, basket, carton (6.1%), and others (2.2%). To improve the ability of Vietnamese auxiliary enterprises; VMEP believes it is necessary to continuously attract FDI in auxiliary enterprises, improve the management level and skills of production workers, and improve the level of innovation and design of enterprises.

To become a company that strongly focuses on innovation and creation, VMEP established an R&D center in Vietnam in 2006. It invested USD 15 million to construct the center. It is envisaged to become a center for motorbike research and development of SYM in the ASEAN region. The planned area totals 300,000 m^2 and it is expected to be completed in 2009. Through this R&D center, VMEP would have the ability to carry out R&D activities and have a single center for testing standardized motorbikes.

VMEP will continuously service the Vietnamese market by focusing on expanding production of scooter motorbikes through innovation. Apart from this, it is involved in environmental causes, social activities, and charitable activities in Vietnam.

3.3. Export Mechanical Tool Stock Company

This export mechanical tool company belongs to the industrial machine and equipment head company under the Ministry of Industry. Its factory is located at 15A Parcel, Quang Minh Industrial Zone, Me Linh, Hanoi. The company manufactures the following products:

- Tools, accessories of motorbikes and cars for big firms such as Honda, Yamaha, VMEP, Suzuki, Toyota and many other local companies.
- Household goods such as grill stove and kitchen tools for export to Western Europe and domestic market in Vietnam.

- Mechanical products and medical equipment

Technical management, production management and technological innovation are pursued by this company. It has an R&D department with 20 engineers and technicians who specialize in designing and developing new products and testing manufactured products according to consumer demand. The department was established in 2002. Information on innovation and improvement is mainly received from customers and sometimes from enterprises involved in the same field or from mechanical enterprise associations.

The company is using technologies such as chemical process, heat treatment and surface treatment that are judged to have passed the ISO 9001:2000 standard certificate. Many products of the company have earned the goal medal awards in trade fairs and assessed as high-quality industrial goods. Many large consignments of the company are exported to Germany, United States, Japan, Eastern Europe, and Western Europe. The growth of the company is evidenced by its increasing revenues. In 2000, before capitalization, the output value of the company was VND 42 billion and in 2006, it increased to VND 165 billion. The yearly dividend interest is from 15 to 20 percent.

The most important customers of the company are Japanese motorbike assemblers in Vietnam such as Honda and Yamaha. By cooperating with these companies that have a strict quality control procedure and advanced production management, the company has built an efficient and effective system of management procedures (such as ISO, 5S), merchandise exchange and inventory management (JIT), and environmental protection. Japanese companies also help the company in coming up with a modern management model and there is regular exchange of information to improve product quality. Cooperating with big companies in Vietnam has been beneficial for the company as manifested by its advanced production level, improved product quality, and ability to export to the overseas market. The company considers its linkage with big companies as the most effective method of innovation and quality improvement.

3.4. Toan Luc Company

Toan Luc Joint Stock Company was established in 2001. It specializes in manufacturing accessories for bicycle and motorbike. The company now has nearly 300 workers and its main factory is located in Phu Minh Industrial Zone, Phu Dien, Tu Liem, Hanoi.

Initially, Toan Luc was manufacturing pedals for the Thong Nhat Bicycle Factory and the LIXEHA Joint Stock Company. Due to the high demand in the Vietnamese market, the company has continuously innovated its technology and improved its ability to manage and manufacture new strategic products such as motorbike accessories. Today, besides pedals, the main products of the company include wheel bosses, brake pads, rims, and grip handles. Yearly, the company supplies about five million products in the market with the Toan Luc brand name.

From 2003 to 2005, the company has reaped awards given by the Hanoi City People's committee (2003,2004) and the Ministry of Finance and Taxation Bureau (2004, 2005) in recognition of its excellent performance. In December 2005, the company gained the certificate of quality standard ISO 9001:2001.

Toan Luc Joint-stock company is a main supplier of the Vietnamese NISSAN brake manufacturing company and the VMEP of Taiwan. In addition, Toan Luc has a technology cooperation with TRASAXE of France and NISSAN of Japan. Toan Luc provides products for THONG NHAT, VIHA, LIXEHA, and VINAMOTOR bicycle manufacturing factories.

The manufacturing components for NISSAN brake company is an important transition for Toan Luc. After three years of being a supplier for Nissan brake company, it started to directly supply for the VMEP motorbike assembling company in 2003.

Cooperation with a prestigious company in the Vietnamese market that has a strict method of quality management and production management has helped Toan Luc to improve its management level and the quality of its products. Through this cooperation, Toan Luc has steadily applied effective management methods such as ISO and 5S and enhanced its trade name.

Toan Luc identifies four crucial values as guideline for all of its activities:

- *Ceaselessly improve*: All Toan Luc staff should always aim for continuous improvement. The company sets objectives and its staff try their best to meet these objectives and continuously set higher objectives. Toan Luc believes that all things can be implemented in a better, quicker and more effective manner through inquiring and learning from experience.
- *Be enthusiastic with customers*: Toan Luc extremely focuses on products and services that their customers want and need.
- *Be creative*: Toan Luc is always creative in thinking, discovering advanced technology and implementing new ideas.
- *Working as a group*: Toan Luc gains success by thinking and working as a group. The strength of the company is striving for a high level of performance and promoting diversification.

Toan Luc is a joint-stock company that has a plan of development in the future. The reputation of the company is built through its high quality products, promoting a lasting relationship with its partners, enhancing the professional skills of its staff and learning from experience.

3.5. Dong Anh Chain and Freewheel One Member SOE

This company produces and processes mechanical products. It mainly assembles details for motorbike such as chain, freewheel, bearing; front chain wheel for bicycle; industrial chains; and accessories for motorbike and car. Its customers include VMEP Vietnam, HONDA Vietnam and YAMAHA Vietnam.

Initially, the company specialized in providing VMEP Vietnam with some products related to motorbike chain. Then, after two years of processing for VMEP, it started transacting with Honda and Yamaha and also began a component manufacturing process for Japanese corporations. The company has applied 5S management system in its factories.

The customers are the company’s information sources for implementing improvements. It enhances its production procedure based on customer demand. It also uses information and insights of supporting organizations based on their experiences. The company has received support from the Technology Assisting Center (TAC) of the Bureau of Enterprise Development, Ministry of Planning and Investment. The company has participated in training courses on 5S Kaizen. It is also supported by JICA experts who would come all the way from Japan to provide on-site training on the 5S procedure. This is an extremely useful support for TAC.

3.6. United Motor Vietnam (UMV)

UMV is a company with 100-percent foreign capital. It belongs to Trung Khanh Corporation in China. The company was granted with an investment license in March 2001. Its total capital investment is more than USD 10 million. The company officially started to operate in September 2001 at the Noi Bai Industrial Zone, Quang Tien Commune, Soc Son, Hanoi. Now, the company has nearly 800 staff.

Using correct strategies and orientations for production, UMV has continuously expanded production and business. Each year, UMV manufactures nearly 1 million of motorbike components which are supplied to the domestic market. The revenue of the company has also quickly increased from VND130 billion to about VND600 billion a year.

UMV specializes in manufacturing spare parts for motorbike with machines and equipment that are mainly imported from China. The main customers of UMV are local assemblers whose goal is to produce cheap motorbike. In cooperation with local assemblers, the company has continuously changed models, improved capacity and reduced production cost to suit market demand.

Since it started operating, the company has continuously diversified its products. At present, UMV produces an almost-complete product line for the motorbike industry which includes motorbike plastic components, engine components, electric components, motorbike body, and many other mechanical components.

According to the general manager of UMV, investment and business in manufacturing motorbike components in Vietnam brings many opportunities and challenges for foreign investors. This creates many opportunities for agencies like UMV because some small companies do not have the ability to compete in the market. Another important thing is that the potential of the motorbike market is at least 20 years. The secret of UMV's success is making many products that suit the taste of consumers and that even low-income consumers can afford.

3.7. Chiu Yi Vietnam (CYV) Limited Company

CYV is a company with 100-percent Taiwanese capital. Its factory is located in 126 Ngo Quyen Street, Ha Dong, Hanoi. The company has more than 80 staff. Its main products are electric components for motorbike such as timers showing speed, petro level, and different kinds of motorbike lights.

Set up in 1999, Chiu Yi Company is an important supplier of VMEP. After its establishment, majority of its products are supplied to VMEP.

Being a trusted partner of one of the biggest corporations in the world, the company’s products require a high degree of accuracy. Thus, the company has a relatively modern and complete facility. Its machines and equipment mainly come from Taiwan and Japan. The company also applies meticulous systems of quality and product management such as 5S, ISO, and TQM.

VMEP and CYV has a close working relationship. VMEP usually appoints technical staff to support the technology for CYV in order to enhance product quality as well as support the development of new products and designs. Meanwhile, CYV appoints technical staffs to examine and process errors on the spot or take part in meetings about quality as well as give proposal to VMEP on improving technology and product styles.

VMEP also helps Chiu Yi in developing its human resources. VMEP usually appoints staff to take part in courses about technical advisory and organizational and production management.

Chiu Yi also continuously diversifies its products and seeks out new customers. Its target customers are Japanese motorbike assemblers in Vietnam. In 2007, the company became an official supplier of components for Yamaha Vietnam Company. Chiu Yi always strives for continuous innovation, technology upgrading, improvement of management system, and creative development of new products with the aim of enhancing product quality and expanding market.

3.8. Hop Phuong (HP) Technology Limited Company

HP is located at Buu Bridge, Way 70, Tan Trieu Commune, Thanh Tri, Hanoi. It was established in 1997. Its main products are margin struts and main struts for motorbike. Now, the company has more than 30 staff.

With its small space, backward technology and little investment capital, its products have a low degree of accuracy. Thus, they are only consumed in cheap motorbike markets and the company's main customers are mainly local assemblers.

Being a small enterprise, the awareness of its managers about innovation is not high. Thus, creation and innovation activities of the company are restricted. It products have not diversified and until now consist of different kinds of struts for motorbike which are consumed only in the local market given its low competitive ability.

The company has backward and small punching machines (less than 80 tons) and because of this, the capacity of the company is relatively low. Some main components needing large size machines and a high degree of accuracy have to be imported overseas. Thus, the profit from each product is very low. The lack of a strict quality managing system leads to inconsistent product quality and a high rate of faulty goods.

The production relationship between HP and its customers is not very close. However, customers have been helpful in providing feedback on product quality. The company has received good support from its customers in developing production management and in checking the quality of its products. However, because the recommendations and concerns of customers are not addressed, the effect is low.

3.9. Armstrong Component Parts Vietnam (ACPV) Co., Ltd.

Armstrong is a company with 100-percent foreign capital. It belongs to Oriental Holdings Bhd Corporation (OH) - Malaysia. The company was established in 2005 and its factory is located in Lot 23, Noi Bai Industrial Zone, Soc Son, Hanoi.

The company officially started to manufacture in Vietnam in 2006. Its first products were spokes and rims of motorbike. With a professional, modern, comprehensive, and mostly automated machine system, the products of the company have a high quality.

Belonging to a big corporation specializing in manufacturing components for motorbike and car, the company is known in the motorbike market for its high-quality products. After officially operating, the company has immediately become a component supplier of leading motorbike assemblers in Vietnam. Its customers include Yamaha and VMEP.

The company has a strict system of quality management. Its products have passed strict quality testing.

Since it was established, the company has applied advanced management system such as ISO, TQM, and 5S. The company also holds training courses for its staff to enhance their awareness of standards in management and production.

The connection between Armstrong and customers is relatively close. The company usually discusses quality problems and appoints engineers to customer companies to immediately solve any problems that may arise in the production process. Meanwhile, customer companies also periodically appoint their staff to check the production activities of the company, check the origin and quality of input materials as well as support and cooperate with Armstrong in the development of new components.

3.10. Tan Hoa Mechanical Limited Company (Tan Hoa)

Tan Hoa was set up in August 2000. Its forerunner was Tan Hoa Cooperative which has more than 20 years of operation and development in manufacturing components for bicycle, motorbike, home mechanical products, and domestic goods.

Tan Hoa factory was built in 2002, in an area of more than 5000 m^2 at the Tu Liem Small and Medium Industrial Zone, Hanoi. It is equipped with a machine system that is relatively modern and has a high level of automation. The company has nearly 200 skilled staff.

Its main products are components for motorbike such as outlets, rims, and struts. Its customers are leading corporations that manufacture motorbike in Vietnam such as Honda, VMEP, and Piagio.

Form a small and medium enterprise with a backward management method, due to the correct orientation and determination to innovate of its managers, Tan Hoa has risen to become a big and trusted company in the motorbike component manufacturing aspect in Vietnam. Its efforts to build a strict and scientific management system led to the success of Tan Hoa. Following are some of the details:

- In December 2004, the company built and applied a system of quality management according to internal standard ISO 9001:2000, which was assessed and granted by BVQI organization.
- Along with the ISO system of quality management, the company deployed and applied management methods such as 5S Kaizen in 2006, with the aim of improving ability of quality management, reducing cost, and delivering goods on time.
- In 2007, the company conducted awareness-raising activities on the JIT (just-in-time) manufacturing system which it also began implementing. Then, in 2008, it promoted awareness of the philosophy “creative spirit in production”.

The management system is implemented seriously and strictly and it is always promoted within the company through awareness-raising activities. For instance, the company always holds training courses for the staff. In training staff, Tan Hoa has also received active support from JICA and customers such as Honda and VMEP.

Besides innovation and application of advanced management methods, the company always upgrades its equipment, hires advisory experts to diversify products, improves quality, and expands market. In 2009, the company received support from Toyota Vietnam in sampling manufacturing car components.

According to Director Le Ngoc Tuan, the key factors of the enterprise’s success are:

1. Determination of the executive board

2. Thorough promotion of company principles and procedures; providing regular training to staff
3. Suitable investment for environment improvement
4. Patience in solving cases using precise and scientific methods
5. Regular check and control
6. Having a suitable award policy.

This small enterprise is able to satisfy foreign customers without using too large investment due to the efforts and determination of its leaders and the serious work of its management staff. Enterprises should follow the example of Tan Hoa in building their own corporate culture, seeking for continuous innovation, and establishing a comprehensive management system.

4. ANALYSIS

4.1. Statistic Analysis

Concerning innovation, all 10 firms confirmed about "significant change in packaging or appearance design". It was one of the most important things for innovation and upgrading in the last three years. Firms upgraded their design and packaging based on customers' orders. "Significant improvement of an existing product/service" and "development of a totally new product/service based on the existing technologies" was implemented by all 10 firms. Using existing technologies is being implemented by upgrading current equipment or changing the key parts and components of these machines without huge investment.

All 10 firms said 'yes' to most of the subquestions in Q11 (improved existing machines, equipment, or facilities; introduced new know-how on production methods). They explain that there are a frequency innovation of suppliers while assemblers always develop their products in the motorcycle industry in Vietnam.

Table 3 Plan or Achievement in Innovation of Interviewed Firms

Indicator	Yes
1. Decrease defective products	10/10
2. Decrease inventories of products	7/10
3. Reduce raw materials and energy	6/10
4. Reduce labor input	4/10
5. Improve quality of goods or services	9/10
6. Improve flexibility of production or service provision	10/10
7. Reduce lead time to introduce a new product or service	8/10
8. Enter new markets or increase market share in the domestic market	10/10
9. Enter new markets abroad or increase exports	5/10
10. Reduce environmental impacts caused by factory operations (noise, waste disposal, etc.)	7/10
11. Meet regulatory requirements on products.	10/10

For manufacturing, there are only six firms that have reduced raw materials and energy, while all 10 firms have decreased defective products, and only seven firms were concerned about the decrease in inventories of products.

The two most important sources of new technologies and information for business upgrading and innovation were the company's own R&D efforts and their cooperation with MNCs. Some Vietnamese firms said the support from MNCs push them to change method of production and firm culture.

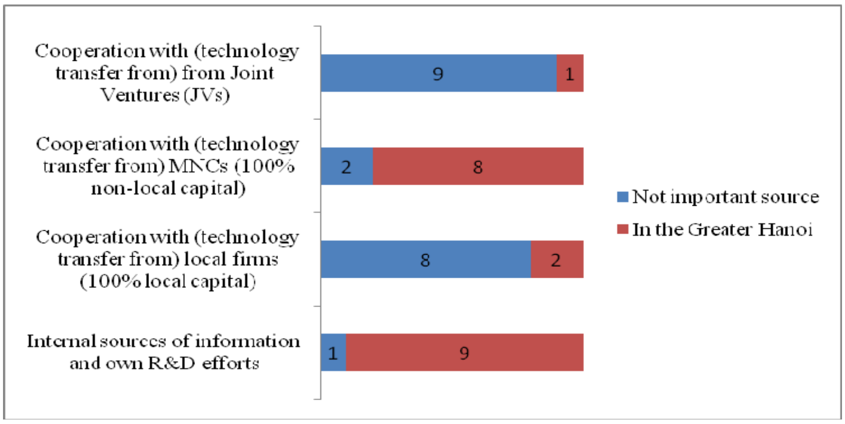


Figure 5 Sources of New Technologies and Information for Business Upgrading and Innovation in the Last Three Years

Source: Author.

Because internal sources are the most important factor to implement innovation and upgrading activities, most of the interviewed firms did not subcontract or outsource R&D work. Seven of the 10 firms have their own R&D department. Some of them have few engineers (such as Toan Luc, Hop Phuong) but despite this, the department can implement many R&D activities.

Table 4 R&D Activities

R&D expenditures	Yes
Does your establishment incur R&D expenditures at present?	9/10
Does your establishment subcontract or outsource R&D at present?	2/10
Does your establishment have R&D facility, R&D center or R&D department?	7/10

The interviewed firms described their technical capabilities in detail as follows. Most of them have adopted ISO, operated QM (quality management) or QC (quality control). As evidence of their technical design capability, more than half of firms have CAD, CAM or CAE. They have also built a just-in-time (JIT) system of delivery. Only less than half of the firms produce their own designs (original design manufacturer or ODM) or their own brands (original brand manufacturer or OBM). On the aspect of training, seven of 10 firms have an on-the-job (OJT) training program for workers and only three of 10 firms have an off-the job (OFF-JT) training program for workers. However, even if many workshops and seminars were conducted frequently, many firms were not paying much attention on providing theory training for their workers.

All of the top management of the 10 firms has a bachelor (BA), master or Ph.D. degree. Most of them can speak English well. This is a very important capability of general directors, especially in domestic firms.

Table 5 Technical Capabilities

Technical capabilities	Yes
1. Does your establishment manufacture products according to design, specification, or drawings made by your establishment?	4/10
2. Does your establishment have CAD, CAM or CAE (Computer-Aided Design, Manufacturing, Engineering)	6/10
3. Is your establishment an OEM (Original Equipment Manufacturer)?	8/10
4. Is your establishment an ODM (Original Design Manufacturer)?	4/10
5. Is your establishment an OBM (Original Brand Manufacturer)?	3/10
6. Has your establishment adopted ISO 9000, 14000 series or other international standards?	9/10
7. Has your establishment operated QM (Quality Management) or QC (Quality Control) circle activities?	9/10
8. Has your establishment adopted just-in-time delivery	6/10
9. Does your establishment have an on-the-job (OJT) training program for workers?	7/10
10. Does your establishment have an off-the job (OFF-JT) training program for workers?	3/10

Source: Author.

4.2. Motivation of Innovation and Upgrading

(1) The following are needed to ensure the quality of products that assemblers require.

Enterprises have to strictly control manufacturing process and ensure quality according to customer demands. In the beginning, this control is usually assisted by engineers from assemblers (Japan, Taiwan, and Italy) or customers (Taiwanese, Japanese, Vietnamese suppliers). Japanese partners usually send more engineers and allow them to stay longer to control and monitor quality.

On upgrading equipment and machines, domestic enterprises often only partially invest in new equipment and machines. Many of them purchase secondhand machines to save cost while some enterprises only use part of the components of these machines in upgrading their current machines.

To reduce cost and to have enough competitiveness to become suppliers, enterprises have to carry out a standard manufacturing process (such as 5S) and control material and time waste as well as product errors in particular.

Human resources are the most important matter for innovation and upgrading of products and technologies. The awareness level of workers is an important factor in making this happen and it is dependent on their education, qualification, and professional skills. However, a firm's culture has a big effect on forming this awareness. A professional and creative working environment helps to make workers obey company rules and encourages them to continuously improve their work.

(2) Upgrading of product quality and technology in local enterprises usually takes places in two stages.

Stage 1: Manufacturing components and parts for other suppliers (Japan, Taiwan, and Vietnam). This stage takes place from two to five years. The enterprises face difficulties and get little support from customers. Thus, they are easy to be eliminated from the market. Successful enterprises mainly gain from factors like joining suppliers market, assessing standards about quality, technology and machine, training human resources, and reducing investment costs by upgrading current equipment. However, they have low profit. Successful enterprises usually turn into directly manufacturing for Japanese assemblers (and Taiwan/Vietnam too). The enterprises with less success will stop at this stage or still manufacture for middle class suppliers.

Stage 2: When supplying for Japanese enterprises, it is difficult at first. Enterprises require more investment. Workers have to be more active and initiative. Problems related to upgrading and innovation happen more frequently. Many enterprises think that innovation is not a big matter. Sometimes they only make some adjustments to the machine to ensure that the details of components are able to reach the required standards in the shortest time. This stage has a close connection with the process of manufacturing management and quality. Therefore, this stage requires more investment with high cost. For assemblers, the technical support is also higher. Along with receiving control engineers, enterprises also get support from customers through direct discussion about technical obstacles from suppliers. There are some enterprises detailing their engineers in the factories of their customers to take part in short courses.

At stage 2, many enterprises receive training programs and support from business promotion organization, especially in addressing problems on organizing manufacturing management (5S). There have been some enterprises that received Japanese experts from JICA who volunteered to work in Vietnamese enterprises through the North enterprises supporting center.

Most of the enterprises that have taken part in production network of motorbike assemblers have good prospects for continuous development. Many enterprises plan to continuously train staff, standardize manufacturing process, continuously create to improve product quality, and manufacture details that have a higher demand from customers or manufacturer for high-end customers in the higher quality motorbike market to gain more profit. Many enterprises focus on the market supplying for electronics, home appliance, and automotive enterprises and have started to connect with these enterprises.

(3) To upgrade technological ability and ensure the supply for assemblers and manufacturer having FDI capital, the main successful factors of local enterprises include the following:

Quality of human sources. The Hanoi mechanical industry has the advantage of having skilled and experienced engineers and staff. However, other skills such as active ability, management ability, and systematic characteristics are not high. Many enterprises assert that training human resources with the aim of satisfying the demand of the market economy is the most difficult matter to ensure that objectives of enterprises are met.

The process of production and management ensures systematic characteristics and easy control. This is a weakness of most Vietnamese enterprises. Interviewed companies believe that this is the biggest barrier that makes it difficult for them to become suppliers for foreign customers.

System of machine and technology. Components and technology have an extremely important role in innovation system of enterprises. In the past, Vietnamese enterprises usually use old machine systems that seem to be backward but relatively sufficient. Successful enterprises have upgraded these components sparingly based on cost considerations. They did this gradually by adding new machines or replacing old components and equipping their factories with modern ones as need arises. Private enterprises usually purchase old components, import secondhand machines, self-manufacture, or take most parts of old machines for their own machines. In general, only few Vietnamese enterprises in the motorbike industry invest in modern and large machines immediately. These enterprises are investing in CNC processing machines that have a high degree of accuracy.

Controlling production cost and cutting down on product errors as much as possible and on material waste are very important. To ensure competitive price, successful companies focus on cost reduction. Many initiatives on innovation and improvement have taken shape. Enterprises realize that it is necessary to identify clear objectives to help staff improve and innovate successfully.

Continuous innovation and improvement. The establishment of self-improvement system in labor force is a key factor in the success of some enterprises (Toan Luc, Tan Hoa, Dong Anh Chain and freewheel). The key issue is to have clear objectives for the system. Many enterprises have set up an innovation system based on two main objectives: reducing cost and ensuring quality according to customer demands.

(4) The technological development and upgrading of domestic suppliers are mainly

based on certain factors. Most enterprises believe that from the three requirements of quality, price and delivery time, supplying enterprises form motives and objectives for continuous innovation and improvement. The resources for innovation include the following factors:

Requirements of customers. Requirements of customers about product, design, quality, and price continuously change. This forces enterprises to change. Unlike in the production of final products, supplying of components varies and is highly dependent on customers.

Internal force of enterprises. Most initiatives of innovating technology, machine, and manufacturing process come from human resources in their own enterprises. They are the biggest and the most effective innovation source because they know an enterprise's weakness and the points where innovation is needed. Successful enterprises believe that encouragement for innovation coming from within the enterprise brings unexpected but positive results. Tan Hoa has formed a reward system for encouraging innovation from within and also systemized some innovation initiatives for workers related to different production lines.

Information from enterprise association and competitors. Information has a big effect on innovation. Information sources having strong impacts come from mechanical enterprises with information related to a product or a technology that is popularly used in the market. Unofficial information from competitors also helps enterprises to have a good orientation for innovation (Toan Luc, UMV, Hanoi Plastic).

Support from enterprise assisting organizations. Many enterprises highly appreciate the support of the North technology assisting center (TAC). Dong Anh Chain and Tan Hoa have received training courses on 5S Kaizen from TAC, including support for its application in the last two years. These companies have also received technical support from Japanese experts (JICA) who came to work for one year to support the 5S application. The program was highly appreciated by Dong Anh and Tan Hoa because it helped increase the awareness of their workers about work quality and efficiency.

5. CONCLUSION AND POLICY IMPLICATIONS

The development of local motorbike suppliers indicates a promising future for the supplying industry of Vietnam particularly in the metal aspect.

For Vietnamese enterprises, continuous upgrading and innovation is a key to become suppliers for foreign assemblers. However, the technology level is not the only key. It is also important to identify the main points needed for improving the manufacturing process, building a good corporate culture, continuously enhancing the working environment, and standardizing the manufacturing process. Investments in innovation can be gradually implemented according to stages depending on manufactured components.

The enterprises in the motorbike industry particularly the FDI companies are able to continuously develop and provide components requiring higher technology as well as supply for higher technology industry such as electronics and car. They will progress more quickly if they have the support of intermediary organizations or potential customers. The Vietnamese government should have associations that can provide assistance programs both to motorbike enterprises and assemblers.

Vietnamese enterprises have the ability to join the production network of electronic, automotive, and automobile industry in the ASEAN area. Vietnam has just entered the middle-income class market, while Malaysia is at the end of this stage and is trying to penetrate the high-income class market in the next 10 years with the focus of developing higher technology industries and considering the upstream and downstream markets. The components for technology industries such as electronics, home appliance, and automotive produced in Malaysia can easily be transported to Vietnam if there is a suitable policy that can promote the cooperation between these countries. ASEAN nations should discuss and come up with policies for optimizing the role of each nation in the production network for each industry.

REFERENCES

IPSI (2009) *Impact of MNCs on Development of Local Small and Medium Size Industrial Enterprises in Vietnam*, MOIT Research project 2009.

Kimura, F. (2008) "The Mechanics of Production Networks in Southeast Asia: The Fragmentations Theory Approach," in Kuroiwa, I., and Toh Mun Heng (eds.) *Production Networks and Industrial Clusters: Integrating Economies in Southeast Asia*, IDE-JETRO and ISEAS, 33-53.

Ministry of Industry (2007) *Master Plan on Developing of Supporting Industries in Vietnam until 2010, Vision of 2020*, Hanoi.

Ohno, K. (ed.) (2007) *Building Supporting Industries in Vietnam*, Vietnam Development Forum (VDF).

Truong Chi Binh (2008) "Factors of Agglomeration in Vietnam and Recommendations", in *Analyses of Industrial Agglomeration, Production Networks and FDI Promotion*, edited by Ariff, M., ERIA Research Project Report 2007, Vol. 3, 155-190.

The Motorbike Joint Working Group (2007) *For Sound Development of the Motorbike Industry in Vietnam*, VDF.

Appendix Case Study

Orientation for Diversification of Private Enterprises in the Plastic Industry in Ho Chi Minh City

Institute for Industry Policy and Strategy (IPSI)

Abstract

The plastic industry is one of the fastest growing industries in Vietnam in the last few years. The export turnover of plastic packaging has continuously increased over the years. The domestic market for industrial plastic products is strongly developing. It is an aspect that has attracted large investments from the private sector. Most of the plastic enterprises in Vietnam are small- and medium-size companies and privately owned. The industry does not receive much investments and support from government. Thus, the private sector has a decisive role in the market economy. The plastic industry of Vietnam, however, primarily focuses on manufacturing plastic packaging and products for the local construction industry. There is only a small amount of enterprises supplying plastic parts and components for other industries or aiming to satisfy the demand of multinational corporations in the domestic market. Many plastic products for industrial supply are still imported, while the low manufacturing and technology levels of Vietnamese enterprises permit them to take part in supplying to other industries. This research focuses on the private enterprises in Ho Chi Minh City where strategic changes can quickly take place. It seeks to analyze the current situation of the plastic industry and provide recommendations for its development.

1. INTRODUCTION

Vietnam's plastic industry is considered as an industrial branch which is relatively young but with a high potential for development, especially because of the emergence of an increasing number of plastic products with fine characteristics that are comparable to other products such as glazed terra-cotta, porcelain, wood and metal. The continuous development of the economy determines the chances for the development of Vietnamese plastic products, with their demand to potentially become bigger when other materials have become increasingly scarce and production costs have become higher. During the initial stage of its development, Vietnam's plastic industry has chosen a suitable path by focusing on manufacturing simple plastic products that are popularly used and that do not require strict adherence to quality standards. Among these key plastic products include those that are used for transportation and packaging. However, along with the production development of the entire branch, these products are gradually being replaced by higher quality and more sophisticated types and models with high added value. Thus, plastic products used in transportation and packaging and certain kinds of plastic bags that have a certain role in producing and exporting plastic products have been experiencing a downward trend in demand.

Table 1 Market structure of exporting plastic products in 2009

Products	**Density according to Value (%)**
Products using for transportation and packaging	44
Slabs, plastic films	14
Industrial plastic products	8
Domestic plastic products	7
Canvas	5
Tools in office, school	4
Others	18

Source: VPA 2009.

In 2009, the export turnover of plastic bags was estimated to have reached USD 250 million, or 34 percent of the total export turnover of the entire branch. This shows the important role of this product to the total export of plastic products. The export of plastic products has given Vietnam an important position in the international markets. Although 2009 has been a difficult year, still the export of plastic bags was relatively successful as compared with the situation in 2008. They were exported to 85 markets, some of which were new ones.

Although the export of polyethylene (PE) plastic bags to the American market in the last months faced difficulties, 2009 was still a satisfactory year. America is the biggest importer of Vietnamese plastic bags. As of November 2009, the export turnover of PE bags has reached USD 63.7 million, accounting for 27 percent of total export turnover for this kind of product. The second biggest market of PE bags is Japan, with an export value of USD 36.1 million or 15 percent of the total export turnover. England is third with a value of USD 22.4, or 10 percent of the total of export turnover of PE bags.

Table 2 Structure of Plastic Bag Plastic Exporting Market

Market	**Value (%)**
America	27
Japan	15
England	10
Germany	9
Cambodia	8
The Netherlands	7
others	24

Source: VPA 2009.

In general, the export of plastic products suffered a downward trend because of the effects of the financial crisis and economic recession. A closer look would reveal, however, that in many markets, there was a big decline in export demand while in others the relatively strong demand has been maintained. America is one of the markets that recorded the strongest decrease; the export turnover to this market in the last year decreased by 36 percent compared with the export in the corresponding period. The export of plastic bags to Japan was not really satisfactory; export turnover reduced by 32 percent compared with the export in the corresponding period. The third biggest market, England, also registered a negative growth with only USD 22.4 million, a reduction of 10 percent compared with the corresponding period. In general, all of the three biggest markets for plastic products in the world registered a reduction of exporting turnovers at different levels. Nevertheless, this may be a chance for Cambodia to seek other foreign markets and create a more reasonable exporting structure.

In other export markets, the picture has been positive. For instance, the export to the fourth market, Germany, increased to 124 percent. Even if the economic recession has strong impacts on the export of plastic products, the market size is relatively large. This indicates promising growth prospects that should be reinforced particularly for other potential markets. Besides Germany, many other markets also recorded relatively high growth levels such as Italy (37%) and Spain (46%).

Although the markets for exporting plastic packaging are developing and growing strongly, the development of other aspects seems to be at a snail's pace. Many plastic packaging manufacturing enterprises can shift their operations to manufacturing components for industrial, manufacturing and building industries. However, because the attraction of the packaging market is too big, enterprises are not encouraged to try these other aspects.

This paper presents the results of the ERIA research in 2007 and 2008 which generally aims to find key points of firm innovation for the plastic industry in Ho Chi Minh City. In particular, it seeks to determine : (1) the objectives and motivation of innovation and upgrading of firms, which include technical aspects such as quality, delivery time, environmental issue and design, and economic aspects such as cost reduction, new client, new market and new product; (2) the innovative level (either incremental or radical manner) whether in the international/domestic level or within the firm/outside the firm level; (3) the strategies of firms that will create efforts towards innovation activities such as investments on R&D, manpower, new technology and machinery, utilization of internal resources and external supports; and (4) key factors for the success of firm innovation activities.

Research Question

The study hopes to answer the following research questions:

1. In what areas have private enterprises in the plastic industry in Ho Chi Minh City succeeded in? What were the problems met and the development orientations?

2. Where were the obstacles of enterprises in joining production networks of multinational corporations?

Hypothesis

The success in manufacturing plastic packaging for export is affected by the market objectives of enterprises. There are some enterprises gaining success in becoming suppliers for manufacturing industries but only a very small number of private enterprises in the plastic industry in Vietnam are following this route. It is hypothesized in the study that the reason may be attributed to the difficulty of penetrating this market and the need for large investment to switch to manufacturing in this area.

2. BACKGROUND: AGGLOMERATION AND PRODUCTION NETWORKS FOR UPGRADING AND INNOVATION

The plastic industry is becoming one of the fastest growing industrial branches in Vietnam. It has shown considerable progress and a steady growth rate of 15 to 20 percent per year.

According to Vietnam Plastic Association (VPA), Vietnam's plastic branch has about 2,000 enterprises that are mainly concentrated in the southern provinces. Among them, Ho Chi Minh City makes up more than 80 percent. In 2007, the plastic branch reached an export turnover of USD 750 million and USD 1 billion in 2008. However, plastic enterprises are facing difficulties in providing materials as they are heavily dependent on import resources and usually affected by the constant changes in the cost of materials for production. In 2009, it had to import 1.8 million tons of these materials valued at USD 3.1 billion.

According to the Ho Chi Minh Plastic Association, the import of high-quality and cheap plastic waste is a unique method to help Vietnamese plastic enterprises to reduce production costs, enhance competitive ability in the domestic and export markets, and help exporting enterprises to quickly increase output and export turnover. The selling price of export plastic products from Vietnam is usually higher by 10 to 15 percent compared to the price of China and India. Thus, although output and export turnover has been increasing at 20 percent each year, the actual value is still lower. Nearly 100 percent of the materials and equipment in the plastic branch are imported. Local suppliers can provide only about 300,000 tons (about 18%) of the materials needed each year. The demand for imported materials is actually 1.6-1.7 million tons.

A representative of a plastic joint stock company in Vietnam relates that the company plans to cooperate with Merlin Plastics Company (Canada) to set up a joint venture to invest in building two plastic waste processing factories in the southern and northern parts of Vietnam. However, after nearly three years of preparation, the two factories have not started operating because the existing equipment could not meet the required standards. The domestic waste collecting system is in poor condition and has not reached the minimum standards of quality and quantity.

According to VPA, if average import cost is USD 1,800 per ton, it will cost Vietnam USD 2.5 billion to import materials for production. Importing plastic waste could help in meeting between 35 percent and 50 percent of the demand for materials, which is equivalent to 650,000 tons of high-quality waste. At a current cost of USD 600 per ton, Vietnam saves USD 780 million each year. Importing plastic waste increases 25 percent of the cost of input materials and reduces 15 percent of production cost. This enhances Vietnam's competitive ability in exporting and helps to make its plastic products at par with those from China and India. In addition, American, European and Japanese customers require that Vietnamese plastic companies make plastic products from at least 10 percent recycled plastic to reduce the selling price and to create products that are environment friendly.

The import of waste is actually a sensitive matter. There are cases violating the import of materials .Thus, along with giving proposal for importing of materials, the VPA also has released certain guidelines or regulations. For example, when importing waste, the goods must have a clear origin and the detailed characteristics of the imported wastes should be indicated. Meanwhile, entities exporting wastes must have a valid license to operate. Besides releasing the regulations on importing waste for production, the Association has also proposed regulations on recycling waste.

These are enterprises having waste processing factories with advanced technologies. The Association performs a supervisory role by conducting regular and unscheduled checks of recycle enterprises. Many countries have learned from past experience that massive importation of waste is detrimental to the environment due to its harmful effects. The fore, not only the quantity should be regulated but the area where the waste will be used should be carefully planned to prevent any negative outcomes.

Currently Vietnam is building a plastic waste recycling center in Cu Chi. VPA appeals for investments in the project. The operational capacity is 150 tons of materials per day for the first period and 750 tons per day for the last period. It is estimated that in 2010, the project will start to operate in the first period. It will perform various processes from collecting of waste to choosing and recycling. The activities of the center will be under the strict control of related specialist bodies.

Although Vietnam can import and recycle plastic waste, it still does not have the ability to satisfy the domestic and foreign demand for plastic materials. Because most of these materials are withdrawn by its own manufacturers for reuse, the quantity being supplied in the market has become even more restricted. Thus, enterprises have to purchase waste materials that are relatively more expensive than the main materials.

3. CASE STUDIES

The research team in Ho Chi Minh City interviewed 10 enterprises. Only two enterprises, both European ones (Germany and Poland), have 100 percent foreign capital. Six private enterprises and two state enterprises have 100 percent domestic capital. There are five enterprises involved in manufacturing plastic packaging for export market. Their customers are big multinational corporations such as a global supermarket chain system and firms manufacturing cosmetics and medicines. Two enterprises manufacture materials for the construction industry such as water pipes and plastic pipes. One company specializes in manufacturing plastic doors for the domestic market. Only two companies manufacture components and equipment for supply to other manufacturing industries. One company manufactures plastic components for motorbikes and electronics for the domestic market. Another company manufactures patterns for the plastic industry and spare parts for the steel industry. The survey group also interviewed representatives of the Vietnam Plastic Association and some plastic experts in Ho Chi Minh City.

3.1. Tung Vinh Limited Company

This is a company with 100 percent domestic capital. Established in September 2002, its factory is located at 26/11 Tran Van Muoi, Xuan Thoi Dong Commune, Hoc Mon District, Ho Chi Minh City. The main products of the company include tarpaulins, packaging materials, plastic coating and advanced paper classes, among others.

From its inception, the company has used 100-percent machines imported from Japan, which are modern ones and highly automated. The company has applied a strict procedure of maintenance to ensure that their machines always operate perfectly and products are always of high quality. The activities of innovating and upgrading technology of the company are mainly processing techniques and upgrading of workshop and working environment. The company also applies a very strict system of controlling quality. The control and monitoring staffs continuously checks threads each hour and make reports each day.

The products of the company are endorsed or guaranteed by Vietnam Maitai Limited Company. Maitai is a company with 100 percent foreign capital and belongs to a big corporation in Japan. It is located at Tan Thuan Processing Zone in Ho Chi Minh City. It has a cooperative relationship with Tung Vinh from time the latter has started to operate. According to Director Ngo Chanh, the relationship between the two companies is very close. Matai Company usually appoints its staffs to visit, check the quality and guide Tung Vinh in developing new products. Maitai Company also helps Tung Vinh in training its staff and building a system for controlling product quality. Maitai also introduces and provides input materials to Tung Vinh.

3.2. Viet Nhat Phu Packaging Joint Stock Company (VNP- Pack JSC)

Established in 2006, it is a company with 100-percent domestic capital. Its physical location is in F12/4 Hamlet 6, Vinh Loc A, Binh Chanh District, Ho Chi Minh City. The company is a designer and manufacturer of modern packaging materials and is comprehensively involved from the initial models to the final products.

The functional activities of the company are as follows:

1. Specializes in manufacturing and providing pallet papers, corner rods by paper that protects interior products and are used for imported products in many aspects such as woodwork, ceramics, electrics, and garment for exporting. In addition, it also provides stretch films, belt laces, product packaging and air bags.
2. Manufactures business papers, plastic materials and plastic packaging
3. Specializes in designing and printing advanced packaging which is used in

industries such as confectionery, coffee, beer, wine, soft drink, gift, promotional materials, (paper, plastic, compress carton).

4. Designs and prints many kinds of desk calendars and wall calendars, catalogs, brochures and flyers

The main customers of the company are enterprises operating locally such as food processing companies and producers of consumer goods such as pottery, glazed terra-cotta and woodwork. From 2008, the company has started to export some of its products to Thailand and Malaysia.

The company uses advanced printing technologies from Germany and Japan and combines these with mechanical machines from Vietnam and China. The company also uses precise checking equipment from Germany and Japan to ensure product quality.

The company has continuously changed models and improved product quality. Based on demand for similar products in the local market and based on available technologies, the company has designed and manufactured many high-quality products that have satisfied customers' demands.

According to its director, the company is also aware of upgrading technologies and improving management system. Information sources of innovation are collected both locally and overseas through direct visits, seeking specialist opinion and learning from other companies.

3.3. Nhat Tien Trading and Manufacturing Limited Company

An enterprise with 100-percent domestic capital, its factory is located at C5 Lot, Duc Hoa Plastic Industrial Zone, Duc Hoa District, Long An Province. The company has more than 300 staff. It main products are plastic baskets, plastic flasks, plastic bottles, construction components (kinds of bearing) and products for the farming and horticultural industries (e.g., flowerpots, breeding facilities). The main customers of the company are enterprises manufacturing chemicals and medicines for veterinary use and farms all over the country.

The company mainly uses machines and materials from Taiwan with casting and flushing plastic as the main technology. Although the machine system is not modern, the company always endeavors to innovate and enhance the quality and mode of products with the aim of meeting all requirements of customers. Recently, the company has used a new electric system that reduces material expenditure and a new technology for supplying materials to help staff do their job easier.

Realizing the high demand of the Vietnam breeding industry, the company has done early research on and manufactured and brought to the market some plastic products for breeding facilities with better properties compared to traditional materials. Aside from manufacturing plastic products for raising cattle and poultry, the company has recently introduced new plastic products for the honeybee breeding industry with many advantageous features.

The company is using the ISO 9001:2000 system for ensuring quality and managing the enterprise comprehensively and strictly. This is in view of its objective to continue bringing out products with the best quality, exactly like what its business guideline says: “Access customers by quality”.

3.4. Ly Xuan Lan plastic manufacturing and trading limited company

Its forerunner is a small manufacturing establishment set up in 1982. The current manufacturing plant is located at Tran Dai Nghia Street, Binh Chanh, Ho Chi Minh City.

The company has 130 staff and its main products are plastic pipes, ribbed pipes, small-sized net pipes that are used for supplying and draining water in family homes and supplying gas and liquid air, and colorful plastic polyvinyl chloride (PVC) plastic grains. These products are mainly consumed in the local market and a small percentage is exported to Cambodia.

Although it is a small manufacturing establishment with relatively backward and asynchronous machines and equipment, the company strives to upgrade them in order to diversify its products, improve production processes and come up with better quality products that suit the demand in the market. According to its director, Ly Xuan Lan, the company usually conducts visits of other manufacturing companies to be exposed to other technologies and attends local and international fairs to learn about new products and processes. This helps the company to position itself in the market.

These days, the company is facing stiff competition from China which offers cheaper products. The company has tried its best to upgrade its equipment, improve product quality and reduce production cost. However, due to the small size of its manufacturing plant and its asynchronous machines, the company has faced many difficulties in innovation and upgrading. Thus, in 2007, the company decided to build a new factory in Vinh Long. It also planned of replacing all of its machines and equipment with new ones that use Taiwanese and Italian technologies. It is estimated that the new factory will start to operate this year. With the new factory, the company also plans to expand its market and export products to Laos, Thailand and some African countries. Asked about his comments on the connection and innovation between the local enterprises, Director Ly Xuan Lan said that this aspect is still weak, the associations and related organizations operate ineffectively, and information exchange between enterprises is also still very restricted.

3.5. Lotus

A company in Ho Chi Minh City with 100-percent foreign capital, it is owned by a Vietnamese businessperson with German nationality. From a small limited company engaged in technology transfer, Lotus has steadily expanded and now has three subsidiary companies operating in three specific aspects namely, technology transfer, manufacture of plastic packaging, and manufacture of plastic components for water and construction industries. The process of innovation and development of Lotus Company can be summarized as follows:

- In 1989, Lotus Pitching Technology Limited Company was established with technology transfer in plastic and packaging industries as its main operation.
- In 1996, Lotus started to manufacture packaging products for export and became one of leading enterprises in Vietnam. In October 2004, Lotus joined RKW Corporation, one of the leading corporations that manufactures films and fibers in Europe, with the aim of combining their forces to become the leading suppliers in the Asia-Pacific region.
- In 1997, Hai Phong Lotus Factory started to manufacture and provide PVC grains and flours replacing imported goods and servicing the industry manufacturing plastic pipe and flat. With this operation, Lotus was able to access and seize the demand of the water and construction industries in Vietnam, investing in developing business in new manufacturing aspects.
- From 2000 to the present, Lotus has expanded its manufacturing and business activities and is also engaged in product diversification. The company is now focusing on developing sanitation products such as disposable nappies and sanitary napkins.
- The plastic packaging products of Lotus has mostly been exported to the European market. Its exports account for 80 percent of the total production capacity of the company. To sustain this success, the company has continuously been pursuing innovations in terms of equipment and application of modern technology with the aim of increasing its competitiveness in production cost and quality vis-à-vis Thailand, Malaysia and China. In the service aspect, the

company has continuously upgraded the quality of service from small things like replying to email inquiries within 24 hours to the use of English by all departments and staff in business transactions.

At an early stage, the company has applied for standard system ISO 9001:2000 to control all procedures in technology transfer and service as well as its manufacturing and trading activities.

The business guideline being followed by the company is to always try its best to cooperate, study, innovate, apply new methods and technologies, and update backward ideas and technologies.

3.6. European Building Material (EBM) Company

"European quality for Vietnamese houses” is the slogan of EBM. Established in 2005 and operating in Ho Chi Minh City, it is a company with 100-percent foreign capital and belongs to ASG Corporation–Poland. It specializes in manufacturing advanced building materials using European technologies. The main products of the company currently include PVC advanced plastic doors having consolidated steel core and windows made of INOUTIC bar imported from Germany.

EBM door products are manufactured at the EBM factory located in Nhon Trach 3 Industrial Zone, Dong Nai Province. The factory is equipped with advanced, comprehensive, highly automated machine and equipment produced by leading firms in the world such as URBAN and RAPID (Germany). Important components are mostly imported from Europe.

The system of controlling product quality of the company is assessed and granted with certificate ISO 9001:2000 by Bureau Veritas (England). All products of the company are strictly controlled and monitored to ensure that they reach European quality standards.

EBM door products have been certified to have passed European quality standard and have received many awards in Vietnam such as Gold Cup of Vietnamese brand integrating WTO, Gold Cup of the Vietnamese building industry, and Gold Medal of product quality.

Although a newly established company, EBM always tries its best to innovate and diversify its product line to expand its market coverage. The company always strives to provide excellent customer service such as in the aspect of technical support in installation and design. It also invests in equipment and continues to enhance its design ability in order to produce products that also suit the taste of the Vietnamese market. Each year, the company sends staff to Europe to study and it also invites local and foreign experts to directly guide and train its staff.

3.7. Binh Dong Hung plastic machinery Company (BPM)

A company with 100-percent domestic capital, it was established in February 1992. Its factory is located at 275B Phan Anh – Binh Tân, Ho Chi Minh City. BPM has over 15 years of specialized experience in producing materials for the plastic manufacturing industry and the light industry.

The company currently has over 50 staff with a high level of technical expertise. The main products of the company are producing equipment, machines (such as mixing machine, pushing machine, fuel providing system), patterns for plastic manufacturing industry, and conversion technologies for manufacturing plastic (PVC in particular). The main customers of the company are local enterprises operating in Ho Chi Minh City and neighboring local industries, which provide 70 percent of the company's total revenue.

The company has a team of experts; mostly professional engineers in manufacturing plastic equipment. It also has a team of freelancers who are experts and professors in universities and in technological and engineering companies in Vietnam and overseas. These freelancers provide support in engineering and methods.

BPM has a factory with a small space, but it is arranged scientifically and sufficiently with advanced machines imported from big companies in Japan (CNC Bed), Germany and China. These machines have electric and mechanical components that have a high degree of precision thus ensuring that final products are of excellent quality.

BPM also applies the most advanced standards of managing the quality of its products. The KCS department is sufficiently equipped with advanced checking equipment and follows a strict quality checking system.

Although it is already a leading company in manufacturing equipment and machines in the plastic industry, its board of managers is aware of the need for continuous innovation and creation. Each year, the company sends its staff overseas to visit, study and collect technical documents and participate in trade fairs. The products of the company are made using advanced technologies from overseas which are also regarded as suitable for the manufacturing situation in Vietnam. Some products have been assessed highly in terms of innovation and technology creation such as its tube expanding machines which are used in the production line of plastic tubes.

The company also has a close relation with customers. It usually appoints engineers to guide customer in using and maintaining equipment and also performs periodic consultation with customers. According to Nguyen Minh, the company director, the ideas and demands of customers are the most valuable motives of the company to continuously innovate and bring out products suitable to the needs of the market.

3.8. Dat Hoa Company

This company is a manufacturing enterprise established in 1978 in Ho Chi Minh City. Initially just a small manufacturing establishment under the name Dat Hoa Limited

Company, it was officially established in 2003 as Dat Hoa Plastic Company with a charter capital of VND 600 million. Of late, the charter capital has increased to VND 55 billion.

Currently, Dat Hoa Plastic Company specializes in manufacturing and providing plastic products for the water supply and drainage industry within Vietnam and overseas. In addition, the company also manufactures some products for building, refrigeration and interior decoration such as net tubes and ceiling straps.

Important factors that determine its production technology include product quality and product competitiveness in the market. Dat Hoa Company continuously invests in modern automated equipment imported from Germany, Korea, Taiwan and China. The company also continuously reinforces association and joint ventures with economic organizations to expand its market. From an initial factory in Binh Tan District, Ho Chi Minh City, the company has opened two new factories, one in Vinh Phuc Province (operational in 2003) which supplies the north market, and one in My Phuoc II Industrial Zone, Binh Duong Province (operational at the end of 2008), its biggest factory occupying a land area of 60,000 m^2. The product supply system of the company is also spread all over the country.

Dat Hoa Company critically applies advanced management systems. In August 2002, it was granted the certificate of quality management system according to standard ISO 9001:2000 by Quacert organization.

Working around the principle “satisfy all demands of customers”, Dat Hoa Plastic Company is always active in studying the market to ensure its products meet the demands of its customers.

Thus, products with trade mark VINA – DAT HOA have always received the appreciation and support of customers in recent years. It is expected that this pleasant reception will continue in the coming years, considering that its products have been known to be of high quality as also evidenced by the Gold Cup of Vietnam Construction Industry award it received. The company continues to strive in making innovations to maintain the trust of its customers and its position in the market.

3.9. Hanoi Plastic Stock Company (HPC)

HPC used to be Hanoi Plastic One Member State Limited Company. Its forerunner is the Hanoi Plastic Branch House which was under the Ministry of Light Industry. It was established in January 24, 1972 and now has nearly 500 staff.

It specializes in manufacturing plastic products for the domestic market and produces patterns for the production of these products, previously using pressure injection technology as its main technology for production. Being an old technology, it had led to low quality and low capacity of production. Thus, HPC has endeavored to continue implementing innovation in technology and methods of production management and its efforts have paid off as it is now one of the strongest brands. From 1995, the company has focused on manufacturing industrial products with high quality by improving the quality and design of its plastic patterns, enhancing plastic processing technology and improving management system. This development strategy stirred the potentials of HPC and helped it to become a significant company in the plastic manufacturing industry in Vietnam.

Hanoi Plastic Company has two main departments. One is involved in pressing plastic and the other produces patterns; both use advanced machines and equipment. From 1998, the company has continuously invested, installed modern production lines, and applied automatic technology into production. Equipped with a complete machine system from Western Europe, United State and Japan and staffed with engineers who are skilled, experienced and have the ability to use automatic technology proficiently, the company has manufactured hundreds of plastic products using advanced technology for the domestic and foreign markets thereby satisfying local demand for imported goods and strengthening export turnover at the same time.

Plastic products manufactured by the company have complicated structures and a high degree of accuracy but are cheaper. Production time is also shorter. These aspects render its products the ability to compete strongly in the domestic and foreign markets. Products are manufactured using imported materials and automated machine system and advanced technologies which are controlled and maintained according to international standard of quality ISO 9001:2000. They have a high quality according to the standard of Japan JIS 10K. These products are used in the motorbike and car industries, electricity and electric communications industry and as materials and equipment for construction. The company is now supplying products to many local companies and big foreign companies such as Honda, Ford, Tostem, Hashimoto, Shoden and Sanko.

The company has built a department that manufactures patterns. It is staffed by an engineering force that utilizes professional software such as AutoCAD, CAD/CAM/CAE to design and program for CNC processing centers and modern CNC electric shock machine. Along with the design and production of frames for its own needs, the company also designs and manufactures frames that are complicated and require a high degree of accuracy. These frames are supplied to customers such as Honda Vietnam, Sanko Japan, Shoden Japan, Asian Plastic Company, Hoa Phat Refrigeration Company and soon it will also be supplying plastic products to Toyota Vietnam.

4. ANALYSIS

4.1. Statistic Analysis

Interviewees highly evaluated the role of upgrading in design in the plastic sector. All 10 firms confirmed the “significant change in packaging or appearance design”. It was considered the most important factor for innovation and upgrading in the last three years. They upgraded their design and packaging based on customers' orders. Most of the customers were foreigners. Only a few interviewees mentioned the domestic market. "Significant improvement of an existing product/service" and "development of a totally new product/service based on the existing technologies" were implemented by all 10 firms.

There were only 4 out of 10 firms that responded 'yes' to most of the subquestions in Q11, which consisted of improved existing machines, equipment or facilities, and introduced new know-how on production methods.

For manufacturing, there were only five firms that have reduced raw materials and energy, while more firms have decreased defective products, and only four firms were concerned about the decrease in inventories.

Table 3 Plan or Achievement in Innovation of Interviewee Firms

Indicator	Yes
1. Decrease defective products	8/10
2. Decrease inventories of products	4/10
3. Reduce raw materials and energy	5/10
4. Reduce labor input	2/10
5. Improve quality of goods or services	4/10
6. Improve flexibility of production or service provision	8/10
7. Reduce lead time to introduce a new product or service	3/10
8. Enter new markets or increase market share in the domestic market	4/10
9. Enter new markets abroad or increase exports	5/10
10. Reduce environmental impacts caused by factory operations (noise, waste disposal, etc.)	3/10
11. Meet regulatory requirements on products.	9/10

Source: Authors.

R&D activities were not so important for enterprises. There were only two out of 10 firms that have their own R&D department. They also did not need to subcontract or outsource for their factory.

There were only five firms that manufacture products according to design, specification, or drawings made by their establishment. Focusing on exporting and packaging plastic products, most of the firms have adopted ISO, but only half of them applied QM (quality management) or QC (quality control). Only one firm is producing products using its own design or specification (ODM or original design manufacturer and OBM or original brand manufacturer) and four firms are OEM or original equipment manufacturers. Only two firms used computer-aided design, manufacturing or engineering (CAD, CAM or CAE)) for enhancing technical design capability and built a just-in-time (JIT) system of delivery.

Table 4 R&D Activities

R&D expenditures	Yes
Does your establishment incur R&D expenditures at present?	2/10
Does your establishment subcontract or outsource R&D at present?	0/10
Does your establishment have R&D facility, R&D center or R&D department?	2/10

Source: Authors.

In terms of training system, only two firms have an on-the-job training (OJT) program and an off-the job training (OFF-JT) program for workers. Although workshops and seminars were conducted frequently, many firms did not pay much attention on providing theory training for their staff.

Table 5 Technical capabilities

Technical capabilities	Yes
1. Does your establishment manufacture products according to design, specification, or drawings made by your establishment?	5/10
2. Does your establishment have CAD, CAM or CAE (Computer-Aided Design, Manufacturing, Engineering)	2/10
3. Is your establishment an OEM (Original Equipment Manufacturer)?	4/10
4. Is your establishment an ODM (Original Design Manufacturer)?	1/10
5. Is your establishment an OBM (Original Brand Manufacturer)?	1/10
6. Has your establishment adopted ISO 9000, 14000 series or other international standards?	9/10
7. Has your establishment operated QM (Quality Management) or QC (Quality Control) circle activities?	5/10
8. Has your establishment adopted just-in-time delivery	2/10
9. Does your establishment have an on-the-job (OJT) training program for workers?	4/10
10. Does your establishment have an off-the job (OFF-JT) training program for workers?	2/10

Source: Authors.

4.2. Motivation for Innovation and Upgrading

The plastic industry in Vietnam is guided by the private economic sector which focuses on manufacturing packages that are mostly for export. There are a few enterprises taking part in manufacturing network of multinational corporations in the process aspect.

Innovation and upgrading process of plastic enterprises take place based on customers' demands. Enterprises have still not been aware and active in this process. They have not been aware of the need for continuous upgrading and innovation.

The good prospects of plastic enterprises rest on manufacturing packaging products with higher quality for industries such as health and cosmetics. Examples would be medicines with plastic packages having high quality and beautiful styles and colors. This outlook is being considered by many enterprises. Many are also turning to the aspect of manufacturing small industrial details and components. Some interviewed enterprises have considered supplying to process industries because they are aware of the long-term profit and they can also increase the value of their own products. However, information on this area is too little in Vietnam.

Different from the motorbike enterprises in Hanoi, the plastic enterprises mainly supply the overseas markets. Majority of plastic enterprises manufacture packaging products for export, supplying retail or trade firms. Innovation of products is an essential requirement to Vietnam's plastic enterprises to meet customer demand for new product models. However, innovation usually happens on a case-to-case basis and is not part of the regular operations of enterprises like plastic enterprises. Due to the particular characteristics of plastic packaging products, upgrading and innovation activities are mostly based on demands of design and are not directly related to technical matters. These activities are also mainly based on customers' demands which explain the reason why they have not been actively pursued by the local enterprises.

Most new plastic enterprises are in the beginning stage of innovation and upgrading. Some enterprises have started to manufacture plastic components for other branches such as motorbike, home appliance and automotive industry. Enterprises have had growth steps gradually like motorbike enterprises. For the remaining enterprise, due to the characteristics of manufacturing plastic packaging for export or construction for domestic demand, innovation activities have not had detailed long-term strategies. Few enterprises are not aware of the importance and effects of innovation on their own enterprises.

Many plastic packaging manufacturing enterprises have succeeded in the market and this success can continue through market expansion and developing more advanced and better quality products. But enterprises relate that profit remains very low and increasing concerns regarding the environmental impacts of plastic products are affecting the industry. However, Vietnam still has many opportunities for improvement and development, including manufacturing products that are environmentally friendly.

Admittedly the market for plastic components in Vietnam is still too young and weak and enterprises are hesitant to consider expanding their business. The success of exporting plastic packaging is a main barrier for innovation in becoming suppliers for other manufacturing firms.

4.3. External Support

VPA and Ho Chi Minh Plastic Association show the role of profession associations relatively well. This is a different point compared with the motorbike industrial branch in Hanoi. This is a general characteristic of associations with members that are private enterprises in Vietnam. The interviewed enterprises mentioned the following main supporting activities of VPA:

International fairs. Due to the import-export activities, the role of plastic associations is clearly demonstrated and enterprises have appraised their function to be relatively good. Plastic packaging exporting enterprises highly appreciate the role of VPA. In 2009, VPA facilitated the participation of enterprises in the Tiprex International Plastic-Packaging Fair which took place in Bangkok, Thailand, from 23 to 26 September 2009. Through VPA, 10 Vietnam plastic enterprises participated in the Tiprex Fair 2009 to display their products. In addition, the VPA team also had 50 members from more than 30 enterprises along with the team visiting and accessing new machine technologies. The Vietnam plastic fair, Vietnamplas 2009, was also organized by VPA. It was conducted on 22 to 25 October 2009 at Phu My Hung Fair Center, Ho Chi Minh. It was participated by many plastic enterprises. More than 250 kiosks had displays of machines, equipment of plastic branch, additives, and chemical substances. Enterprises displayed their plastic products including plastic components. In 2009, VPA also supported enterprises to attend the biggest plastic fair in Asia, Chinaplas 2009, held in May 2009 in Quangzhou, China. VPA had the participation of more than 120 members from nearly 80 enterprises all over the nation.

Training: In 2009, VPA held three training courses on plastic materials and additives, operating and servicing, maintaining thermal plastic equipments, production management towards reducing costs in production, recycle technologies, transfer technologies, manufacturing soft and soldering packaging, and packaging printing technologies. These training courses attracted nearly 20 trainees. They are one of VPA's annual activities that are highly appreciated by the interviewed enterprises.

Trading support. On 31 March 2009, American companies submitted a petition to the US Department of Commerce (DOC) to sue Vietnamese enterprises for devaluation and provision of subsidies for their PE carrier plastic bags. According to documents provided by DOC, the list of defendants included nearly 50 enterprises. VPA established an appeals committee to support the enterprises involved in the case. They include nine members, three of which are members of the Association and the rest are representatives of domestic and foreign-owned enterprises.

5. CONCLUSION AND POLICY IMPLICATIONS

This study has revealed a number of important points.

(1) The government needs to orient and guide the plastic industry to move towards supplying products, details and component parts for manufacturing industries such as motorbikes, electronics, home appliance and automotive industry.

(2) The government should continue to attract foreign investments into Vietnam particularly in aspects related to manufacturing plastic details and component parts.

(3) The government should come up with methods to encourage plastic enterprises to shift investments and production operation to manufacturing component parts for other industrial branches. At present, even the VPA is not aware of the potential of this aspect. The government should also come up with policies on

tax incentives or preferential treatment on land, workshop and labor cost for enterprises that manufacture plastic additives for industrial branches.

(4) For developing macro policies for nations in the ASEAN area, it is necessary to have a detailed assessment of each industrial branch. For example, for the plastic branch, it is necessary to examine the relationship between branches in each area. Then, for each area, there are also national inter-area polices about the development of these industrial branch groups.

REFERENCES

IPSI (2009) *Impact of MNCs on Development of Local Small and Medium Size Industrial Enterprises in Vietnam*, MOIT Research Project 2009.

Kimura, F. (2008) "The Mechanics of Production Networks in Southeast Asia: The Fragmentations Theory Approach," in Ikuo Kuroiwa and Toh Mun Heng (eds.) *Production Networks and Industrial Clusters: Integrating Economies in Southeast Asia*, IDE-JETRO and ISEAS, 33-53.

Ministry of Industry (2007) *Master Plan on Developing of Supporting Industries in Vietnam until 2010, Vision of 2020*, Hanoi.

Truong Chi Binh (2008) "Factors of Agglomeration in Vietnam and Recommendations," in Ariff M. (ed.) *Analyses of Industrial Agglomeration, Production networks and FDI Promotion*, ERIA Research Project Report 2007, Vol. 3, 155-190.

VDF (2007) *Building Supporting Industries in Vietnam*, Ohno K. (Chief editor), VDF-GRIPS.

VPA (2009) *Annual Report 2009*.

7

Empirical Analysis of Information Linkages and Capability in ASEAN Economies: Case of Indonesia, the Philippines, Thailand and Vietnam

Masatsugu Tsuji and Shoichi Miyahara

Abstract

This paper refers to the channel by which a donor transfers technology to a recipient as "Linkage," which connects MNCs or large firms with local firms. This paper attempts to identify (i) effective information linkages and (ii) the capability or potentiality of respondents for innovation, which is termed "Innovation Capability." The linkages themselves are not necessary conditions for achieving innovation and upgrading, since information convoyed through them is useless if the recipients do not possess the capability or potentiality to convert it to applications or innovations. We conducted comprehensive surveys in four ASEAN economies (Indonesia, the Philippines, Thailand and Vietnam), and received approximately 700 responses. The surveys contained questions on information linkages required for innovation and on the sources of information such as university, public agencies, industry/trade organizations, and public R&D institutions as well as MNCs. As a result, MNCs were identified as important sources which transmit information through not only production but also human linkages. With regard to necessary capability for connecting linkages, we identified ODM, OBM and patent rights for the MNCs linkages, and patent right for the public institutions. Lastly, this paper calculates probability of particular capability for firms to connect with MNCs and public institutions, and these are patent rights, top management who have experience working in MNCs, engineers with the level of college graduates, and granted licensing technology for the MNC linkage.

1. INTRODUCTION

Recent economic development in the East Asian economies, termed the "Growth Center of the Global Economy," was achieved by the fact that the area became the "Factory of the World." The explosion of economic growth was initiated by MNCs (Multinational Corporations), which since the middle of 1980s have established branch headquarters and factories in the area to exploit the relatively cheap natural resources such as labor, land and raw materials. The MNCs combined these resources with in-house technologies, including business management as well as engineering. Ongoing agglomeration of MNCs has seen them invite affiliated firms to also establish themselves in neighboring areas. In addition, local firms have emerged as a result of technology transfer from MNCs, and these are promoting further agglomeration. The results of this process have transformed the areas into industrial clusters. The formation of clusters in turn leads to the greater flow of information, which initiated further transformation of the areas, namely the upgrading of the areas from production bases to innovative areas.[1]

Transformation to innovative economies requires qualitative changes, which local firms have to cope with by upgrading themselves. One of the factors which has made this possible is the transfer of technology from MNCs and other large firms. Technology transfer is achieved by a number of different forms or transmission mechanisms. This paper refers to the channel by which a donor transfers technology to a recipient as "Linkage," which connects MNCs or large firms with local firms. In Tsuji and Miyahara [2010], linkages were described as consisting of the following: (i) production linkages; (ii) research linkages; and (iii) human linkages. Production linkages indicate that information related to innovation is convoyed through market transactions. This consists of the "Forward" and "Backward Linkages": the former represents technology which is transferred from customers to firms, and the latter from suppliers to firms.[2] A typical example of the former is the hierarchical production

---

[1] An epoch-making event symbolizing this was Toyota Motor Corporation's announcement that it would establish an R&D center in a suburb of Bangkok.

[2] Theoretical as well as empirical research has been conducted to establish fundamental theories or to identify such linkages. For more analysis of linkages, see, for instance, Amara and Landry (1999), Vega-Jurado, Gutiérrez-Gracia, Fernández-de-Lucio, and Manjarrés-Henríquez (2008), and Frenz and Ietto-Gillies (2009). Among them, Javorcik (2004), and Blalock and Gertler (2008) found that backward linkage impacts productivity upgrading for upstream suppliers that occur from customers of MNCs. Most recently, Machikita and Ueki (2010a), (2010b) provided new evidence that the impact of knowledge flows through forward linkages as well as backward linkages. In the context of this paper, the main issue is to verify that firms with a greater variety of linkages achieve more innovations.

structure of the Japanese automotive industry. The automotive assemblers provide cutting-edge technology to their suppliers through blueprints, or by sending their engineers to teach and train the engineers of the suppliers. They often have joint projects to apply new technologies. Suppliers also spontaneously develop new technology by themselves in the process of parts production. An example of backward linkage is found in the case of a firm which purchases new machines and equipment, and then develops new products by making full use of them.[3] Firms can obtain new technologies through universities or other public R&D institutions, which are examples of research linkage. Human linkages are the transfer of new technologies via top management and senior engineers.

The linkages themselves, however, are not necessary conditions for achieving innovation and upgrading, since information convoyed through them is useless if the recipients do not possess the capability or potentiality to convert it to applications or innovations. In this paper, we term this "Capability" or "Innovation Capability," indicating the ability to absorb new information, including that related to technology, management, marketing, or the market, and integrate them to achieve innovation. Innovation capability is thus related to both the current or potential level of technology and that of engineers or employees, which can be measured by their current situation. If firms have already applied for patents, then it is reasonable to consider they have higher technological ability. If their engineers have earned higher engineering degrees such as MS or higher, they have high potentiality of new technologies. In this paper, we construct several measures to indicate the innovation capability of firms, on the basis that innovation is actually the joint result of information linkage and capability. Without both, innovation is hard to be achieved.

In Tsuji and Miyahara (2010), linkages in four ASEAN economies were widely

[3] Machikita and Ueki (2010) showed forward linkages are important of innovation, while backward are not.

analyzed based on survey data, which was also used to examine innovation capability. The aim of the present paper is to identify the level of innovation capability of these four ASEAN economies. The paper consists of six sections. Section 2 provides the results of a survey conducted in the four economies and shows current status of innovation and the sources of information which allow the realization of innovation. In Section 3, the analytical methodology and estimation models used to identify the linkages which contribute to achieving innovation are presented; and in section 4, similarly models are examined with regard to capability. Section 5 incorporates the analyses in the previous two sections, since it is the linkages and capability together which matter to innovation. In this section we extract those factors which jointly affect innovation, and calculate how they actually contribute to performing innovation. Brief concluding remarks are provided in the final section.

2. SURVEYS AND DATA

Firstly, we present here the result of a survey conducted in November and December 2009 in the four ASEAN economies of Indonesia, the Philippines, Thailand and Vietnam, which is the basis of the analysis in this study.

2.1. Product Innovation

This survey aimed to obtain fundamental data on the innovation activities as well as innovation performances of respondents. Innovation is categorized into two types, product and process innovation, but in accordance with the questionnaire, this paper examines only product innovation. Product innovation was classified into the following four types in the questionnaire.

1. *What has your establishment achieved among the following?*

(a) Significant change in packaging or appearance design

(b) Significant improvement of an existing product/service

(c) Development of a totally new product/service based on existing technologies

(d) Development of a totally new product/service based on new technologies

Schumpeter defined the supply of new products or services as examples of product innovation, but this paper adopts more detailed categories. From (1.a) to (1.d), the categories represent an increasingly higher level of innovation; that is, the survey started from the simple improvement of existing products/services and extended to the creation of entirely new products based on new technology. The distribution of product innovation in different economies is summarized in Table 1 and Figure 1. Unlike the findings of two previous surveys, which found little innovation, the present survey indicated that firms in each economy have improved their achievement of innovation.

Table 1 Product Innovation

	Indonesia		Philippines		Thailand		Vietnam		Total	
	freq.	%	freq.	%	freq.	%	freq.	%	freq.	%
Significant change in packaging or appearance design	95	68.35	102	50.25	41	42.71	237	79.00	475	64.36
Significant improvement of an existing product/service	114	82.01	152	74.88	74	77.08	278	92.67	618	83.74
Development of a new product/service based on the existing technologies	102	73.38	113	55.67	60	62.50	234	78.00	509	68.97
Development of a new product/service based on new technologies	94	67.63	103	50.74	53	55.21	162	54.00	412	55.83

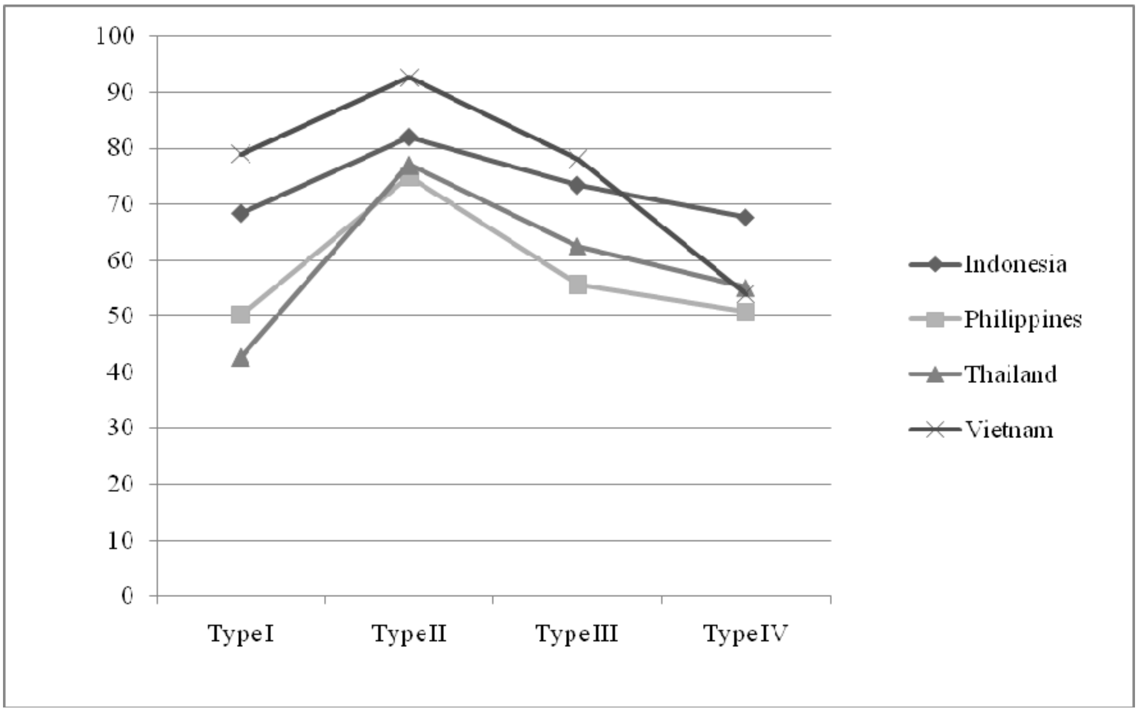


Figure 1 Product Innovation

Notes: Type I Significant change in packaging or appearance design)
Type II Significant improvement of an existing product/service
Type III Development of a new product/service based on the existing technologies
Type IV Development of a new product/service based on new technologies

2.2. Characteristics of Respondent Firms

Table 2 indicates the distribution of firms by the year of establishment, showing that the largest number of firms is aged 11-20 years old, except for Vietnam, which has younger firms. Table 3 shows the type of establishment, indicating that factories/plants account for more than 50% in each economy, followed by headquarters/main office, and that these two categories account for more than 90% of the total. The capital structure of firms is shown in Table 4, indicating that most are locally owned. Tables 5 and Table 6 show the size of SMEs in terms of employment and capital, respectively. The former shows that more than 50% of firms have fewer than 199 employees, while the latter shows a different distribution, namely firms with more than US$100,000 are dominant. Thus the respondents consisted primarily of larger firms. Table 7 shows the distribution of categories of industry to which the SMEs belonged. Each economy had a different distribution: in Indonesia and the Philippines, light industries such as food, beverages, and tobacco or apparel were major, while Thailand and Vietnam had assembly and processing industries such as automobiles and machinery as the largest categories.

Table 2 Years since Establishment

	Indonesia		Philippines		Thailand		Vietnam		Total	
	freq.	%	freq.	%	freq.	%	freq.	%	freq.	%
0 - 10	39	29.77	48	23.65	18	21.18	157	52.51	262	36.49
11 - 20	39	29.77	101	49.75	31	36.47	100	33.44	271	37.74
21 - 30	33	25.19	30	14.78	17	20.00	19	6.35	99	13.79
31 - 40	16	12.21	15	7.39	12	14.12	16	5.35	59	8.22
41 - 50	3	2.29	7	3.45	3	3.53	6	2.01	19	2.65
over 50	1	0.76	2	0.99	3	3.53	1	0.33	7	0.97
Total	131		203		85		299		718	

Table 3 Type of Establishment

	Indonesia		Philippines		Thailand		Vietnam		Total	
	freq.	%	freq.	%	freq.	%	freq.	%	freq.	%
Headquarters/Main office	50	35.97	20	9.85	38	40.00	97	32.33	205	27.82
Regional Headquarters	3	2.16	1	0.49	3	3.16	4	1.33	11	1.49
Factory/Plant	78	56.12	182	89.66	46	48.42	197	65.67	503	68.25
Branch Office/Sales Office	8	5.76	0	0.00	8	8.42	2	0.67	18	2.44
Total	139		203		95		300		737	

Table 4 Capital Structure

	Indonesia		Philippines		Thailand		Vietnam		Total	
	freq.	%	freq.	%	freq.	%	freq.	%	freq.	%
100% Local-owned	109	79.56	101	49.75	60	63.16	231	77.00	501	68.16
100% Foreign-owned	12	8.76	54	26.60	13	13.68	54	18.00	133	18.10
Joint Venture	16	11.68	48	23.65	22	23.16	15	5.00	101	13.74
Total	137		203		95		300		735	

Table 5 Number of Full-time Employees

.	Indonesia		Philippines		Thailand		Vietnam		Total	
	freq.	%	freq.	%	freq.	%	freq.	%	freq.	%
1 - 19 persons	1	0.72	13	6.40	12	12.77	43	14.33	69	9.39
20 - 49	64	46.38	31	15.27	21	22.34	60	20.00	176	23.95
50 - 99	21	15.22	42	20.69	9	9.57	42	14.00	114	15.51
100 - 199	16	11.59	38	18.72	12	12.77	56	18.67	122	16.60
200 - 299	1	0.72	22	10.84	8	8.51	26	8.67	57	7.76
300 - 399	0	0.00	9	4.43	5	5.32	18	6.00	32	4.35
400 - 499	5	3.62	5	2.46	6	6.38	15	5.00	31	4.22
500 - 999	11	7.97	23	11.33	10	10.64	21	7.00	65	8.84
1,000 - 1,499	2	1.45	6	2.96	4	4.26	11	3.67	23	3.13
1,500 - 1,999	5	3.62	6	2.96	0	0.00	3	1.00	14	1.90
2,000 and above	12	8.70	8	3.94	7	7.45	5	1.67	32	4.35
Total	138		203		94		300		735	

Table 6 Size of Firms (Capital)

Unit: US$

	Indonesia		Philippines		Thailand		Vietnam		Total	
	freq.	%	freq.	%	freq.	%	freq.	%	freq.	%
Less than 10,000	4	4.65	3	1.48	1	1.28	29	9.67	37	5.55
10,000 - 24,999	9	10.47	6	2.96	1	1.28	26	8.67	42	6.30
25,000 - 49,999	6	6.98	11	5.42	3	3.85	22	7.33	42	6.30
50,000 - 74,999	10	11.63	9	4.43	2	2.56	19	6.33	40	6.00
75,000 - 99,999	4	4.65	6	2.96	3	3.85	15	5.00	28	4.20
100,000 - 499,999	13	15.12	28	13.79	15	19.23	33	11.00	89	13.34
500,000 - 999,999	11	12.79	32	15.76	11	14.10	38	12.67	92	13.79
1 million - 4.9 mil.	11	12.79	42	20.69	15	19.23	56	18.67	124	18.59
5 mil. - 9.9 mil.	3	3.49	26	12.81	8	10.26	25	8.33	62	9.30
10 million and above	15	17.44	40	19.70	19	24.36	37	12.33	111	16.64
Total	86		203.00		78		300.00		667	

Table 7 Category of Industry

	Indonesia		Philippines		Thailand		Vietnam		Total	
	freq.	%	freq.	%	freq.	%	freq.	%	freq.	%
Food, beverages, tobacco	29	21.17	34	17.09	5	5.88	19	6.33	87	12.07
Textiles	11	8.03	2	1.01	6	7.06	20	6.67	39	5.41
Apparel, leather	11	8.03	22	11.06	0	0.00	3	1.00	36	4.99
Wood, wood products	11	8.03	11	5.53	3	3.53	9	3.00	34	4.72
Paper, paper products, printing	15	10.95	5	2.51	5	5.88	9	3.00	34	4.72
Coal, petroleum products	1	0.73	0	0.00	1	1.18	2	0.67	4	0.55
Chemicals, chemical products	9	6.57	11	5.53	6	7.06	12	4.00	38	5.27
Plastic, rubber products	4	2.92	15	7.54	5	5.88	39	13.00	63	8.74
Other non-metallic mineral products	0	0.00	8	4.02	2	2.35	3	1.00	13	1.80
Iron, steel	5	3.65	13	6.53	5	5.88	18	6.00	41	5.69
Non-ferrous metals	1	0.73	1	0.50	0	0.00	0	0.00	2	0.28
Metal products	2	1.46	15	7.54	4	4.71	29	9.67	50	6.93
Machinery, equipment, tools	3	2.19	5	2.51	2	2.35	40	13.33	50	6.93
Computers & computer parts	0	0.00	7	3.52	5	5.88	3	1.00	15	2.08
Other electronics & components	5	3.65	22	11.06	2	2.35	45	15.00	74	10.26
Precision instruments	0	0.00	2	1.01	0	0.00	14	4.67	16	2.22
Automobile, auto parts	5	3.65	14	7.04	9	10.59	6	2.00	34	4.72
Other transportation equipments and parts	1	0.73	2	1.01	1	1.18	4	1.33	8	1.11
Others	24	17.52	10	5.03	24	28.24	25	8.33	83	11.51
Total	137		199		85		300		721	

2.3. Linkages: Sources of Information

This paper focuses on information linkages in an area, which consist of various networks within the area, including production, research, and human linkages. Production linkages are related to sources through market transactions such as purchasing and sales, and these linkages are divided into forward and backward linkages. The former implies that firms receive information from their upstream customers, and the latter from their downstream suppliers. Research linkages indicate the flow of information from universities, public research institutions and so on.

To identify the sources of information, we prepared the following questions regarding production linkages:

2. *Sources of knowledge and new technologies: production linkages*

(a) Internal sources of information and own R&D efforts

(b) Cooperation with (technology transfer from) local firms (100% local capital)

(c) Cooperation with (technology transfer from) MNCs (100% non-local capital)

(d) Cooperation with (technology transfer from) from Joint Ventures (JVs)

These four questions were aimed at identifying sources. To examine their relationships in more details, we asked the following questions:

3. *Relationships with partners*

(a) Whether partners were customers or suppliers

(b) Duration of the relationship

(c) Size of partners in terms of employment

(d) Geographical distance

(e) Frequency of communications.

In addition to information through production linkages, firms receive cutting-edge information as well as practical information from various sources. The former is supplied by research institutions such as universities, whereas the latter is transferred through human resources who own skills and know-how. This paper selected the following other sources:

4. *Sources of knowledge and new technologies: other linkages*

Research linkages: new technologies and information

(a) Technical assistance by government/public agencies

(b) Technical assistance by industrial/trade organizations

(c) Technical assistance by community organizations (NGOs or NPOs)

(d) Technical assistance by government-owned financial institutions

(e) Cooperation with (assistance from) universities/higher educational institutions

(f) Cooperation with (assistance from) government or public research institutes

Human linkages: provided by support organizations such as seminars, lectures, training, or consultants/experts dispatched or hired by them

(g) University professors or researchers personally closed contracts with your firm

(h) Dispatch of engineers to universities/higher educational institutions

(i) Dispatch of engineers to government or public research institutes

(j) Recruitment of middle-ranking personnel or mid-carrier engineers

(k) Recruitment of senior engineers retired from MNCs, JVs, or large local firms

(l) Headhunting of top management from MNCs, JVs, or large local firms

Other sources

(m) Technical information obtainable from academic publications

(n) Technical information obtainable from patents

(o) Introduction of "foreign-made" equipment and software

(p) Reverse engineering

(q) Participation in conferences, trade fairs, exhibitions

These definitions of linkages are comprehensive and contain not only organizations as partners but also functions. In accordance with the results of Tsuji and Miyahara [2010], this paper focuses on partners only, and summarizes the following three important partners:

5. *Type of linkage*

(a) MNCs (2.c)

(b) Public Institutes (4.a, 4.d, 4.f, 4.i)

(c) Universities (4.e, 4.g, 4.h)

2.4. Innovation Capability

In addition to linkages, another important subject in this paper is innovation capability or the potentiality of firms in the area. This capability is derived from two concepts: the firm and regional level. The former implies how much firms possess the ability to absorb new information, including that related to technology, management, marketing, or the market, and integrate them to achieve innovation. In contrast, the latter is related to the ability of the particular region as a whole. This concept can be referred to as "local innovation system."[4] This paper concentrates on the former.

(a) Technological capability

The innovation capability of firms is not observable and it is accordingly difficult to identify whether firms actually possess or not. We therefore selected the following as proxies for capability: (i) technology; and (ii) human resources. These are proxies of the firms' unknown or true ability to absorb new technologies. The level of technology which a firm currently owns, for example, indicates its ability to absorb new ones. More concretely, if a firm has already registered an intellectual property right, or if it is engaged in its own R&D activities by establishing departments or by sending personnel to university laboratories, these reveal they already have strong potential to deal with new technologies. Further, the production methods they currently use might be a proxy for technological potentiality.

Based on the above, the questionnaire asked firms about their capability and strategy for technological upgrading and innovation.

6. *Does your establishment hold any intellectual property rights?*

7. *Does your establishment carry out R&D activities?*

8. *Technical and management systems*

(a) OEM (Original Equipment Manufacturer)

(b) ODM (Original Design Manufacturer)

(c) OBM (Original Brand Manufacturer)

[4] The local innovation system is an important issue in this area. For the establishment of such a system, see the discussions in the conclusion of this paper.

(d) Adoption of ISO 9000, 14000 series or other international standards

(e) Operation of QM (Quality Management) or QC (Quality Control) activities

(f) Granted licensing technologies or know-how from other firms

Whether they are OEM, ODM or OBM depends on their technological capability. Among the capabilities shown in 4, 5 and 6, the latter indicates higher technological potentiality in general.

(b) Human capability

Human resources, categorized into top, middle and lower management, are also proxies for true potentiality or ability. Capability can be measured by education and experiences. Thus, we asked the following questions to measure human capability:

9. *Academic qualifications of top management and employees*

(a) Top management possesses a bachelor (BA), master or Ph.D. degree

(b) Top management has the experience of working for an MNC/JV

(c) Top management was spun-off or headhunted from an MNC/JV or local large firm

(d) Percentage of engineers are technical college graduates or higher

According to the theory of information, the following characteristic is also a proxy for true ability, namely acceptance (dispatch) of personnel to their customers (suppliers), and indicates a firm’s total capabilities. We therefore asked the following questions:

10. *Dispatching or accepting engineers from/to customers/suppliers*

(a) Does your establishment dispatch engineers to customers/suppliers?

(b) Do customers/suppliers dispatch engineers to your establishment?

(c) Does your establishment dispatch trainers to customers/suppliers?

(d) Does your establishment dispatch trainees to customers/suppliers?

(e) Do customers/suppliers dispatch trainers to your establishment?

(f) Do customers/suppliers dispatch trainees to your establishment?

11. *Characteristics of recruiting and basis of management*

(a) Recruit personnel who worked for the customer/supplier

(b) Customer/supplier recruits personnel who worked for your establishment

(c) Is your establishment a spin-off from the customer/supplier?

(d) Is the customer/supplier a spin-off from your establishment?

3. ESTIMATION OF EFFECTIVE LINKAGES

Here we use rigorous econometric analysis to identify linkages which contribute to respondents' innovation.

3.1. Estimation Models

(a) Dependent variables

This paper, which focuses only on product innovation, takes the number of performed innovations as a dependent variable, as shown in Table 1, and it takes from zero to four. The ordered logit model is used for estimation.

(b) Independent variables

As mentioned in the previous section, we selected three important sources, which included production, research and human linkages, namely (i) MNCs, (ii) public institutes and (iii) university, and treated them as independent variables. To extract the characteristics of the relationships, the following variables were selected: (3. b) duration of the relationship; (3.c) size of partner in terms of employment; (3.d) distance to the customer/supplier; and (3.e) frequency of communications. I addition to these, the independent variable includes relationships via human networks such as sending and accepting (i) engineers (10.a and 10.b), (ii) trainers (10.c, and 10.d), and (iii) trainees

(10.e and 10.f). Moreover, we added variables related to recruiting attitudes: (i) recruit personnel (11.a. and 11.b) and (ii) type of management (11.c and 11.d). Lastly, we added (8.f) granted licensing technologies or know-how from other firms. We also added characteristics of respondents such as years of establishment, and size of firm by employment, and category of industry. County dummies are also included. The summary statistics are shown in Table 8.

(c) Estimation method

As mentioned above, since the dependent variable takes discrete values, ordered logit estimation is adopted. Here we examined two models depending on the selection of customer or supplier: in the customer (supplier) model, the characteristics of the relationships are those related to customers (suppliers); in the basic model, all samples are taken for estimation; while in the importance model, customers (suppliers) are selected according their share of sales (purchases) which are more than 50%. Moreover, the full model implies that all variables are utilized for estimation, while in the selected model, the particular variable is used with those related to firm characteristics as well as county dummies. The results of estimation are indicated in Table 9.

Table 8 Summary Statistics

	Variable	Obs	Mean	Std. Dev.	Min	Max
Innovation						
1	Number of innovation	738	2.729	1.313	0	4
Characteristics of firms						
	Age (establishment)	717	16.197	13.136	0	181
	Number of full-time employees	735	325.306	499.268	10	2000
	Textiles, Apparel, leather	738	0.102	0.302	0	1
	Wood, Paper products	738	0.092	0.289	0	1
	Coal, Chemical products	738	0.057	0.232	0	1
	Iron, Metal products	738	0.126	0.332	0	1
	Computers, Other electronics	738	0.121	0.326	0	1
	Automobile, Other transportation	738	0.057	0.232	0	1
Linkages						
5.a	MNCs (2.c)	738	0.562	0.496	0	1
5.b	Public Institutes (4.a, 4.d, 4.f, 4.i)	738	0.619	0.486	0	1
5.c	Universities (4.e, 4.g, 4.h)	738	0.505	0.500	0	1
Most important customer						
3.b	Duration of the relationship with the customer	738	6.576	3.612	0	10
3.c	Employment size of the customer	738	365.108	355.217	50	1000
3.d	Please indicate distance from your establishment to the customer (kilo meter)	715	454.785	701.802	5	2000
3.e	How often does your establishment have communications for the collaborations?	738	1.916	1.444	0	4
Most important supplier						
3.b	Duration of the relationship with the supplier	738	6.289	3.569	0	10
3.c	Employment size of the supplier	738	325.881	333.774	50	1000
3.d	Please indicate distance from your establishment to the supplier (kilo meter)	709	533.351	749.780	5	2000
3.e	How often does your establishment have communications for the collaborations?	738	1.672	1.371	0	4

Table 9 Basic and Importance Model

		Basic model				Importance model			
		Customer full sample		Supplier full sample		Customer selected sample (Importance > 50%)		Supplier selected sample (Importance > 50%)	
		Full model	Selected model	Full model	Selected model	Full model	Selected model	Full model	Selected model
	Age (establishment)								
	Number of full-time employees (logarithmic)	***	***	***	***	**	**	***	***
	Textiles, Apparel, leather								
	Wood, Paper products								
	Coal, Chemical products				*				
	Iron, Metal products	[***]	[***]	[***]	[***]	[***]	[***]		
	Computers, Other electronics								
	Automobile, Other transportation								
5.a	MNCs (2.c)	**	***	**	***	*	**	**	**
5.b	Public Institutes (4.a, 4.d, 4.f, 4.i)	*	**		**	*	**		
5.c	Universities (4.e, 4.g, 4.h)								
3.b	Duration of the relationship with the customer					*	**		
3.c	Employment size of the customer				*				
3.d	Please indicate distance from your establishment to the customer (kilo meter)								
3.e	How often does your establishment have communications for the collaborations?		*		*	*	**	**	***
8.f	Granted licensing technologies or know-how from other firms	***	***	***	***	***	***	**	***
10.a, 10.b	Does the customer/supplier dispatch an engineer to your establishment?	[**]	[**]			[**]	[**]		
10.c, 10.d	Does your establishment dispatch trainers to the customer/supplier?								
10.e, 10.f	Does your establishment dispatch trainees to the customer/supplier?		*		*				
11.a, 11.b	Recruit personnel who worked for the customer/supplier							[***]	[***]
11.c, 11.d	Is your establishment a spin-off from the customer/supplier?					*	*		
	Dummy (Indonesia)	***	***	***	***	**	**	**	***
	Dummy (Thai)								
	Dummy (Hanoi)	*	**					**	**
	Dummy (Ho Chi Minh)	***	***	***	***	***	***	**	***

Notes: ***, ** and * indicate the significance level at the 1%, 5% and 10%. [ ] indicates that the sign of a estimated coefficient is negative..

3.2. Estimation Results: Linkages

The results showed that, among the three linkages, MMCs were significant for all estimations, implying that all respondents receive information from them. Linkages with public institutes were significant only with regard to customers in the basic model and also in the importance model, albeit that they may not be significant in either of the two models. Since the estimates for "customers" implies that the respondents are suppliers which sell their products to customers, they are concerned with both quality as well as price, both of which are both related to innovation. It is interesting that "frequency of communications" was significant in the importance model, indicating that respondents communicated with important business partners intimately and that this promoted innovation.[5] Neither "Distance to customer/supplier" nor "duration of the relationship" was significant. In addition to these variables, providing or receiving technology licenses or know-how among business partners also contributed to the innovation of the respondents. These results appear realistic. Human linkages, on the other hand, are mostly not significant, but "dispatching/receiving engineers" and "recruit personnel" have negative signs in some models.[6] These variables appear to be obstacles to innovation and require resolution. Lastly, universities were found to be insignificant in all models, and their role in further innovation should be reconsidered.

4. ANALYSIS OF CAPABILITY

Here, we examined the difference in relevance between innovation and capability, and identified from the estimates which elements of respondents' capability were

---

[5] Tsuji and Miyahara (2010), on the other hand, obtained different results, namely that distance to partners is significant, while frequency is not.

[6] Or respondents might be satisfied with their personnel and do not need these variables.

significant determinants of innovation.

4.1. Estimation Models

Since capability consists of technological and human factors, we examined the technological and human capacity models. The dependent variable is again the number of product innovations achieved.

(a) Technological capability model

This model contains elements of technological capability shown in section 2.4 as dependent variables. We also add (8.f) "granted licensing technology and know-how from other firms," since this enhances the technological ability of the recipients.

(b) Human capability model

We selected variables from questions 9 and 10 in consideration of correlations among variables.

In addition to the above variables, attributes of respondents and country dummies are also included. Again, the ordered logit model was utilized and two of the full and selected models were estimated. Since the correlations among variables were rather high, the selected model provided better results.

4.2. Results of Estimation

(a) Technological capability model

The results of the technological capability model are shown in Table 10. Among variables, (8.f) "granted licensing technology and know-how" showed the highest significance level, followed by OEM and OBM, which were also significant. Although owning patents and QM (QC) were significant in the selected model only, they might provide some effect in achieving innovation.

Table 10 Technological Capability Model

	Technological capability	Full model	Selected model
	Age (establishment)		[*]
	Number of full-time employees (logarithmic)	***	***
	Textiles, Apparel, leather		
	Wood, Paper products		
	Coal, Chemical products		*
	Iron, Metal products	[***]	[***]
	Computers, Other electronics		
	Automobile, Other transportation		
6	Does your establishment hold an intellectual property right?		**
7	Does your establish carry out R&D activities?		
8.a	OEM (Original Equipment Manufacturer)	**	***
8.b	ODM (Original Design Manufacturer)		***
8.c	OBM (Original Brand Manufacturer)	**	***
8.d	Adopting ISO 9000, 14000 series or other international standards		
8.e	Operating QM (Quality Management) or QC (Quality Control) activities		***
8.f	Granted licensing technologies or know-how from other firms	***	***
	Dummy (Indonesia)	***	***
	Dummy (Thai)		
	Dummy (Hanoi)		**
	Dummy (Ho Chi Minh)	***	***

Note 1: ***, ** and * indicate the significance level at the 1%, 5% and 10%
Note 2: [ ] indicates that the sign of a estimated coefficient is negative.

(b) Human capability model

In this model, the experience of top management working for MNCs/JV was significant in both models. Other human capabilities, such as education or experience, were not significant. Dispatching/receiving engineers or trainees was significant only in the selected model. The summary of estimation results is shown in Table 11.

Table 11 Human Capability Model

	Human capability	Full model	Selected model
	Age (establishment)		[*]
	Number of full-time employees (logarithmic)	***	***
	Textiles, Apparel, leather		
	Wood, Paper products		
	Coal, Chemical products		*
	Iron, Metal products	[***]	[***]
	Computers, Other electronics		
	Automobile, Other transportation		
9.a	Top management owns a bachelor (BA), master or Ph.D. degree		
9.b	Top management owns an experience of working for a MNC/JV	***	***
9.c	Spin-off or headhunted from a MNC/JV or local large firm		
9.d	Percentage of engineers are technical college graduates or higher		
10.a, 10.b	Does the customer/supplier dispatch an engineer to your establishment?		**
10.c, 10.d, 10.e, 10.f	Does your establishment (customer/supplier) dispatch trainees to the customer/supplier (your establishment)?		**
	Dummy (Indonesia)	***	***
	Dummy (Thai)		
	Dummy (Hanoi)		*
	Dummy (Ho Chi Minh)	***	***

Note 1: ***, ** and * indicate the significance level at the 1%, 5% and 10%
Note 2: [ ] indicates that the sign of a estimated coefficient is negative.

5. INTEGRATED EFFECT OF LINKAGES AND CAPABILITY

As already mentioned, either linkages or capability alone do not contribute to the achievement of innovation. Once integrated into one, however, they do become effective. Here we examine which linkages and capability are incorporated. For this purpose, we combine together the two models discussed in the previous sections.

5.1. Estimation Model: Linkage-Capability Model

Here the same variable shown Table 1 is taken as a dependent variable. With regard to constructing independent variables, we used linkages such as MNCs, public institutes and universities as well as all elements of capability listed in 9, 10 and 11 in section 2.[7] To analyze the hypothesis that such linkages and capabilities together promote innovation, we constructed new variables by multiplying each linkage and each element of capability. Since the linkages were assumed to take 1 if they were reported as important by respondents, and otherwise 0, each element of capability is thought to be effective in absorbing information convoyed through the particular linkage. Details of the elements of capability are also shown in Table 12.

The estimation equation is expressed in the following way:

$$y_i = a_0 + a_1 x_i + a_2 x_i z_i + \sum a_3 w_i + \varepsilon_i \quad (1)$$

where y_i, x_i and z_i stand for the number of innovations, x_i the particular linkage (dummy variable), z_i the element of capability, and w_i the attributes of the *i*-th firm, respectively. $x_i z_i$ is a cross-term of linkage and capability, and e is residual. There are thus three models according to linkages, and for each model, we attempted 14 estimates for each element of capability.

5.2. Result of Estimation

The estimation results of the linkage-capability model are shown in Table 12. This table presents the three linkage models, namely MNCs, public institutes and universities, and all elements of capability are also listed. The "Linkage" column shows correspondence to a particular linkage (dummy variable), and "Cross term" column shows correspondence to linkage times capability.

---

[7] Universities do not affect innovation, but this is added as a reference.

Table 12 Linkage-capability Model

		MNC		Public institute		University	
		Linkage	Cross term	Linkage	Cross term	Linkage	Cross term
	Technological capability						
6	Does your establishment hold an intellectual property right?	***	**	*	***		**
7	Does your establish carry out R&D activities?	***		**		**	
8.a	OEM (Original Equipment Manufacturer)	***			*		**
8.b	ODM (Original Design Manufacturer)	***	*		*		
8.c	OBM (Original Brand Manufacturer)	**	*		***		*
8.d	Adopting ISO 9000, 14000 series or other international standards	***		*		***	[*]
8.e	Operating QM (Quality Management) or QC (Quality Control) activities	**			*		
8.f	Granted licensing technologies or know-how from other firms	***			**		
	Human capability						
9.a	Top management owns a bachelor (BA), master or Ph.D. degree	***		**			
9.b	Top management owns an experience of working for a MNC/JV	***			***		
9.c	Spin-off or headhunted from a MNC/JV or local large firm	***		***		**	
9.d	Percentage of engineers are technical college graduates or higher	***	[***]	***	[**]	**	
10.a, 10.b	Does the customer/supplier dispatch an engineer to your establishment?	***					
10.c, 10.d, 10.e, 10.f	Does your establishment (customer/supplier) dispatch trainees to the customer/supplier (your establishment)?	***					

Note 1: ***, ** and * indicate the significance level at the 1%, 5% and 10%

Note 2: [ ] indicates that the sign of a estimated coefficient is negative.

With regard to linkage through MNCs, the cross term “patent rights” shows the highest significance level, followed by ODM and OBM. “Percentage of college graduates” reveals a negative sign, indicating it is an obstacle. Public institutes have no significant terms common to both of linkages and capability except “patent rights” and “percentage of college graduates,” and the latter has a negative sign. University does not have any significant term in common.

Estimation results from the element of capability show that ODM, OEM, “patent rights” and “percentage of college graduates” are important for both linkages and capability.

In sum, firms which own patents or are operating ODM and OBM are able to absorb information from MNCs and exploit them to achieve innovation. For firms which own patents and are operating QM, OEM, granted technical licenses, and top management has experience of working at MNCs, information obtained through public institutes can be realized as innovation. In order for collaborating universities to enhance innovation, the conditions such that they are operating either OEM or OBM, or they already have patents are necessary.

5.3. Estimation Model II: Capability to Obtain Linkages

In the previous section, the capability for firms to perform innovation by absorbing information on new technology was clarified. Here, we derive what kind of capability is required for collaboration with the linkages, particularly focusing on MNCs and public institutions.

For MNCs and public institutes, the dependant variable takes 1 if firms replied that the particular linkage was important to them, otherwise 0. With regard to independent variables, we selected factors among technological and human capabilities according to previous analyses, and are listed in Table 13. Again, we estimated full and selected models. By utilizing the logit model, we calculate the marginal probability of independent variables regarding the linkages. The estimation equation can be expressed in the following way:

$$\Pr\,(MNC_i = 1) = a_0 + \sum a_1 Capability_i + \sum a_2 w_i + \varepsilon_i \qquad (2)$$

or

$$\Pr\,(Public_i = 1) = a_0 + \sum a_1 Capability_i + \sum a_2 w_i + \varepsilon_i \qquad (3)$$

The marginal probability tells us how much the probability of having collaboration with MNCs or public institutions would increase, if firms satisfied an element of capability. Let us consider the example of “patent rights” and linkage with MNCs. The coefficient of “patent rights” shows that if firms registered a patent, then the probability of starting tie-ups with MNCs would increase at the same percentage as the coefficient.

5.4. Estimation Result II

Tables 13 and 14 show the results of estimations for MNC linkage and the public institutes, respectively. The former table tells that in both the full and selected models, according to values of marginal effect, significant variables were (i) top management’s working experience in MNCs; (ii) granted technical licenses and know-how; (iii) patent rights; and (iv) percentage of engineers who were college graduates. Since the marginal effect of (i) is 16.3% in the full model, if firms can recruit top management from MNCs, then the probability for this firm to start collaborating with MNCs increases by 16.3%. In the selected model, in addition to these elements, (v) operating an OBM was also identified.

Similarly, in the latter public institutions model, the common significant variables were (i) granted technical licenses and know-how; (ii) top management's working experience in MNCs; and (iii) percentage of engineers who were college graduates. In the selected model, in addition to these elements, (iv) operating QM and (v) practicing R&D activities were also identified.

In sum, we thus obtained important information on the capability of firms to connect to linkages such as MNCs or public institutions from the different method. In order to have collaborations with MNCs, human networks, such as top management work experience with MNCs, as well as technological capability to obtain patents, technical licenses, and engineers' educational qualification are required. For linkage with public institutes, a lower level of qualifications such as QM and R&D activities are particularly necessary, but holding patents is not required. These conclusions can be applied to policy making.

Table 13 Capability Required for MNCs

		Full model	Selected model
		Marginal Effect	Marginal Effect
6	Does your establishment hold an intellectual property right?	0.098 **	0.144 ***
8.b	ODM (Original Design Manufacturer)	-0.005	0.055
8.c	OBM (Original Brand Manufacturer)	0.016	0.081 *
8.e	Operating QM (Quality Management) or QC (Quality Control) activities	-0.021	0.067
8.f	Granted licensing technologies or know-how from other firms	0.143 ***	0.177 ***
9.b	Top management owns an experience of working for a MNC/JV	0.163 ***	0.203 ***
9.d	Percentage of engineers are technical college graduates or higher	0.090 *	0.130 ***

Note: ***, ** and * indicate the significance level at the 1%, 5% and 10%

Table 14 Capability Required for Public Institutions

		Full model	Selected model
		Marginal Effect	Marginal Effect
6	Does your establishment hold an intellectual property right?	-0.037	0.006
7	Does your establish carry out R&D activities?	0.077	0.094 **
8.a	OEM (Original Equipment Manufacturer)	-0.022	0.026
8.b	ODM (Original Design Manufacturer)	0.004	0.053
8.c	OBM (Original Brand Manufacturer)	0.025	0.067
8.e	Operating QM (Quality Management) or QC (Quality Control) activities	0.037	0.098 *
8.f	Granted licensing technologies or know-how from other firms	0.125 ***	0.141 ***
9.b	Top management owns an experience of working for a MNC/JV	0.087 **	0.119 ***
9.d	Percentage of engineers are technical college graduates or higher	0.082 *	0.124 ***

Note: ***, ** and * indicate the significance level at the 1%, 5% and 10%

6. CONCLUSIONS

(a) Summary of results

The objectives of this paper were to identify effective information linkages and the capability or potentiality of respondents for innovation. Based on the same data, Tsuji and Miyahara [2010] focused on the former and attempted to extract linkages which enhanced innovation in the four ASEAN economies. In the results, MNCs were identified as important sources which transmit information through not only production relationships but also human networks; namely, MNCs are sources of supply of high-ranked management to firms in the area, thanks to their advanced managerial systems, and the high ability it confers on managers who have experience of having worked there. Among the research linkages, government-owned financial institutions were significant sources which provide not only financial but also technical assistance, while government/public agencies or government/public research intuitions were significant, since firms need funds for innovation and upgrading, in addition to information for R&D activities, making these sources indispensable. In contrast to these linkages, university and other higher educational institutions were not significant in any model. Based these results, this paper focuses only on MNCs and public institutions.

With regard to capability, this paper attempted to identify which factors were more effective for the achievement of innovation. Result showed that, among technological capabilities, OEM, OBM and “granted licensing technology and know-how” were significant. Among human capabilities, top management’s experience of having worked at MNCs was significant.

Since innovation is achieved by the incorporation of linkages and capability, this paper developed a model to analyze this process by considering the cross terms of multiplication of these two factors. The rigorous estimation model identified ODM, OBM and patent rights for the MNCs linkages, and patent right for the public institutions.

Lastly, this paper derives the necessary capability for firms to connect with MNCs and public institutions, and without these kinds of capabilities, firms cannot make full use of information from the linkages. These are patent rights, top management who have experience working in MNCs, engineers with the level of college graduates, and granted licensing technology for the MNC linkage; and top management who have experience working in MNCs, engineers with the level of college graduates, and granted licensing technology for the public institutions linkage. These are necessary conditions for connecting with the information linkages.

(b) Policy implications

These last points are important for further upgrading of local firms. Since MNCs play important roles in transferring not only technology but also managerial skills, further policies should be implemented to invite MNCs to these areas. Doing so requires the establishment of legal as well as physical infrastructure, subsidies and tax exemption for MNCs, and deregulation for effective functioning market mechanisms.[8] Further development of public institutions which provide funds and technical assistance to local firms is required. This is related to establishing the local innovation system, which consists of all entities, public, private, or NPO and NGO.

Another important policy is to empower local firms to enhance technology and human resources, in particular to establish practical training for engineers and workers. Although universities tend to provide higher-level education to engineers, their roles also lie in this function.

According to the results of this analysis, we conclude that innovation in this area heavily depends on MNCs, and that the areas require an endogenous innovation process to further upgrade their economies.

ACKNOWLEDGEMENT

This paper is based on research conducted under the international project "Fostering Production- and Science & Technology Linkages to Stimulate Innovation in ASEAN" that was sponsored by the Economic Research Institute for ASEAN and East Asia (ERIA) in FY 2009. This project also has been carried with cooperation from the Center for Strategic and International Studies (CSIS) of Indonesia, the Philippine Institute for Development Studies (PIDS), Sirindhorn International Institute of Technology (SIIT) of Thammasat University, Thailand, The Institute for Industry Policy and Strategy (IPSI), Ministry of Industry and Trade of Vietnam. This paper is indebted to their efforts to collect data from a survey. Thanks are also due to Dr. Y. Akematsu, research fellow of JSPS, who performed the perfect statistical analysis.

[8] The flowchart approach can provides more practical examples of these policies. See Kuchiki and Tsuji (2005), (2008), (2009)

REFERENCES

Amara, N. and R. Landry (2005) "Sources of Information as Determinants of Novelty of Innovation in Manufacturing Firms: Evidence from the 1999 Statistics Canada Innovation Survey," *Technovation*, vol. 25, issue 3, pp. 245-59.

Blalock, G.. and P. J. Gertler (2008) "Welfare Gains from Foreign Direct Investment through Technology Transfer to Local Suppliers," *Journal of International Economics*, Vol. 74, pp. 402-21.

Frenz, M. and G. Ietto-Gillies (2009) "The Impact on Innovation Performance of Different Sources of Knowledge: Evidence from the UK Community Innovation Survey," *Research Policy*, vol. 38, issue 7, pp. 1125-35.

Javorcik, B. (2004) "Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages," *American Economic Review*, Vol. 94, No. 3, pp. 605-27.

Kuchiki, A. and M. Tsuji (2005) *Industrial Clusters in Asia: Analyses of their competition and cooperation*, Basingstroke, UK, Palgrave and Macmillan.

Kuchiki, A. and M. Tsuji (2008) *The Flowchart Approach to Industrial Cluster policy*, Basingstroke, UK, Palgrave and Macmillan.

Kuchiki, A. and M. Tsuji (2009) *From Agglomeration to Innovation*, Basingstroke, UK, Palgrave and Macmillan.

Machikita, T. and Y. Ueki (2010a) "Linked Versus Non-linked Firms in Innovation: The Effects of Economies of Network in Agglomeration in East Asia," mimeo, Institute of Developing Economies.

Machikita, T. and Y. Ueki (2010b) "Learning and Innovation in Upstream-Downstream Relations: Mutual Knowledge Exchanges and Types of Transferred Technologies," mimeo, IDE.

Tsuji, M. and S. Miyahara (2010) "Empirical Analysis of Innovation and the Proximity of Information Linkages in ASEAN Economies: Case of Indonesia, the Philippines, Thailand and Vietnam," mimeo IDE

APPENDIX

A1. Questionnaire

Innovation

1. What has your establishment achieved among the following?
(a) Significant change in packaging or appearance design
(b) Significant improvement of an existing product/service
(c) Development of a totally new product/service based on existing technologies
(d) Development of a totally new product/service based on new technologies

Sources

2. Sources of knowledge and new technologies: production linkages
(a) Internal sources of information and own R&D efforts
(b) Technology transfer from local firms (100% local capital)
(c) Technology transfer from MNCs (100% non-local capital)
(d) technology transfer from Joint Ventures (JVs)

3. Relationships with partners
(a) Whether partners were customers or suppliers
(b) Duration of the relationship
(c) Size of partners in terms of employment
(d) Geographical distance
(e) Frequency of communications.

4. Sources of knowledge and new technologies: other linkages
(a) Technical assistance by government/public agencies
(b) Technical assistance by industrial/trade organizations
(c) Technical assistance by community organizations (NGOs or NPOs)
(d) Technical assistance by government-owned financial institutions
(e) Cooperation with (assistance from) universities/higher educational institutions
(f) Cooperation with (assistance from) government or public research institutes
(g) University professors or researchers personally closed contracts with your firm
(h) Dispatch of engineers to universities/higher educational institutions
(i) Dispatch of engineers to government or public research institutes
(j) Recruitment of middle-ranking personnel or mid-carrier engineers
(k) Recruitment of senior engineers retired from MNCs, JVs, or large local firms
(l) Headhunting of top management from MNCs, JVs, or large local firms
(m) Technical information obtainable from academic publications
(n) Technical information obtainable from patents
(o) Introduction of “foreign-made” equipment and software
(p) Reverse engineering
(q) Participation in conferences, trade fairs, exhibitions

5. Type of linkage
(a) MNCs (2.c)
(b) Public Institutes (4.a, 4.d, 4.f, 4.i)
(c) Universities (4.e, 4.g, 4.h)

Capabilities

6. Does your establishment hold any intellectual property rights?

7. Does your establishment carry out R&D activities?

8. Technical and management systems

(a) OEM (Original Equipment Manufacturer)
(b) ODM (Original Design Manufacturer)
(c) OBM (Original Brand Manufacturer)
(d) Adoption of ISO 9000, 14000 series or other international standards
(e) Operation of QM (Quality Management) or QC (Quality Control) activities
(f) Granted licensing technologies or know-how from other firms

9. Academic qualifications of top management and employees

(a) Top management possesses a bachelor (BA), master or Ph.D. degree
(b) Top management has the experience of working for an MNC/JV
(c) Top management was spun-off or headhunted from an MNC/JV or local large firm
(d) Percentage of engineers are technical college graduates or higher

10. Dispatching or accepting engineers from/to customers/suppliers

(a) Does your establishment dispatch engineers to customers/suppliers?
(b) Do customers/suppliers dispatch engineers to your establishment?
(c) Does your establishment dispatch trainers to customers/suppliers?
(d) Does your establishment dispatch trainees to customers/suppliers?
(e) Do customers/suppliers dispatch trainers to your establishment?
(f) Do customers/suppliers dispatch trainees to your establishment?

11. Characteristics of recruiting and basis of management

(a) Recruit personnel who worked for the customer/supplier
(b) Customer/supplier recruits personnel who worked for your establishment
(c) Is your establishment a spin-off from the customer/supplier?
(d) Is the customer/supplier a spin-off from your establishment?

Table A2 Estimation Result of Basic Model (Customer full sample) (Table 9)

		Full model	Selected model 1	Selected model 2	Selected model 3	Selected model 4	Selected model 5	Selected model 6	Selected model 7	Selected model 8	Selected model 9
		Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
	Age (establishment)	-0.008	-0.008	-0.008	-0.009	-0.008	-0.010	-0.009	-0.009	-0.010 *	-0.009
		(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
	Number of full-time employees (logarithmic)	0.199 ***	0.197 ***	0.202 ***	0.200 ***	0.192 ***	0.196 ***	0.194 ***	0.189 ***	0.197 ***	0.195 ***
		(0.058)	(0.058)	(0.058)	(0.058)	(0.057)	(0.057)	(0.057)	(0.057)	(0.057)	(0.057)
	Textiles, Apparel, leather	-0.177	-0.188	-0.160	-0.173	-0.137	-0.216	-0.184	-0.221	-0.210	-0.228
		(0.257)	(0.257)	(0.257)	(0.257)	(0.255)	(0.252)	(0.252)	(0.252)	(0.251)	(0.252)
	Wood, Paper products	-0.190	-0.168	-0.215	-0.195	-0.176	-0.217	-0.207	-0.236	-0.219	-0.239
		(0.257)	(0.256)	(0.257)	(0.257)	(0.256)	(0.258)	(0.258)	(0.257)	(0.258)	(0.258)
	Coal, Chemical products	0.364	0.350	0.377	0.363	0.358	0.417	0.355	0.347	0.427	0.415
		(0.316)	(0.315)	(0.313)	(0.312)	(0.312)	(0.312)	(0.313)	(0.313)	(0.310)	(0.310)
	Iron, Metal products	-0.706 ***	-0.718 ***	-0.720 ***	-0.734 ***	-0.726 ***	-0.670 ***	-0.686 ***	-0.696 ***	-0.673 ***	-0.673 ***
		(0.221)	(0.220)	(0.220)	(0.219)	(0.219)	(0.219)	(0.218)	(0.218)	(0.218)	(0.218)
	Computers, Other electronics	-0.006	-0.001	0.053	0.059	0.008	0.070	0.047	0.019	0.047	0.055
		(0.253)	(0.253)	(0.253)	(0.253)	(0.251)	(0.249)	(0.249)	(0.251)	(0.249)	(0.249)
	Automobile, Other transportation	-0.182	-0.188	-0.176	-0.179	-0.159	-0.110	-0.158	-0.171	-0.133	-0.130
		(0.330)	(0.329)	(0.328)	(0.328)	(0.325)	(0.324)	(0.326)	(0.326)	(0.323)	(0.324)
5.a	MNCs (2.c)	0.410 **	0.422 **			0.397 **	0.484 ***	0.462 ***	0.445 ***	0.458 ***	0.488 ***
		(0.172)	(0.165)			(0.170)	(0.170)	(0.169)	(0.170)	(0.170)	(0.169)
5.b	Public Institutes (4.a, 4.d, 4.f, 4.i)	0.295 *		0.317 *		0.292 *	0.327 *	0.314 *	0.314 *	0.336 **	0.342 **
		(0.173)		(0.162)		(0.172)	(0.170)	(0.171)	(0.171)	(0.171)	(0.171)
5.c	Universities (4.e, 4.g, 4.h)	-0.114			0.095	-0.115	-0.022	-0.048	-0.035	-0.037	-0.038
		(0.172)			(0.156)	(0.171)	(0.169)	(0.170)	(0.169)	(0.169)	(0.169)
3.b	Duration of the relationship with the customer	0.035	0.034	0.034	0.033	0.034	0.022	0.022	0.023	0.024	0.024
		(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
3.c	Employment size of the customer	-0.025	-0.021	-0.014	-0.011	-0.050	-0.026	-0.042	-0.044	-0.028	-0.033
		(0.076)	(0.075)	(0.075)	(0.075)	(0.073)	(0.075)	(0.073)	(0.073)	(0.072)	(0.073)
3.d	Please indicate distance from your establishment to the customer (kilo	0.020	0.025	0.019	0.024	0.020	0.032	0.032	0.034	0.033	0.035
		(0.047)	(0.047)	(0.047)	(0.047)	(0.047)	(0.047)	(0.047)	(0.047)	(0.047)	(0.047)
3.e	How often does your establishment have communications for the collaborations?	0.056	0.056	0.063	0.064	0.065	0.098 *	0.085	0.079	0.085	0.081
		(0.055)	(0.055)	(0.055)	(0.055)	(0.054)	(0.054)	(0.054)	(0.054)	(0.054)	(0.054)
8.f	Granted licensing technologies or know-how from other firms	0.465 ***	0.471 ***	0.480 ***	0.489 ***	0.450 ***					
		(0.104)	(0.103)	(0.103)	(0.104)	(0.097)					
10.a, 10.b	Does the customer/supplier dispatch an engineer to your establishment?	-0.241 **	-0.242 **	-0.228 *	-0.227 *		-0.009				
		(0.122)	(0.122)	(0.121)	(0.122)		(0.103)				

10.c,	Does your establishment dispatch	0.099	0.108	0.096	0.107			0.157			
10.d	trainers to the customer/supplier?	(0.142)	(0.141)	(0.141)	(0.142)			(0.114)			
10.e,	Does your establishment dispatch	0.095	0.102	0.114	0.122				0.178 *		
10.f	trainees to the customer/supplier?	(0.128)	(0.127)	(0.127)	(0.127)				(0.103)		
11.a,	Recruit personnel who worked for the	-0.001	-0.014	0.024	0.013					0.139	
11.b	customer/supplier	(0.126)	(0.126)	(0.125)	(0.125)					(0.114)	
11.c,	Is your establishment a spin-off from the	0.134	0.118	0.102	0.082						0.279
11.d	customer/supplier?	(0.181)	(0.181)	(0.179)	(0.179)						(0.171)
	Dummy (Indonesia)	0.783 ***	0.849 ***	0.848 ***	0.933 ***	0.820 ***	0.827 ***	0.846 ***	0.861 ***	0.818 ***	0.839 ***
		(0.253)	(0.244)	(0.248)	(0.248)	(0.250)	(0.251)	(0.250)	(0.250)	(0.249)	(0.249)
	Dummy (Thai)	-0.175	-0.124	-0.105	-0.039	-0.098	-0.141	-0.212	-0.185	-0.153	-0.154
		(0.269)	(0.264)	(0.264)	(0.263)	(0.262)	(0.262)	(0.266)	(0.262)	(0.261)	(0.261)
	Dummy (Hanoi)	0.419 *	0.491 **	0.389	0.471 *	0.365	0.274	0.207	0.258	0.244	0.267
		(0.252)	(0.244)	(0.250)	(0.248)	(0.243)	(0.244)	(0.244)	(0.240)	(0.241)	(0.240)
	Dummy (Ho Chi Minh)	1.856 ***	1.823 ***	2.038 ***	2.006 ***	1.709 ***	1.382 ***	1.313 ***	1.374 ***	1.364 ***	1.393 ***
		(0.270)	(0.268)	(0.260)	(0.259)	(0.248)	(0.247)	(0.240)	(0.236)	(0.236)	(0.237)
	/cut1	-0.534	-0.591	-0.516	-0.587	-0.620	-0.669	-0.732	-0.780	-0.666	-0.665
		(0.501)	(0.499)	(0.500)	(0.499)	(0.492)	(0.497)	(0.493)	(0.495)	(0.491)	(0.491)
	/cut2	0.488	0.428	0.503	0.427	0.395	0.332	0.272	0.223	0.335	0.339
		(0.500)	(0.498)	(0.499)	(0.498)	(0.491)	(0.495)	(0.492)	(0.493)	(0.489)	(0.490)
	/cut3	1.578	1.515	1.581	1.503	1.479	1.402	1.345	1.298	1.406	1.409
		(0.503)	(0.501)	(0.502)	(0.501)	(0.494)	(0.498)	(0.494)	(0.495)	(0.492)	(0.493)
	/cut4	2.783	2.717	2.779	2.698	2.679	2.572	2.517	2.472	2.579	2.583
		(0.508)	(0.506)	(0.507)	(0.506)	(0.499)	(0.502)	(0.498)	(0.499)	(0.497)	(0.497)
	Number of observation	696	696	696	696	696	696	696	696	696	696
	Log likelihood	-939.16	-940.63	-942.00	-943.73	-941.64	-952.56	-951.61	-951.08	-951.81	-951.21
	Pseudo R2	0.081	0.080	0.078	0.077	0.079	0.068	0.069	0.069	0.069	0.069

Table A3 Estimation Result of Basic Model (Supplier full sample) (Table 9)

		Full model	Selected model 1	Selected model 2	Selected model 3	Selected model 4	Selected model 5	Selected model 6	Selected model 7	Selected model 8	Selected model 9
		Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
	Age (establishment)	0.003	0.001	0.003	0.001	0.002	0.000	0.001	0.001	0.001	0.002
		(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
	Number of full-time employees (logarithmic)	0.198 **	0.206 **	0.212 **	0.218 **	0.178 **	0.203 **	0.191 **	0.193 **	0.193 **	0.190 **
		(0.091)	(0.091)	(0.090)	(0.091)	(0.090)	(0.090)	(0.089)	(0.089)	(0.089)	(0.090)
	Textiles, Apparel, leather	-0.233	-0.304	-0.197	-0.274	-0.159	-0.255	-0.193	-0.211	-0.211	-0.254
		(0.405)	(0.402)	(0.406)	(0.403)	(0.393)	(0.390)	(0.391)	(0.388)	(0.388)	(0.391)
	Wood, Paper products	-0.127	-0.064	-0.245	-0.180	-0.109	-0.160	-0.122	-0.131	-0.132	-0.135
		(0.417)	(0.413)	(0.412)	(0.409)	(0.411)	(0.414)	(0.415)	(0.414)	(0.413)	(0.414)
	Coal, Chemical products	0.231	0.169	0.291	0.227	0.163	0.340	0.241	0.279	0.279	0.278
		(0.494)	(0.490)	(0.490)	(0.486)	(0.491)	(0.482)	(0.490)	(0.483)	(0.479)	(0.478)
	Iron, Metal products	-1.179 ***	-1.214 ***	-1.212 ***	-1.263 ***	-1.304 ***	-1.195 ***	-1.221 ***	-1.228 ***	-1.226 ***	-1.152 ***
		(0.415)	(0.410)	(0.406)	(0.405)	(0.405)	(0.410)	(0.407)	(0.408)	(0.408)	(0.408)
	Computers, Other electronics	0.182	0.118	0.337	0.286	0.051	0.041	0.016	0.024	0.023	0.065
		(0.448)	(0.441)	(0.443)	(0.440)	(0.446)	(0.439)	(0.439)	(0.439)	(0.439)	(0.442)
	Automobile, Other transportation	0.161	0.097	0.189	0.124	-0.054	0.041	-0.022	-0.011	-0.013	0.040
		(0.496)	(0.499)	(0.491)	(0.494)	(0.492)	(0.486)	(0.488)	(0.486)	(0.486)	(0.490)
5.a	MNCs (2.c)	0.560 *	0.618 **			0.494 *	0.596 **	0.560 **	0.569 **	0.566 **	0.553 *
		(0.289)	(0.262)			(0.285)	(0.286)	(0.285)	(0.285)	(0.285)	(0.285)
5.b	Public Institutes (4.a, 4.d, 4.f, 4.i)	0.526 *		0.596 **		0.489 *	0.572 **	0.548 *	0.553 *	0.555 *	0.604 **
		(0.296)		(0.268)		(0.291)	(0.286)	(0.287)	(0.286)	(0.288)	(0.290)
5.c	Universities (4.e, 4.g, 4.h)	-0.156			0.295	-0.195	-0.190	-0.213	-0.199	-0.199	-0.207
		(0.312)			(0.263)	(0.307)	(0.304)	(0.307)	(0.308)	(0.305)	(0.307)
3.b	Duration of the relationship with the customer	0.071 *	0.078 **	0.071 *	0.080 **	0.076 *	0.058	0.063	0.062	0.063	0.064
		(0.040)	(0.040)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)
3.c	Employment size of the customer	-0.056	-0.061	-0.071	-0.078	-0.132	-0.025	-0.073	-0.063	-0.064	-0.080
		(0.118)	(0.117)	(0.117)	(0.117)	(0.110)	(0.114)	(0.110)	(0.110)	(0.107)	(0.108)
3.d	Please indicate distance from your establishment to the customer (kilo	-0.029	-0.037	-0.022	-0.031	-0.021	0.007	0.004	0.005	0.006	0.012
		(0.064)	(0.064)	(0.064)	(0.064)	(0.063)	(0.062)	(0.062)	(0.062)	(0.062)	(0.062)
3.e	How often does your establishment have communications for the collaborations?	0.147 *	0.150 *	0.155 *	0.158 *	0.127	0.181 **	0.168 **	0.170 **	0.169 **	0.149 *
		(0.086)	(0.085)	(0.085)	(0.085)	(0.083)	(0.083)	(0.082)	(0.083)	(0.083)	(0.083)
8.f	Granted licensing technologies or know-how from other firms	0.616 ***	0.638 ***	0.624 ***	0.649 ***	0.466 ***					
		(0.174)	(0.172)	(0.174)	(0.172)	(0.153)					
10.a, 10.b	Does the customer/supplier dispatch an engineer to your establishment?	-0.436 **	-0.412 **	-0.421 **	-0.391 **		-0.155				
		(0.199)	(0.198)	(0.199)	(0.198)		(0.161)				
10.c, 10.d	Does your establishment dispatch trainers to the customer/supplier?	0.190	0.217	0.199	0.220			0.064			
		(0.228)	(0.227)	(0.227)	(0.226)			(0.170)			
10.e, 10.f	Does your establishment dispatch trainees to the customer/supplier?	-0.145	-0.172	-0.143	-0.176				-0.003		
		(0.228)	(0.227)	(0.227)	(0.227)				(0.165)		

11.a, 11.b	Recruit personnel who worked for the customer/supplier	-0.241	-0.261	-0.210	-0.226					0.013	
		(0.208)	(0.207)	(0.207)	(0.206)					(0.172)	
11.c, 11.d	Is your establishment a spin-off from the customer/supplier?	0.490 *	0.454 *	0.472 *	0.428						0.401 *
		(0.268)	(0.268)	(0.267)	(0.267)						(0.233)
	Dummy (Indonesia)	0.683 **	0.762 **	0.759 **	0.821 **	0.671 **	0.689 **	0.720 **	0.711 **	0.710 **	0.771 **
		(0.345)	(0.332)	(0.334)	(0.339)	(0.335)	(0.333)	(0.333)	(0.334)	(0.333)	(0.336)
	Dummy (Thai)	-0.008	0.064	0.073	0.141	0.001	0.002	-0.032	-0.004	-0.006	-0.001
		(0.368)	(0.362)	(0.359)	(0.360)	(0.356)	(0.355)	(0.363)	(0.357)	(0.356)	(0.354)
	Dummy (Hanoi)	0.451	0.511	0.437	0.502	0.328	0.359	0.233	0.281	0.278	0.228
		(0.482)	(0.479)	(0.482)	(0.479)	(0.462)	(0.461)	(0.471)	(0.459)	(0.455)	(0.457)
	Dummy (Ho Chi Minh)	2.228 ***	2.122 ***	2.513 ***	2.431 ***	1.678 ***	1.416 **	1.300 **	1.341 **	1.337 **	1.457 **
		(0.675)	(0.655)	(0.663)	(0.654)	(0.615)	(0.607)	(0.609)	(0.611)	(0.602)	(0.606)
	/cut1	0.170	-0.005	0.164	-0.037	-0.211	0.217	0.045	0.078	0.076	0.102
		(0.750)	(0.744)	(0.747)	(0.742)	(0.735)	(0.739)	(0.731)	(0.738)	(0.726)	(0.723)
	/cut2	1.096	0.909	1.085	0.871	0.692	1.095	0.922	0.955	0.953	0.989
		(0.757)	(0.749)	(0.754)	(0.747)	(0.739)	(0.745)	(0.736)	(0.744)	(0.731)	(0.729)
	/cut3	1.961	1.768	1.942	1.721	1.536	1.926	1.751	1.783	1.781	1.822
		(0.764)	(0.756)	(0.761)	(0.753)	(0.745)	(0.752)	(0.742)	(0.750)	(0.738)	(0.736)
	/cut4	2.967	2.768	2.937	2.710	2.520	2.890	2.711	2.743	2.741	2.787
		(0.771)	(0.763)	(0.768)	(0.759)	(0.750)	(0.759)	(0.749)	(0.757)	(0.744)	(0.742)
	Number of observation	261	261	261	261	261	261	261	261	261	261
	Log likelihood	-355.59	-357.19	-357.50	-359.36	-360.33	-364.59	-364.99	-365.06	-365.05	-363.54
	Pseudo R2	0.091	0.087	0.086	0.081	0.079	0.068	0.067	0.067	0.067	0.071

Table A4 Estimation Result of Importance Model (Customer selected sample) (Table 9)

		Full model	Selected model 1	Selected model 2	Selected model 3	Selected model 4	Selected model 5	Selected model 6	Selected model 7	Selected model 8	Selected model 9
		Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
	Age (establishment)	-0.007	-0.007	-0.007	-0.007	-0.007	-0.008	-0.009	-0.008	-0.009	-0.009
		(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
	Number of full-time employees	0.176 ***	0.176 ***	0.180 ***	0.181 ***	0.175 ***	0.178 ***	0.183 ***	0.183 ***	0.184 ***	0.185 ***
	(logarithmic)	(0.059)	(0.059)	(0.059)	(0.059)	(0.058)	(0.059)	(0.058)	(0.058)	(0.058)	(0.058)
	Textiles, Apparel, leather	-0.102	-0.106	-0.092	-0.098	-0.122	-0.131	-0.158	-0.135	-0.180	-0.179
		(0.254)	(0.254)	(0.254)	(0.254)	(0.251)	(0.253)	(0.250)	(0.251)	(0.249)	(0.250)
	Wood, Paper products	-0.037	-0.017	-0.059	-0.040	-0.079	-0.079	-0.091	-0.070	-0.100	-0.104
		(0.264)	(0.263)	(0.264)	(0.263)	(0.261)	(0.263)	(0.263)	(0.263)	(0.264)	(0.262)
	Coal, Chemical products	0.490	0.483	0.512 *	0.508	0.499	0.482	0.494	0.452	0.490	0.486
		(0.313)	(0.312)	(0.311)	(0.310)	(0.311)	(0.310)	(0.310)	(0.311)	(0.310)	(0.310)
	Iron, Metal products	-0.624 ***	-0.633 ***	-0.634 ***	-0.645 ***	-0.632 ***	-0.598 ***	-0.607 ***	-0.597 ***	-0.595 ***	-0.593 ***
		(0.220)	(0.220)	(0.219)	(0.219)	(0.219)	(0.218)	(0.219)	(0.218)	(0.219)	(0.218)
	Computers, Other electronics	0.053	0.063	0.121	0.134	0.063	0.046	0.028	0.024	0.047	0.045
		(0.248)	(0.248)	(0.247)	(0.246)	(0.247)	(0.247)	(0.247)	(0.248)	(0.247)	(0.247)
	Automobile, Other transportation	-0.102	-0.102	-0.101	-0.097	-0.104	-0.131	-0.132	-0.136	-0.104	-0.109
		(0.325)	(0.325)	(0.324)	(0.323)	(0.324)	(0.323)	(0.322)	(0.323)	(0.323)	(0.322)
5.a	MNCs (2.c)	0.399 **	0.407 **			0.410 **	0.441 ***	0.437 **	0.432 **	0.463 ***	0.463 ***
		(0.171)	(0.163)			(0.170)	(0.170)	(0.170)	(0.170)	(0.169)	(0.169)
5.b	Public Institutes ((4.a, 4.d, 4.f, 4.i)	0.277		0.300 *		0.288 *	0.320 *	0.332 *	0.316 *	0.339 **	0.340 **
		(0.174)		(0.163)		(0.174)	(0.173)	(0.172)	(0.173)	(0.172)	(0.172)
5.c	Universities (4.e, 4.g, 4.h)	-0.105			0.100	-0.102	-0.052	-0.064	-0.055	-0.041	-0.045
		(0.173)			(0.157)	(0.172)	(0.171)	(0.172)	(0.171)	(0.171)	(0.171)
3.b	Duration of the relationship with the	0.008	0.007	0.008	0.007	0.010	0.007	0.010	0.005	0.007	0.007
	customer	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
3.c	Employment size of the customer	0.131	0.129	0.134	0.132	0.139 *	0.130	0.136 *	0.130	0.149 *	0.148 *
		(0.082)	(0.082)	(0.082)	(0.082)	(0.081)	(0.082)	(0.081)	(0.081)	(0.081)	(0.081)
3.d	Please indicate distance from your	-0.016	-0.021	-0.021	-0.027	-0.015	-0.006	-0.006	-0.009	-0.006	-0.006
	establishment to the customer (kilo	(0.048)	(0.048)	(0.048)	(0.048)	(0.048)	(0.048)	(0.048)	(0.048)	(0.048)	(0.048)
3.e	How often does your establishment have	0.076	0.076	0.080	0.080	0.075	0.100 *	0.091	0.091	0.107 *	0.101 *
	communications for the collaborations?	(0.057)	(0.057)	(0.057)	(0.057)	(0.056)	(0.055)	(0.056)	(0.056)	(0.056)	(0.057)
8.f	Granted licensing technologies or know-	0.328 ***	0.337 ***	0.340 ***	0.351 ***	0.337 ***					
	how from other firms	(0.104)	(0.103)	(0.103)	(0.103)	(0.096)					
10.a,	Does the customer/supplier dispatch an	0.009	0.018	0.018	0.028		0.128				
10.b	engineer to your establishment?	(0.115)	(0.115)	(0.115)	(0.114)		(0.099)				
10.c,	Does your establishment dispatch	0.049	0.044	0.060	0.056			0.144			
10.d	trainers to the customer/supplier?	(0.118)	(0.117)	(0.117)	(0.117)			(0.097)			
10.e,	Does your establishment dispatch	0.075	0.083	0.089	0.099				0.188 *		
10.f	trainees to the customer/supplier?	(0.131)	(0.131)	(0.131)	(0.131)				(0.108)		

11.a, 11.b	Recruit personnel who worked for the customer/supplier	-0.121	-0.124	-0.113	-0.115					-0.005	
		(0.128)	(0.128)	(0.128)	(0.128)					(0.120)	
11.c, 11.d	Is your establishment a spin-off from the customer/supplier?	-0.042	-0.050	-0.062	-0.071						0.071
		(0.182)	(0.182)	(0.180)	(0.180)						(0.173)
	Dummy (Indonesia)	0.851 ***	0.902 ***	0.924 ***	0.988 ***	0.794 ***	0.883 ***	0.858 ***	0.854 ***	0.829 ***	0.828 ***
		(0.260)	(0.251)	(0.253)	(0.256)	(0.253)	(0.257)	(0.254)	(0.254)	(0.255)	(0.253)
	Dummy (Thai)	-0.199	-0.142	-0.134	-0.065	-0.185	-0.187	-0.247	-0.259	-0.206	-0.208
		(0.274)	(0.267)	(0.268)	(0.267)	(0.269)	(0.268)	(0.269)	(0.269)	(0.269)	(0.268)
	Dummy (Hanoi)	0.246	0.300	0.217	0.279	0.253	0.138	0.190	0.127	0.193	0.195
		(0.249)	(0.241)	(0.247)	(0.247)	(0.240)	(0.242)	(0.238)	(0.241)	(0.239)	(0.238)
	Dummy (Ho Chi Minh)	1.423 ***	1.394 ***	1.589 ***	1.562 ***	1.443 ***	1.174 ***	1.181 ***	1.180 ***	1.236 ***	1.244 ***
		(0.273)	(0.272)	(0.263)	(0.263)	(0.258)	(0.255)	(0.253)	(0.252)	(0.253)	(0.252)
	/cut1	-0.199	-0.310	-0.229	-0.358	-0.166	-0.214	-0.199	-0.259	-0.168	-0.172
		(0.482)	(0.476)	(0.482)	(0.477)	(0.480)	(0.480)	(0.479)	(0.481)	(0.480)	(0.479)
	/cut2	0.841	0.726	0.806	0.673	0.871	0.817	0.832	0.771	0.860	0.856
		(0.482)	(0.475)	(0.482)	(0.476)	(0.480)	(0.480)	(0.479)	(0.481)	(0.479)	(0.479)
	/cut3	1.930	1.812	1.885	1.749	1.956	1.893	1.909	1.847	1.933	1.929
		(0.488)	(0.480)	(0.486)	(0.480)	(0.485)	(0.485)	(0.484)	(0.486)	(0.484)	(0.484)
	/cut4	3.148	3.028	3.096	2.957	3.172	3.094	3.111	3.050	3.132	3.129
		(0.494)	(0.487)	(0.493)	(0.486)	(0.492)	(0.491)	(0.490)	(0.492)	(0.491)	(0.491)
	Number of observation	690	690	690	690	690	690	690	690	690	690
	Log likelihood	-934.55	-935.82	-937.26	-938.74	-935.38	-940.83	-940.55	-940.14	-941.65	-941.57
	Pseudo R2	0.077	0.076	0.074	0.073	0.076	0.071	0.071	0.072	0.070	0.070

Table A5 Estimation Result of Importance Model (Suppiers selected sample) (Table 9)

		Full model	Selected model 1	Selected model 2	Selected model 3	Selected model 4	Selected model 5	Selected model 6	Selected model 7	Selected model 8	Selected model 9
		Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
	Age (establishment)	-0.014	-0.014	-0.015	-0.015	-0.010	-0.010	-0.010	-0.011	-0.012	-0.011
		(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
	Number of full-time employees (logarithmic)	0.385 ***	0.385 ***	0.410 ***	0.409 ***	0.337 ***	0.339 ***	0.337 ***	0.336 ***	0.361 ***	0.342 ***
		(0.114)	(0.114)	(0.113)	(0.113)	(0.111)	(0.112)	(0.111)	(0.111)	(0.112)	(0.112)
	Textiles, Apparel, leather	0.159	0.167	0.191	0.188	0.161	0.095	0.072	0.070	0.069	0.077
		(0.445)	(0.443)	(0.444)	(0.444)	(0.435)	(0.435)	(0.434)	(0.434)	(0.436)	(0.434)
	Wood, Paper products	0.675	0.688	0.565	0.601	0.590	0.583	0.563	0.558	0.632	0.568
		(0.475)	(0.471)	(0.472)	(0.470)	(0.470)	(0.473)	(0.472)	(0.471)	(0.471)	(0.470)
	Coal, Chemical products	0.320	0.331	0.371	0.405	0.403	0.360	0.343	0.373	0.352	0.311
		(0.522)	(0.518)	(0.513)	(0.511)	(0.510)	(0.507)	(0.509)	(0.508)	(0.511)	(0.510)
	Iron, Metal products	-0.535	-0.547	-0.550	-0.561	-0.532	-0.484	-0.480	-0.471	-0.482	-0.492
		(0.411)	(0.410)	(0.403)	(0.403)	(0.404)	(0.403)	(0.404)	(0.406)	(0.406)	(0.404)
	Computers, Other electronics	-0.185	-0.159	-0.075	-0.049	-0.219	-0.272	-0.254	-0.238	-0.269	-0.265
		(0.497)	(0.494)	(0.498)	(0.501)	(0.490)	(0.489)	(0.483)	(0.483)	(0.483)	(0.486)
	Automobile, Other transportation	-0.027	-0.034	-0.035	-0.043	-0.141	-0.144	-0.095	-0.097	-0.117	-0.117
		(0.514)	(0.515)	(0.508)	(0.509)	(0.501)	(0.504)	(0.503)	(0.504)	(0.499)	(0.500)
5.a	MNCs (2.c)	0.728 **	0.683 **			0.642 **	0.698 **	0.730 **	0.742 **	0.730 **	0.732 **
		(0.316)	(0.289)			(0.303)	(0.307)	(0.304)	(0.307)	(0.302)	(0.302)
5.b	Public Institutes ((4.a, 4.d, 4.f, 4.i)	0.060		0.159		0.167	0.253	0.260	0.261	0.227	0.262
		(0.321)		(0.288)		(0.315)	(0.310)	(0.309)	(0.309)	(0.311)	(0.310)
5.c	Universities (4.e, 4.g, 4.h)	-0.140			0.163	-0.206	-0.228	-0.213	-0.226	-0.183	-0.230
		(0.326)			(0.276)	(0.320)	(0.319)	(0.320)	(0.319)	(0.321)	(0.319)
3.b	Duration of the relationship with the customer	0.018	0.018	0.020	0.022	0.020	0.012	0.011	0.010	0.004	0.010
		(0.042)	(0.042)	(0.042)	(0.042)	(0.041)	(0.041)	(0.040)	(0.040)	(0.041)	(0.040)
3.c	Employment size of the customer	0.182	0.185	0.168	0.170	0.143	0.158	0.181	0.179	0.195	0.157
		(0.139)	(0.139)	(0.137)	(0.138)	(0.132)	(0.137)	(0.136)	(0.134)	(0.133)	(0.133)
3.d	Please indicate distance from your establishment to the customer (kilo	-0.060	-0.065	-0.076	-0.082	-0.045	-0.027	-0.024	-0.021	-0.033	-0.029
		(0.073)	(0.072)	(0.072)	(0.073)	(0.072)	(0.070)	(0.070)	(0.071)	(0.070)	(0.070)
3.e	How often does your establishment have communications for the collaborations?	0.188 **	0.183 **	0.179 **	0.173 *	0.159 *	0.194 **	0.207 **	0.210 **	0.228 ***	0.180 **
		(0.092)	(0.091)	(0.091)	(0.091)	(0.088)	(0.087)	(0.088)	(0.089)	(0.088)	(0.087)
8.f	Granted licensing technologies or know-how from other firms	0.426 **	0.432 **	0.453 **	0.467 ***	0.260					
		(0.183)	(0.180)	(0.183)	(0.180)	(0.159)					
10.a, 10.b	Does the customer/supplier dispatch an engineer to your establishment?	0.109	0.105	0.163	0.160		0.032				
		(0.222)	(0.222)	(0.217)	(0.218)		(0.174)				
10.c, 10.d	Does your establishment dispatch trainers to the customer/supplier?	-0.082	-0.088	-0.077	-0.084			-0.095			
		(0.253)	(0.252)	(0.250)	(0.250)			(0.185)			
10.e, 10.f	Does your establishment dispatch trainees to the customer/supplier?	-0.242	-0.236	-0.187	-0.186				-0.107		
		(0.250)	(0.249)	(0.248)	(0.248)				(0.187)		
11.a, 11.b	Recruit personnel who worked for the customer/supplier	-0.602 ***	-0.609 ***	-0.597 ***	-0.612 ***					-0.376 *	
		(0.228)	(0.227)	(0.227)	(0.227)					(0.199)	

11.c,	Is your establishment a spin-off from	0.377	0.377	0.277	0.281						0.220
11.d	the customer/supplier?	(0.271)	(0.271)	(0.265)	(0.265)						(0.250)
	Dummy (Indonesia)	0.911 **	0.878 **	1.046 ***	1.019 ***	0.811 **	0.858 **	0.835 **	0.848 **	0.904 **	0.853 **
		(0.374)	(0.356)	(0.355)	(0.368)	(0.358)	(0.360)	(0.357)	(0.356)	(0.360)	(0.358)
	Dummy (Thai)	0.000	-0.005	0.157	0.163	-0.264	-0.323	-0.297	-0.295	-0.281	-0.328
		(0.411)	(0.402)	(0.399)	(0.395)	(0.386)	(0.385)	(0.388)	(0.389)	(0.385)	(0.383)
	Dummy (Hanoi)	1.442 **	1.428 **	1.274 **	1.294 **	1.015 *	0.862	0.938 *	0.937 *	1.024 *	0.858
		(0.593)	(0.583)	(0.594)	(0.589)	(0.559)	(0.552)	(0.558)	(0.555)	(0.554)	(0.549)
	Dummy (Ho Chi Minh)	1.386 **	1.395 **	1.581 ***	1.582 ***	0.901	0.687	0.741	0.751	0.798	0.728
		(0.607)	(0.606)	(0.596)	(0.595)	(0.561)	(0.552)	(0.556)	(0.557)	(0.555)	(0.550)
	/cut1	1.457	1.435	1.356	1.298	1.171	1.244	1.338	1.329	1.377	1.217
		(0.790)	(0.778)	(0.784)	(0.771)	(0.765)	(0.762)	(0.779)	(0.772)	(0.763)	(0.761)
	/cut2	2.304	2.282	2.193	2.134	1.995	2.065	2.159	2.151	2.206	2.040
		(0.804)	(0.791)	(0.797)	(0.784)	(0.777)	(0.774)	(0.791)	(0.785)	(0.776)	(0.773)
	/cut3	3.129	3.107	3.005	2.947	2.803	2.871	2.964	2.956	3.020	2.845
		(0.819)	(0.806)	(0.810)	(0.798)	(0.791)	(0.787)	(0.805)	(0.798)	(0.791)	(0.787)
	/cut4	4.128	4.105	3.986	3.930	3.775	3.834	3.928	3.919	3.994	3.808
		(0.832)	(0.820)	(0.822)	(0.810)	(0.801)	(0.798)	(0.816)	(0.809)	(0.803)	(0.798)
	Number of observation	236	236	236	236	236	236	236	236	236	236
	Log likelihood	-320.53	-320.62	-323.29	-323.27	-325.36	-326.69	-326.57	-326.54	-324.93	-326.31
	Pseudo R2	0.092	0.092	0.084	0.084	0.079	0.075	0.075	0.075	0.080	0.076

Table A6 Estimation Result of Technological Capability Model (Table 10)

		Full model		Selected model 1		Selected model 2		Selected model 3		Selected model 4		Selected model 5		Selected model 6		Selected model 7		Selected model 8	
		Coef.		Coef.		Coef.		Coef.		Coef.		Coef.		Coef.		Coef.		Coef.	
	Age (establishment)	-0.006		-0.010	*	-0.010	*	-0.010	*	-0.010	*	-0.010	*	-0.010	*	-0.011	*	-0.006	
		(0.006)		(0.006)		(0.006)		(0.006)		(0.006)		(0.006)		(0.006)		(0.006)		(0.006)	
	Number of full-time employees (logarithmic)	0.159	***	0.198	***	0.200	***	0.199	***	0.210	***	0.203	***	0.222	***	0.207	***	0.200	***
		(0.057)		(0.054)		(0.056)		(0.054)		(0.053)		(0.054)		(0.054)		(0.054)		(0.053)	
	Textiles, Apparel, leather	-0.118		-0.165		-0.116		-0.225		-0.149		-0.098		-0.157		-0.160		-0.105	
		(0.250)		(0.243)		(0.246)		(0.245)		(0.245)		(0.246)		(0.244)		(0.244)		(0.245)	
	Wood, Paper products	-0.045		-0.121		-0.158		-0.151		-0.186		-0.094		-0.171		-0.119		-0.136	
		(0.258)		(0.253)		(0.252)		(0.254)		(0.253)		(0.254)		(0.253)		(0.252)		(0.252)	
	Coal, Chemical products	0.327		0.414		0.464		0.488		0.465		0.396		0.502	*	0.455		0.479	
		(0.309)		(0.305)		(0.305)		(0.304)		(0.305)		(0.304)		(0.303)		(0.304)		(0.305)	
	Iron, Metal products	-0.708	***	-0.669	***	-0.660	***	-0.661	***	-0.628	***	-0.596	***	-0.637	***	-0.660	***	-0.701	***
		(0.216)		(0.213)		(0.213)		(0.213)		(0.213)		(0.213)		(0.213)		(0.214)		(0.213)	
	Computers, Other electronics	0.111		0.207		0.176		0.200		0.155		0.180		0.206		0.228		0.129	
		(0.248)		(0.240)		(0.240)		(0.240)		(0.241)		(0.241)		(0.240)		(0.240)		(0.242)	
	Automobile, Other transportation	-0.191		0.013		0.019		0.003		0.040		0.009		0.053		-0.057		-0.035	
		(0.324)		(0.315)		(0.316)		(0.313)		(0.316)		(0.317)		(0.314)		(0.317)		(0.319)	
6	Does your establishment hold an intellectual property right?	0.252		0.513	***														
		(0.181)		(0.183)															
7	Does your establish carry out R&D activities?	-0.115				0.201													
		(0.186)				(0.159)													
8.a	OEM (Original Equipment Manufacturer)	0.383	**					0.633	***										
		(0.177)						(0.163)											
8.b	ODM (Original Design Manufacturer)	0.144								0.439	***								
		(0.169)								(0.146)									
8.c	OBM (Original Brand Manufacturer)	0.410	**									0.632	***						
		(0.177)										(0.156)							
8.d	Adoption of ISO 9000, 14000 series or other international standards	0.013												-0.014					
		(0.167)												(0.179)					
8.e	Operating QM (Quality Management) or QC (Quality Control) activities	0.272														0.439	**		
		(0.192)														(0.176)			
8.f	Granted licensing technologies or know-how from other firms	0.595	***															0.684	***
		(0.155)																(0.153)	
	Dummy (Indonesia)	0.869	***	1.033	***	1.004	***	0.899	***	0.948	***	1.009	***	0.983	***	0.820	***	0.983	***
		(0.240)		(0.224)		(0.224)		(0.225)		(0.224)		(0.225)		(0.224)		(0.233)		(0.223)	
	Dummy (Thai)	0.116		0.158		0.120		0.093		0.138		0.219		0.147		0.118		0.115	
		(0.246)		(0.241)		(0.242)		(0.242)		(0.241)		(0.242)		(0.241)		(0.241)		(0.241)	

Dummy (Hanoi)	0.127	0.407 **	0.328	0.186	0.200	0.146	0.334	0.361 *	0.334
	(0.219)	(0.206)	(0.205)	(0.208)	(0.210)	(0.210)	(0.205)	(0.205)	(0.205)
Dummy (Ho Chi Minh)	1.155 ***	1.411 ***	1.424 ***	1.037 ***	1.338 ***	1.220 ***	1.469 ***	1.471 ***	1.697 ***
	(0.257)	(0.211)	(0.213)	(0.238)	(0.215)	(0.220)	(0.211)	(0.210)	(0.218)
/cut1	-0.653	-0.844	-1.134	-1.102	-1.074	-0.965	-1.137	-1.149	-0.935
	(0.338)	(0.332)	(0.316)	(0.316)	(0.317)	(0.320)	(0.316)	(0.316)	(0.319)
/cut2	0.363	0.136	-0.162	-0.124	-0.100	0.020	-0.168	-0.174	0.055
	(0.334)	(0.326)	(0.308)	(0.309)	(0.309)	(0.313)	(0.308)	(0.308)	(0.312)
/cut3	1.416	1.151	0.844	0.895	0.909	1.037	0.836	0.835	1.080
	(0.338)	(0.329)	(0.309)	(0.310)	(0.310)	(0.315)	(0.309)	(0.309)	(0.314)
/cut4	2.604	2.293	1.979	2.049	2.052	2.184	1.969	1.976	2.236
	(0.346)	(0.335)	(0.315)	(0.316)	(0.316)	(0.321)	(0.315)	(0.315)	(0.321)
Number of observation	715	715	715	715	715	715	715	715	715
Log likelihood	-968.16	-988.37	-991.50	-984.72	-987.77	-984.06	-992.29	-989.15	-982.03
Pseudo R2	0.078	0.059	0.056	0.062	0.059	0.063	0.055	0.058	0.065

Table A7 Estimation Result of Human Capability Model (Table 11)

		Full model	Selected model 1	Selected model 2	Selected model 3	Selected model 4	Selected model 5	Selected model 6
		Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
	Age (establishment)	-0.009	-0.010 *	-0.010 *	-0.010 *	-0.010 *	-0.009	-0.009
		(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
	Number of full-time employees (logarithmic)	0.185 ***	0.209 ***	0.202 ***	0.220 ***	0.222 ***	0.203 ***	0.203 ***
		(0.055)	(0.054)	(0.054)	(0.053)	(0.053)	(0.054)	(0.054)
	Textiles, Apparel, leather	-0.035	-0.123	-0.100	-0.155	-0.162	-0.089	-0.085
		(0.250)	(0.245)	(0.245)	(0.244)	(0.245)	(0.247)	(0.246)
	Wood, Paper products	-0.113	-0.168	-0.124	-0.168	-0.173	-0.141	-0.144
		(0.252)	(0.251)	(0.252)	(0.252)	(0.252)	(0.253)	(0.252)
	Coal, Chemical products	0.392	0.475	0.411	0.496	0.511 *	0.484	0.408
		(0.310)	(0.304)	(0.304)	(0.304)	(0.305)	(0.304)	(0.307)
	Iron, Metal products	-0.708 ***	-0.630 ***	-0.695 ***	-0.636 ***	-0.635 ***	-0.669 ***	-0.659 ***
		(0.213)	(0.212)	(0.213)	(0.212)	(0.213)	(0.213)	(0.213)
	Computers, Other electronics	0.115	0.208	0.130	0.208	0.214	0.162	0.163
		(0.244)	(0.239)	(0.242)	(0.239)	(0.240)	(0.241)	(0.241)
	Automobile, Other transportation	-0.115	0.030	-0.089	0.047	0.058	0.027	-0.025
		(0.318)	(0.314)	(0.318)	(0.315)	(0.314)	(0.313)	(0.316)
9.a	Top management owns a bachelor (BA), master or Ph.D. degree	0.161	0.260					
		(0.174)	(0.170)					
9.b	Top management owns an experience of working for a MNC/JV	0.452 ***		0.508 ***				
		(0.156)		(0.146)				
9.c	Spin-off or headhunted from a MNC/JV or local large firm	-0.130			0.084			
		(0.287)			(0.279)			
9.d	Percentage of engineers are technical college graduates or higher	-0.143				-0.046		
		(0.172)				(0.169)		
10.a, 10.b	Does the customer/supplier dispatch an engineer to your establishment?	0.237					0.384 **	
		(0.190)					(0.164)	
10.c, 10.d,	Does your establishment (customer/supplier) dispatch trainees to the customer/supplier (your establishment)?	0.151						0.395 **
		(0.196)						(0.168)
	Dummy (Indonesia)	1.002 ***	0.988 ***	0.959 ***	0.986 ***	0.977 ***	1.067 ***	1.014 ***
		(0.229)	(0.223)	(0.224)	(0.223)	(0.225)	(0.227)	(0.224)
	Dummy (Thai)	0.023	0.093	0.082	0.150	0.152	0.125	0.071
		(0.244)	(0.243)	(0.241)	(0.241)	(0.241)	(0.240)	(0.242)
	Dummy (Hanoi)	0.290	0.355 *	0.333	0.331	0.353	0.226	0.205
		(0.226)	(0.205)	(0.204)	(0.205)	(0.216)	(0.210)	(0.212)
	Dummy (Ho Chi Minh)	1.402 ***	1.474 ***	1.442 ***	1.457 ***	1.493 ***	1.345 ***	1.315 ***
		(0.243)	(0.210)	(0.212)	(0.215)	(0.226)	(0.217)	(0.220)

/cut1	-0.999	-1.134	-1.062	-1.141	-1.151	-1.027	-1.041
	(0.324)	(0.316)	(0.317)	(0.317)	(0.320)	(0.320)	(0.319)
/cut2	-0.010	-0.162	-0.082	-0.172	-0.181	-0.049	-0.061
	(0.318)	(0.308)	(0.309)	(0.309)	(0.312)	(0.312)	(0.311)
/cut3	1.017	0.845	0.934	0.832	0.823	0.963	0.953
	(0.320)	(0.309)	(0.310)	(0.309)	(0.313)	(0.314)	(0.313)
/cut4	2.170	1.981	2.082	1.965	1.956	2.101	2.090
	(0.326)	(0.315)	(0.317)	(0.315)	(0.319)	(0.320)	(0.319)
Number of observation	715	715	715	715	715	715	715
Log likelihood	-983.35	-991.12	-986.18	-992.25	-992.25	-989.55	-989.54
Pseudo R2	0.063	0.056	0.061	0.055	0.055	0.058	0.058

Table A8 Estimation Result of Linkage-capability Model I (Table 12)

	6. Does your establishment hold an intellectual property right?			7. Does your establish carry out R&D activities?			8.a. OEM (Original Equipment Manufacturer)			8.b. ODM (Original Design Manufacturer)		
	Case (I)	Case (II)	Case (III)	Case (I)	Case (II)	Case (III)	Case (I)	Case (II)	Case (III)	Case (I)	Case (II)	Case (III)
Source	0.492 ***	0.271 *	0.165	0.646 ***	0.409 **	0.335 **	0.580 ***	0.250	0.046	0.512 ***	0.271	0.136
	(0.161)	(0.162)	(0.155)	(0.157)	(0.162)	(0.154)	(0.182)	(0.180)	(0.179)	(0.170)	(0.175)	(0.174)
Cross term	0.528 **	0.646 ***	0.497 **	0.022	0.084	-0.195	0.143	0.346 *	0.458 **	0.310 *	0.336 *	0.310
	(0.207)	(0.209)	(0.224)	(0.222)	(0.211)	(0.230)	(0.212)	(0.178)	(0.196)	(0.186)	(0.176)	(0.193)
Dummy (Indonesia)	0.640 ***	0.573 **	0.671 ***	0.711 ***	0.725 ***	0.752 ***	0.699 ***	0.702 ***	0.769 ***	0.702 ***	0.716 ***	0.762 ***
	(0.216)	(0.224)	(0.222)	(0.214)	(0.220)	(0.219)	(0.215)	(0.219)	(0.219)	(0.215)	(0.219)	(0.219)
Dummy (Thai)	-0.189	-0.152	-0.076	-0.189	-0.127	-0.072	-0.182	-0.107	-0.016	-0.173	-0.103	-0.039
	(0.234)	(0.236)	(0.234)	(0.234)	(0.236)	(0.234)	(0.234)	(0.236)	(0.235)	(0.234)	(0.236)	(0.235)
Dummy (Ho Chi Minh)	1.273 ***	1.572 ***	1.545 ***	1.214 ***	1.558 ***	1.513 ***	1.141 ***	1.459 ***	1.439 ***	1.140 ***	1.509 ***	1.491 ***
	(0.220)	(0.207)	(0.206)	(0.218)	(0.207)	(0.206)	(0.242)	(0.212)	(0.209)	(0.222)	(0.208)	(0.207)
Dummy (Hanoi)	0.179	0.101	0.125	0.140	0.026	0.063	0.126	-0.021	0.060	0.108	-0.036	0.046
	(0.193)	(0.202)	(0.200)	(0.193)	(0.202)	(0.199)	(0.193)	(0.201)	(0.198)	(0.193)	(0.202)	(0.199)
/cut1	-1.709	-1.745	-1.824	-1.708	-1.729	-1.830	-1.719	-1.773	-1.850	-1.726	-1.758	-1.836
	(0.173)	(0.178)	(0.172)	(0.173)	(0.178)	(0.173)	(0.173)	(0.180)	(0.173)	(0.173)	(0.179)	(0.173)
/cut2	-0.769	-0.811	-0.896	-0.771	-0.800	-0.905	-0.781	-0.844	-0.923	-0.788	-0.827	-0.909
	(0.154)	(0.160)	(0.152)	(0.154)	(0.160)	(0.153)	(0.154)	(0.161)	(0.153)	(0.154)	(0.160)	(0.153)
/cut3	0.211	0.156	0.062	0.206	0.160	0.053	0.196	0.118	0.037	0.191	0.136	0.048
	(0.151)	(0.156)	(0.148)	(0.151)	(0.156)	(0.148)	(0.151)	(0.157)	(0.148)	(0.151)	(0.156)	(0.148)
/cut4	1.327	1.261	1.160	1.315	1.254	1.146	1.305	1.217	1.135	1.303	1.233	1.141
	(0.157)	(0.161)	(0.152)	(0.157)	(0.161)	(0.152)	(0.157)	(0.162)	(0.152)	(0.157)	(0.161)	(0.152)
Number of observation	738	738	738	738	738	738	738	738	738	738	738	738
Log likelihood	-1033.71	-1037.88	-1042.07	-1037.03	-1042.64	-1044.22	-1036.81	-1040.83	-1041.84	-1035.65	-1040.88	-1043.28
Pseudo R2	0.048	0.044	0.040	0.045	0.039	0.038	0.045	0.041	0.040	0.046	0.041	0.039

Note: Case (I): MNCs
Case (II): Public Institutes
Case (III): University

	8.c. OBM (Original Brand Manufacturer)			8.d. Adopting ISO 9000, 14000 series or other international standards			8.e. Operating QM (Quality Management) or QC (Quality Control) activities			8.f. Granted licensing technologies or know-how from other firms		
	Case (I)	Case (II)	Case (III)	Case (I)	Case (II)	Case (III)	Case (I)	Case (II)	Case (III)	Case (I)	Case (II)	Case (III)
Source	0.439 **	0.111	0.060	0.743 ***	0.338 *	0.510 ***	0.494 **	0.085	0.078	0.552 ***	0.272	0.185
	(0.185)	(0.187)	(0.190)	(0.199)	(0.189)	(0.196)	(0.247)	(0.236)	(0.239)	(0.178)	(0.170)	(0.170)
Cross term	0.384 *	0.538 ***	0.373 *	-0.143	0.145	-0.330 *	0.198	0.412 *	0.263	0.194	0.373 **	0.227
	(0.201)	(0.181)	(0.200)	(0.202)	(0.177)	(0.200)	(0.252)	(0.214)	(0.234)	(0.192)	(0.174)	(0.190)
Dummy (Indonesia)	0.725 ***	0.761 ***	0.797 ***	0.695 ***	0.740 ***	0.716 ***	0.713 ***	0.743 ***	0.776 ***	0.718 ***	0.734 ***	0.769 ***
	(0.215)	(0.220)	(0.220)	(0.215)	(0.221)	(0.220)	(0.214)	(0.219)	(0.219)	(0.214)	(0.219)	(0.219)
Dummy (Thai)	-0.140	-0.046	-0.005	-0.180	-0.137	-0.064	-0.202	-0.121	-0.071	-0.188	-0.140	-0.079
	(0.235)	(0.237)	(0.237)	(0.235)	(0.236)	(0.234)	(0.235)	(0.235)	(0.234)	(0.234)	(0.236)	(0.234)
Dummy (Ho Chi Minh)	1.085 ***	1.468 ***	1.480 ***	1.236 ***	1.539 ***	1.546 ***	1.181 ***	1.535 ***	1.512 ***	1.275 ***	1.611 ***	1.543 ***
	(0.228)	(0.209)	(0.207)	(0.220)	(0.207)	(0.206)	(0.221)	(0.207)	(0.206)	(0.227)	(0.209)	(0.207)
Dummy (Hanoi)	0.106	-0.071	0.046	0.134	0.028	0.070	0.150	0.061	0.103	0.141	0.022	0.070
	(0.193)	(0.203)	(0.199)	(0.192)	(0.201)	(0.199)	(0.193)	(0.202)	(0.200)	(0.192)	(0.200)	(0.198)
/cut1	-1.724	-1.778	-1.833	-1.711	-1.736	-1.823	-1.709	-1.737	-1.822	-1.705	-1.722	-1.821
	(0.173)	(0.180)	(0.173)	(0.173)	(0.178)	(0.172)	(0.173)	(0.178)	(0.172)	(0.173)	(0.178)	(0.172)
/cut2	-0.785	-0.841	-0.905	-0.773	-0.806	-0.896	-0.771	-0.804	-0.895	-0.766	-0.789	-0.894
	(0.154)	(0.161)	(0.153)	(0.154)	(0.160)	(0.152)	(0.154)	(0.160)	(0.152)	(0.154)	(0.160)	(0.152)
/cut3	0.193	0.126	0.052	0.204	0.155	0.060	0.207	0.158	0.063	0.212	0.177	0.064
	(0.151)	(0.157)	(0.148)	(0.151)	(0.156)	(0.147)	(0.151)	(0.156)	(0.148)	(0.151)	(0.156)	(0.148)
/cut4	1.306	1.226	1.145	1.313	1.249	1.153	1.316	1.255	1.155	1.321	1.276	1.157
	(0.157)	(0.161)	(0.152)	(0.157)	(0.161)	(0.152)	(0.157)	(0.161)	(0.152)	(0.157)	(0.161)	(0.152)
Number of observation	738	738	738	738	738	738	738	738	738	738	738	738
Log likelihood	-1035.22	-1038.30	-1042.83	-1036.79	-1042.38	-1043.20	-1036.73	-1040.87	-1043.95	-1036.52	-1040.40	-1043.86
Pseudo R2	0.046	0.043	0.039	0.045	0.040	0.039	0.045	0.041	0.038	0.045	0.041	0.038

Note: Case (I): MNCs
Case (II): Public Institutes
Case (III): University

Table A9 Estimation Result of Linkage-capability Model II (Table 12)

	9.a. Top management owns a bachelor (BA), master or Ph.D. degree			9.b. Top management owns an experience of working for a MNC/JV			9.c. Spin-off or headhunted from a MNC/JV or local large firm		
	Case (I)	Case (II)	Case (III)	Case (I)	Case (II)	Case (III)	Case (I)	Case (II)	Case (III)
Source	0.590 ***	0.353 **	0.229	0.514 ***	0.165	0.136	0.637 ***	0.438 ***	0.298 **
	(0.159)	(0.163)	(0.157)	(0.178)	(0.177)	(0.173)	(0.151)	(0.159)	(0.149)
Cross term	0.227	0.293	0.217	0.250	0.523 ***	0.310	0.156	-0.077	-0.058
	(0.205)	(0.201)	(0.216)	(0.182)	(0.174)	(0.190)	(0.290)	(0.316)	(0.347)
Dummy (Indonesia)	0.718 ***	0.727 ***	0.775 ***	0.718 ***	0.730 ***	0.765 ***	0.716 ***	0.713 ***	0.758 ***
	(0.214)	(0.219)	(0.219)	(0.215)	(0.219)	(0.219)	(0.215)	(0.220)	(0.219)
Dummy (Thai)	-0.228	-0.185	-0.106	-0.190	-0.150	-0.073	-0.188	-0.129	-0.073
	(0.237)	(0.239)	(0.236)	(0.234)	(0.235)	(0.234)	(0.234)	(0.236)	(0.234)
Dummy (Ho Chi Minh)	1.219 ***	1.553 ***	1.532 ***	1.219 ***	1.523 ***	1.526 ***	1.192 ***	1.560 ***	1.524 ***
	(0.218)	(0.207)	(0.206)	(0.218)	(0.207)	(0.206)	(0.221)	(0.209)	(0.207)
Dummy (Hanoi)	0.158	0.042	0.098	0.155	0.062	0.097	0.138	0.014	0.075
	(0.193)	(0.201)	(0.200)	(0.193)	(0.201)	(0.199)	(0.192)	(0.200)	(0.198)
/cut1	-1.707	-1.737	-1.820	-1.706	-1.754	-1.823	-1.709	-1.732	-1.822
	(0.173)	(0.178)	(0.172)	(0.173)	(0.179)	(0.172)	(0.173)	(0.178)	(0.172)
/cut2	-0.768	-0.806	-0.893	-0.766	-0.820	-0.896	-0.772	-0.802	-0.897
	(0.154)	(0.160)	(0.152)	(0.154)	(0.160)	(0.152)	(0.154)	(0.160)	(0.152)
/cut3	0.210	0.157	0.064	0.213	0.149	0.064	0.205	0.158	0.059
	(0.151)	(0.156)	(0.148)	(0.151)	(0.156)	(0.148)	(0.151)	(0.156)	(0.147)
/cut4	1.320	1.253	1.156	1.323	1.255	1.158	1.314	1.252	1.151
	(0.157)	(0.161)	(0.152)	(0.157)	(0.161)	(0.152)	(0.157)	(0.161)	(0.152)
Number of observation	738	738	738	738	738	738	738	738	738
Log likelihood	-1036.42	-1041.65	-1044.07	-1036.08	-1038.15	-1043.24	-1036.89	-1042.69	-1044.56
Pseudo R2	0.045	0.040	0.038	0.045	0.044	0.039	0.045	0.039	0.038

Note: Case (I): MNCs
Case (II): Public Institutes
Case (III): University

	9.d. Percentage of engineers are technical college graduates or higher			10.a, 10.b. Does the customer/supplier dispatch an engineer to your establishment?			10.c, 10.d, 10.e, 10.f. Does your establishment (customer/supplier) dispatch trainees to the customer/supplier (your establishment)?		
	Case (I)	Case (II)	Case (III)	Case (I)	Case (II)	Case (III)	Case (I)	Case (II)	Case (III)
Source	1.054 ***	0.716 ***	0.476 **	0.772 ***	0.293	0.242	0.686 ***	0.228	0.100
	(0.198)	(0.197)	(0.194)	(0.209)	(0.198)	(0.205)	(0.226)	(0.208)	(0.216)
Cross term	-0.677 ***	-0.452 **	-0.296	-0.178	0.206	0.072	-0.048	0.279	0.260
	(0.214)	(0.192)	(0.208)	(0.215)	(0.190)	(0.211)	(0.229)	(0.194)	(0.218)
Dummy (Indonesia)	0.623 ***	0.620 ***	0.701 ***	0.674 ***	0.773 ***	0.777 ***	0.703 ***	0.774 ***	0.806 ***
	(0.216)	(0.223)	(0.222)	(0.219)	(0.225)	(0.224)	(0.216)	(0.223)	(0.222)
Dummy (Thai)	-0.185	-0.144	-0.080	-0.194	-0.126	-0.071	-0.188	-0.137	-0.071
	(0.235)	(0.236)	(0.234)	(0.235)	(0.235)	(0.234)	(0.234)	(0.235)	(0.234)
Dummy (Ho Chi Minh)	1.462 ***	1.641 ***	1.570 ***	1.250 ***	1.536 ***	1.514 ***	1.222 ***	1.528 ***	1.497 ***
	(0.232)	(0.210)	(0.209)	(0.223)	(0.207)	(0.207)	(0.223)	(0.208)	(0.207)
Dummy (Hanoi)	0.210	0.118	0.123	0.154	-0.016	0.068	0.142	-0.014	0.051
	(0.194)	(0.205)	(0.201)	(0.193)	(0.202)	(0.200)	(0.193)	(0.201)	(0.200)
/cut1	-1.697	-1.710	-1.811	-1.707	-1.742	-1.824	-1.708	-1.747	-1.833
	(0.173)	(0.178)	(0.172)	(0.173)	(0.178)	(0.172)	(0.173)	(0.179)	(0.173)
/cut2	-0.753	-0.778	-0.884	-0.770	-0.811	-0.899	-0.771	-0.814	-0.905
	(0.154)	(0.160)	(0.153)	(0.154)	(0.160)	(0.152)	(0.154)	(0.160)	(0.153)
/cut3	0.232	0.187	0.073	0.206	0.152	0.057	0.206	0.149	0.053
	(0.151)	(0.156)	(0.148)	(0.151)	(0.156)	(0.148)	(0.151)	(0.156)	(0.148)
/cut4	1.351	1.288	1.167	1.317	1.247	1.149	1.315	1.245	1.145
	(0.158)	(0.162)	(0.153)	(0.157)	(0.161)	(0.152)	(0.157)	(0.161)	(0.152)
Number of observation	738	738	738	738	738	738	738	738	738
Log likelihood	-1031.96	-1039.92	-1043.55	-1036.69	-1042.13	-1044.51	-1037.01	-1041.68	-1043.86
Pseudo R2	0.049	0.042	0.039	0.045	0.040	0.038	0.045	0.040	0.038

Note: Case (I): MNCs
Case (II): Public Institutes
Case (III): University

Table A10 Estimation Result of Capability Required for MNCs (Table 13)

		Full model	Selected model 1	Selected model 2	Selected model 3	Selected model 4	Selected model 5	Selected model 6	Selected model 7
		Marginal Effect	Marginal Effect	Marginal Effect	Marginal Effect	Marginal Effect	Marginal Effect	Marginal Effect	Marginal Effect
6	Does your establishment hold an	0.098 **	0.067						
	intellectual property right?	(0.049)	(0.050)						
8.b	ODM (Original Design	-0.005		0.055					
	Manufacturer)	(0.049)		(0.041)					
8.c	OBM (Original Brand	0.016			0.081 *				
	Manufacturer)	(0.051)			(0.043)				
8.e	Operation of QM (Quality	-0.021				0.144 ***			
	Management) or QC (Quality	(0.052)				(0.044)			
8.f	Granted licensing technologies or	0.143 ***					0.203 ***		
	know-how from other firms	(0.041)					(0.038)		
9.b	Top management owns an	0.163 ***						0.130 ***	
	experience of working for a	(0.041)						(0.045)	
9.d	Percentage of engineers are	0.090 *							0.177 ***
	technical college graduates or	(0.047)							(0.039)
	Dummy (Indonesia)	0.233 ***	0.238 ***	0.229 ***	0.234 ***	0.193 ***	0.239 ***	0.249 ***	0.239 ***
		(0.049)	(0.044)	(0.045)	(0.044)	(0.049)	(0.045)	(0.044)	(0.045)
	Dummy (Thai)	0.274 ***	0.284 ***	0.283 ***	0.287 ***	0.278 ***	0.273 ***	0.280 ***	0.281 ***
		(0.045)	(0.043)	(0.043)	(0.043)	(0.044)	(0.044)	(0.044)	(0.044)
	Dummy (Ho Chi Minh)	0.447 ***	0.450 ***	0.445 ***	0.436 ***	0.457 ***	0.449 ***	0.421 ***	0.478 ***
		(0.037)	(0.033)	(0.034)	(0.035)	(0.032)	(0.033)	(0.037)	(0.031)
	Dummy (Hanoi)	0.057	0.094 *	0.069	0.061	0.099 *	0.087 *	0.038	0.079
		(0.059)	(0.051)	(0.053)	(0.054)	(0.051)	(0.052)	(0.055)	(0.052)

Table A11 Capability Required for Public Institutions (Table 14)

		Full model	Selected model 1	Selected model 2	Selected model 3	Selected model 4	Selected model 5	Selected model 6	Selected model 7	Selected model 8	Selected model 9
		Marginal Effect	Marginal Effect	Marginal Effect	Marginal Effect	Marginal Effect	Marginal Effect	Marginal Effect	Marginal Effect	Marginal Effect	Marginal Effect
6	Does your establishment hold an	-0.037	0.098 *								
	intellectual property right?	(0.050)	(0.053)								
7	Does your establish carry out R&D	0.077		0.026							
	activities?	(0.047)		(0.046)							
8.a	OEM (Original Equipment	-0.022			0.053						
	Manufacturer)	(0.052)			(0.040)						
8.b	ODM (Original Design	0.004				0.067					
	Manufacturer)	(0.049)				(0.043)					
8.c	OBM (Original Brand	0.025					0.094 **				
	Manufacturer)	(0.051)					(0.045)				
8.e	Operation of QM (Quality	0.037						0.006			
	Management) or QC (Quality	(0.037)						(0.046)			
8.f	Granted licensing technologies or	0.125 ***							0.119 ***		
	know-how from other firms	(0.040)							(0.038)		
9.b	Top management owns an	0.087 **								0.124 ***	
	experience of working for a	(0.040)								(0.046)	
9.d	Percentage of engineers are	0.082 *									0.141 ***
	technical college graduates or	(0.048)									(0.038)
	Dummy (Indonesia)	0.329 ***	0.305 ***	0.295 ***	0.296 ***	0.299 ***	0.303 ***	0.295 ***	0.299 ***	0.309 ***	0.301 ***
		(0.035)	(0.035)	(0.036)	(0.036)	(0.036)	(0.036)	(0.037)	(0.036)	(0.035)	(0.036)
	Dummy (Thai)	0.308 ***	0.312 ***	0.308 ***	0.310 ***	0.313 ***	0.311 ***	0.309 ***	0.304 ***	0.308 ***	0.307 ***
		(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.036)	(0.035)	(0.035)
	Dummy (Ho Chi Minh)	-0.050	-0.043	-0.049	-0.051	-0.063	-0.020	-0.030	-0.048	-0.099 *	0.004
		(0.071)	(0.052)	(0.062)	(0.054)	(0.056)	(0.051)	(0.051)	(0.053)	(0.059)	(0.051)
	Dummy (Hanoi)	0.284 ***	0.306 ***	0.292 ***	0.286 ***	0.283 ***	0.303 ***	0.296 ***	0.298 ***	0.267 ***	0.295 ***
		(0.042)	(0.036)	(0.037)	(0.037)	(0.038)	(0.036)	(0.036)	(0.036)	(0.040)	(0.036)

8

Empirical Analysis of Innovation and the Proximity of Information Linkages in ASEAN Economies: Case of Indonesia, the Philippines, Thailand and Vietnam

Masatsugu Tsuji and Shoichi Miyahara

Abstract

The success factors of remarkable economic growth East Asian economies lie in the agglomeration of firms in this region, being initiated by MNCs. The agglomeration created another agglomeration in such a way that MNCs' affiliated firms, such as parts suppliers and supporting firms, were founded in locations near the MNCs and local firms were developed due to technology transfer from MNCs. This leads to the transformation of the regional economies into innovative economies: transformation from agglomeration to innovation. A key factor is information flow among all entities of the area; information is related to technology, know-how, management, marketing and market, and on the sources of information such as university, public agencies, industry/trade organizations, and public R&D institutions as well as MNCs. The transmission channel of information to firms is referred to as "linkages." This paper classifies this into four categories; (i) production; (ii) research; (iii) human; and (iv) other linkages. Based on comprehensive surveys conducted in four ASEAN economies (Indonesia, the Philippines, Thailand and Vietnam), and received approximately 700 responses. Based on the surveys, this paper attempts to identify rigorously which linkages are statistically significant for innovation. This paper is particularly concerned with the proximity between firms and partners, and attempts to examine whether neighboring or remote partners are more related to their innovation. By rigorous econometric analysis, among the production linkages, MNCs are identified. Government owned financial institutions government/public research intuitions are found to be significant among research linkages. As for human linkages, recruiting managers as well as engineers from various sources such as MNCs, JVs or other large firms are found significant. Related to the proximity, government-owned financial institutions located in the neighboring areas and remote government/public agencies or government/public research institutions are found to be significant. This paper also identified required linkages for firms to upgrade from low to high level of innovation.

1. INTRODUCTION

East Asian economies have been achieving remarkable economic growth. One of their success factors lies in the agglomeration of firms in this region, giving it the moniker, “Factory of the World.” Multi-national corporations (MNCs) have been establishing their factories or branch headquarters in this region since the middle of 1980s in order to exploit relatively cheap natural resources such as labor, land and raw materials. MNCs combined these resources with their technologies, including business management and engineering. This initiated a “big bang” of economic growth in the region, and since then more firms have been agglomerating in this region. The agglomeration created the following two transformations of the regional economies: (i) MNCs’ affiliated firms, such as parts suppliers and supporting firms, were founded in locations near the MNCs; and (ii) local firms were established by local business people, due to technology transfer from MNCs.[1] Technology transfer consists of various forms such as formal and informal; the former includes local firms learning technology and know-how from MNCs, whereas in the latter, they learned technology from backward engineering or copying new products. By repeating these processes of agglomeration and upgrading, the areas then became industrial clusters, and sustainable economic growth is being achieving exactly as described by the endogenous growth theory. Industrial clusters in these areas originated as production bases. But further agglomeration itself created the power to transform the clusters. The more firms or factories agglomerated, the more the flow of information grew and became enriched. This resulted in the second explosion in the areas. In other words, agglomeration created the transformation from quantity to quality in these areas. This is the second developing process which can be viewed from the point of innovation and upgrading. The aftermath of these processes is qualitative transformation in these areas, that is, more innovation and upgrading are being achieved. Previous studies have clearly identified these

[1] The agglomeration is hypothesized by Kuchiki and Tsuji (2005), (2008) and (2009) as the Flowchart approach, which represents the requirements of industrial clustering. This approach vividly describes the clustering process in East Asia as follows: first MNCs, referred to as anchor firms, establish their factories in industrial estates or parks, and then parts suppliers and supporting firms are established near them. This is origin of industrial clusters in an area.

activities as increasing.[2]

The main issues in this context are how information on technology and management has been transmitted among local entities in the region, and how information has contributed to innovation performances in the region. This mechanism consists of following two elements: (i) sources of information from the view point of the recipients; and (ii) contents of information conveyed in the mechanism. The former can be termed information linkages. Examples include MNCs, customers, suppliers, and competitors in the regions or government/public agencies such as universities, or regional research institutions. The latter is related to technology, management, skills of engineers and workers, etc. It is difficult, however, to distinguish these two elements clearly, and accordingly this paper attempts to identify which transmission channels or linkages contributes more significantly to innovation performances of firms in their areas.

Other issues are related to the relevancy between agglomeration and innovation. In this context, Fujita, Krugman, and Venables (1999), Krugman (1991), Porter (1980), Markusen (1996) and Saxenian (1994) present representative theories. The essence of these theories lies in the flow of information generated by agglomeration; that is, in areas where firms, research institutions and other organizations agglomerate, collaboration and competition among those entities and organizations create positive motions for spontaneous upgrading or innovation. In our previous papers, we verified the relationship between agglomeration and innovation by applying the Flowchart approach initiated by Kuchiki and Tsuji (2005), (2008), (2009). This paper, on the other hand, takes a different approach: we focus instead on the geographic proximity of linkages, that is, if neighboring or remote linkages have larger effects on innovation. Firms attempt to find and connect to partners for transactions in the market or for

[2] Tsuji, Miyahara and Ueki (2008), Tsuji and Miyahara (2009).

information related to innovation, and since partners are scattered all over an area, firms can choose them according to partners' locations as well as their specific advantages. This paper thus examines their proximity.

To do so, we conducted comprehensive surveys in four ASEAN economies (Indonesia, the Philippines, Thailand and Vietnam), and received approximately 700 responses. The surveys contained questions on information linkages required for innovation such as technology, know-how, management, marketing and market, and on the sources of information such as university, public agencies, industry/trade organizations, and public R&D institutions as well as global partners such as MNCs. Based on the surveys, this paper attempts to identify rigorously which linkages are statistically significant for innovation.

This paper consists of the five sections. Section 2 provides the results of survey conducted on four economies and shows the current situation of innovation and the sources of information that create innovation. In Section 3, we present the analytical methodology and estimation models. Their results are also extensively discussed in this section. The analysis here is based on the cross-section static data, but Section 4 utilizes a more dynamic methodology and analyzes factors that move these economies to innovative stages. A brief concluding discussion is provided in the final section. The conclusion is that technology transfer to firms seems to occur through human resources rather than production or research networks. This is an important conclusion obtained by this paper.

2. SURVEYS AND DATA

First, we present here the result of the survey conducted in November and December 2009 in four ASEAN economies (Indonesia, the Philippines, Thailand and Vietnam) that form the basis of the analysis in this study.

2.1. Innovation

(a) Product innovation

This mail survey sought to obtain fundamental data on the innovative activities as well as innovation performances of respondents. Following Schumpeter (1934), this paper defines two types of innovation as product and process innovation. First, the following four types of product innovation were asked in the questionnaire.

1. *What has your establishment achieved among the following?*

 (a) Significant change in packaging or appearance design

 (b) Significant improvement of an existing product/service

 (c) Development of a totally new product/service based on the existing technologies

 (d) Development of a totally new product/service based on new technologies

Schumpeter defined supplying new products or services as examples of product innovation, but this paper adopts the more detailed categories. From (1.a) to (1.d) the categories increase in the level of innovation. That is, we asked establishments about activities from simple improvement of existing products/services to creating entire new products/services based on new technologies. The distribution of product innovation in different economies is summarized in Table 1 and Figure 1. Firms in each economy have been accomplishing quite more innovative achievements, which is quite different from those of previous two surveys.

Table 1 Product Innovation

	Indonesia		Philippines		Thailand		Vietnam		Total	
	freq.	%	freq.	%	freq.	%	freq.	%	freq.	%
Significant change in packaging or appearance design	95	68.35	102	50.25	41	42.71	237	79.00	475	64.36
Significant improvement of an existing product/service	114	82.01	152	74.88	74	77.08	278	92.67	618	83.74
Development of a new product/service based on the existing technologies	102	73.38	113	55.67	60	62.50	234	78.00	509	68.97
Development of a new product/service based on new technologies	94	67.63	103	50.74	53	55.21	162	54.00	412	55.83

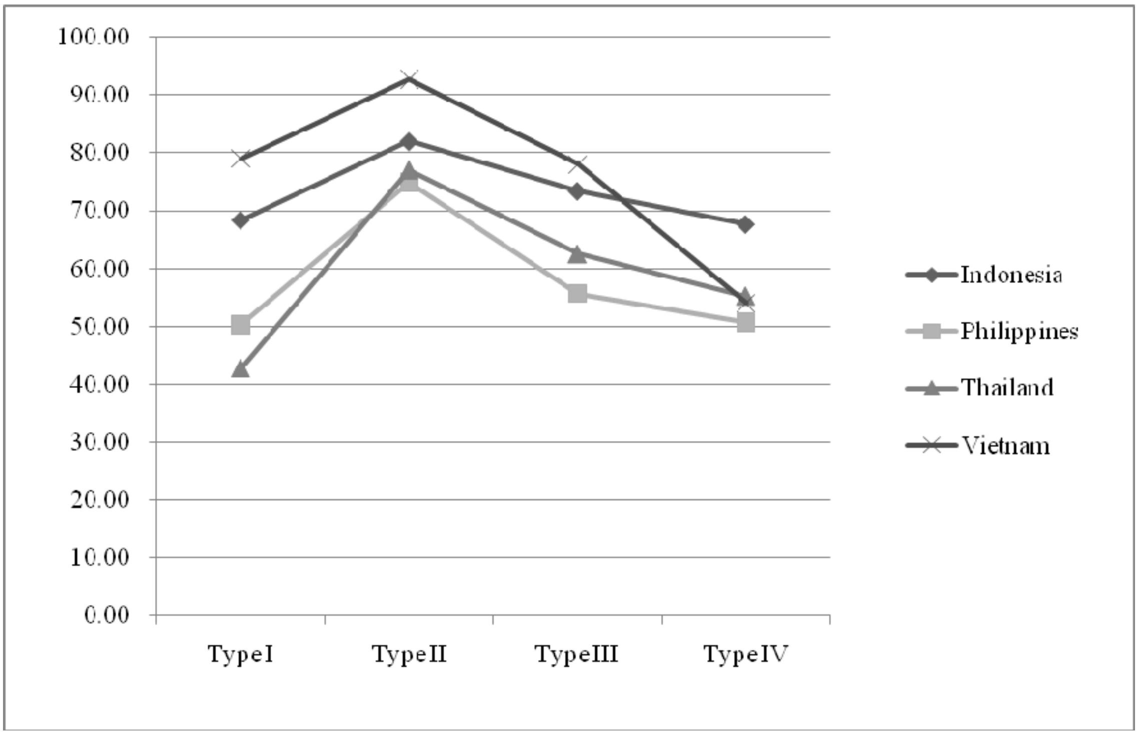


Figure 1 Product Innovation

Notes:
Type I Significant change in packaging or appearance design
Type II Significant improvement of an existing product/service
Type III Development of a new product/service based on the existing technologies
Type IV Development of a new product/service based on new technologies

(b) Process innovation

Schumpeterian definition of process innovation consists of (i) introducing new production or supply methods; (ii) obtaining new customers; (iii) finding new suppliers;

and (iv) establishing new managerial organization. In the questionnaire, the following question was related to process innovation:

2. *Has your establishment achieved substantial organizational changes in the following managerial systems?*

(a) Sales and marketing

(b) Quality control

(c) Production control and management

(d) Inventory control and management

In general, process innovation is not necessarily limited to these categories, but this paper focuses on the above four. Responses related to process innovation are presented in Table 2 and Figure 2. Again most economies show better performances than the previous surveys.

Table 2 Process Innovation

	Indonesia		Philippines		Thailand		Vietnam		Total	
	freq.	%	freq.	%	freq.	%	freq.	%	freq.	%
Sales and marketing	118	84.89	111	54.68	73	76.04	275	91.67	577	78.18
Quality control	131	94.24	147	72.41	82	85.42	259	86.33	619	83.88
Production control and management	122	87.77	152	74.88	75	78.13	249	83.00	598	81.03
Inventory control and management	110	79.14	132	65.02	75	78.13	235	78.33	552	74.80

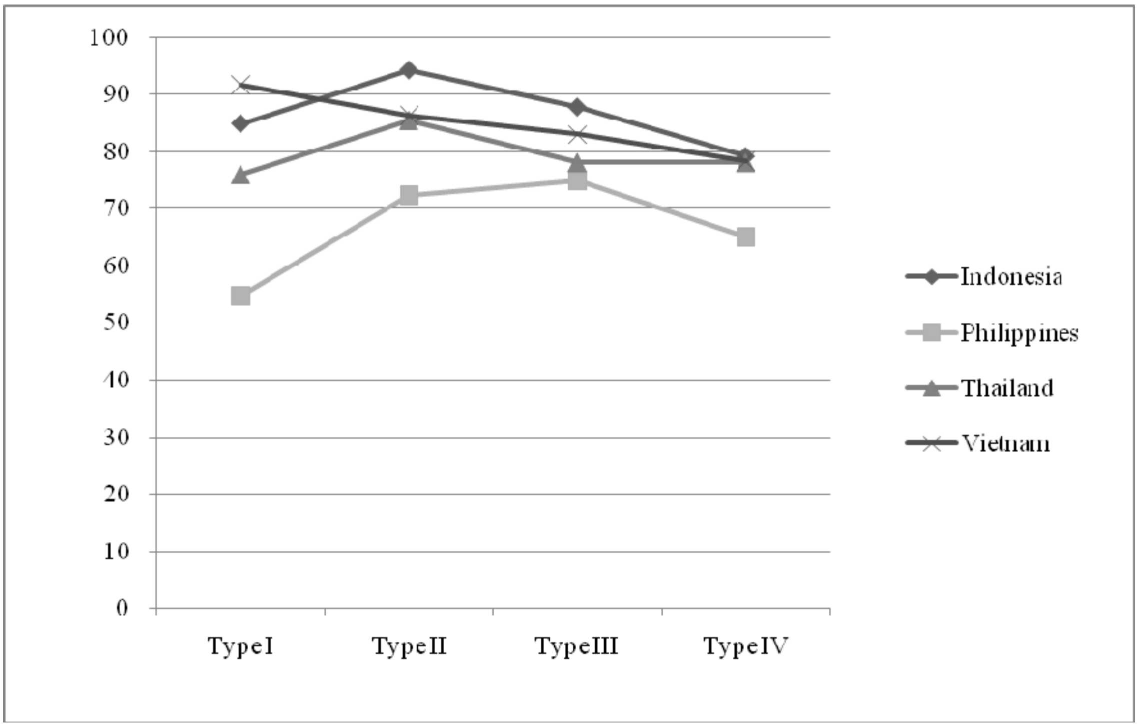


Figure 2 Process Innovation

Notes:	Type I	Sales and marketing
	Type II	Quality control
	Type III	Production control and management
	Type IV	Inventory control and management

2.2. Characteristics of Respondent Firms

Table 3 indicates the distribution of the year of establishment. Most firms are 11-20 years old, except in Vietnam, which has younger firms. Table 4 shows the type of establishment. In each economy, factory/plant accounts for more than 50 percent, followed by headquarters/main office. These two categories make up more than 90 percent of all establishments. The capital structure of establishments is shown in Table 5, which are mostly local owned. Tables 6 and Table 7 show the size of small and medium-sized enterprises (SMEs) in terms of employees and capital, respectively. The former shows the firms with less than 199 employees account for more than 50% of all firms, whereas the latter shows a different distribution. That is, larger firms with more than US$100,000 dominated. Thus the respondents belong to larger firms. Table 8 shows the distribution of the categories of industry to which the SMEs belong; each economy has a different distribution. In Indonesia and the Philippines, light industries such as food, beverages, and tobacco or apparel are dominant, whereas in Thailand and Vietnam, assembling and processing industries such as automobile and machinery are the largest categories.

Table 3 Years Since Establishment

	Indonesia		Philippines		Thailand		Vietnam		Total	
	freq.	%	freq.	%	freq.	%	freq.	%	freq.	%
0 - 10	39	29.77	48	23.65	18	21.18	157	52.51	262	36.49
11 - 20	39	29.77	101	49.75	31	36.47	100	33.44	271	37.74
21 - 30	33	25.19	30	14.78	17	20.00	19	6.35	99	13.79
31 - 40	16	12.21	15	7.39	12	14.12	16	5.35	59	8.22
41 - 50	3	2.29	7	3.45	3	3.53	6	2.01	19	2.65
over 50	1	0.76	2	0.99	3	3.53	1	0.33	7	0.97
Total	131		203		85		299		718	

Table 4 Type of Establishment

	Indonesia		Philippines		Thailand		Vietnam		Total	
	freq.	%	freq.	%	freq.	%	freq.	%	freq.	%
Headquarters/Main office	50	35.97	20	9.85	38	40.00	97	32.33	205	27.82
Regional Headquarters	3	2.16	1	0.49	3	3.16	4	1.33	11	1.49
Factory/Plant	78	56.12	182	89.66	46	48.42	197	65.67	503	68.25
Branch Office/Sales Office	8	5.76	0	0.00	8	8.42	2	0.67	18	2.44
Total	139		203		95		300		737	

Table 5 Capital Structure

	Indonesia		Philippines		Thailand		Vietnam		Total	
	freq.	%	freq.	%	freq.	%	freq.	%	freq.	%
100% Local-owned	109	79.56	101	49.75	60	63.16	231	77.00	501	68.16
100% Foreign-owned	12	8.76	54	26.60	13	13.68	54	18.00	133	18.10
Joint Venture	16	11.68	48	23.65	22	23.16	15	5.00	101	13.74
Total	137		203		95		300		735	

Table 6 Number of Full-time Employees

.	Indonesia		Philippines		Thailand		Vietnam		Total	
	freq.	%	freq.	%	freq.	%	freq.	%	freq.	%
1 - 19 persons	1	0.72	13	6.40	12	12.77	43	14.33	69	9.39
20 - 49	64	46.38	31	15.27	21	22.34	60	20.00	176	23.95
50 - 99	21	15.22	42	20.69	9	9.57	42	14.00	114	15.51
100 - 199	16	11.59	38	18.72	12	12.77	56	18.67	122	16.60
200 - 299	1	0.72	22	10.84	8	8.51	26	8.67	57	7.76
300 - 399	0	0.00	9	4.43	5	5.32	18	6.00	32	4.35
400 - 499	5	3.62	5	2.46	6	6.38	15	5.00	31	4.22
500 - 999	11	7.97	23	11.33	10	10.64	21	7.00	65	8.84
1,000 - 1,499	2	1.45	6	2.96	4	4.26	11	3.67	23	3.13
1,500 - 1,999	5	3.62	6	2.96	0	0.00	3	1.00	14	1.90
2,000 and above	12	8.70	8	3.94	7	7.45	5	1.67	32	4.35
Total	138		203		94		300		735	

Table 7 Size of Firms (Capital)

Unit: US$

	Indonesia		Philippines		Thailand		Vietnam		Total	
	freq.	%	freq.	%	freq.	%	freq.	%	freq.	%
Less than 10,000	4	4.65	3	1.48	1	1.28	29	9.67	37	5.55
10,000 - 24,999	9	10.47	6	2.96	1	1.28	26	8.67	42	6.30
25,000 - 49,999	6	6.98	11	5.42	3	3.85	22	7.33	42	6.30
50,000 - 74,999	10	11.63	9	4.43	2	2.56	19	6.33	40	6.00
75,000 - 99,999	4	4.65	6	2.96	3	3.85	15	5.00	28	4.20
100,000 - 499,999	13	15.12	28	13.79	15	19.23	33	11.00	89	13.34
500,000 - 999,999	11	12.79	32	15.76	11	14.10	38	12.67	92	13.79
1 million - 4.9 mil.	11	12.79	42	20.69	15	19.23	56	18.67	124	18.59
5 mil. - 9.9 mil.	3	3.49	26	12.81	8	10.26	25	8.33	62	9.30
10 million and above	15	17.44	40	19.70	19	24.36	37	12.33	111	16.64
Total	86		203.00		78		300.00		667	

Table 8 Category of Industry

	Indonesia		Philippines		Thailand		Vietnam		Total	
	freq.	%	freq.	%	freq.	%	freq.	%	freq.	%
Food, beverages, tobacco	29	21.17	34	17.09	5	5.88	19	6.33	87	12.07
Textiles	11	8.03	2	1.01	6	7.06	20	6.67	39	5.41
Apparel, leather	11	8.03	22	11.06	0	0.00	3	1.00	36	4.99
Wood, wood products	11	8.03	11	5.53	3	3.53	9	3.00	34	4.72
Paper, paper products, printing	15	10.95	5	2.51	5	5.88	9	3.00	34	4.72
Coal, petroleum products	1	0.73	0	0.00	1	1.18	2	0.67	4	0.55
Chemicals, chemical products	9	6.57	11	5.53	6	7.06	12	4.00	38	5.27
Plastic, rubber products	4	2.92	15	7.54	5	5.88	39	13.00	63	8.74
Other non-metallic mineral products	0	0.00	8	4.02	2	2.35	3	1.00	13	1.80
Iron, steel	5	3.65	13	6.53	5	5.88	18	6.00	41	5.69
Non-ferrous metals	1	0.73	1	0.50	0	0.00	0	0.00	2	0.28
Metal products	2	1.46	15	7.54	4	4.71	29	9.67	50	6.93
Machinery, equipment, tools	3	2.19	5	2.51	2	2.35	40	13.33	50	6.93
Computers & computer parts	0	0.00	7	3.52	5	5.88	3	1.00	15	2.08
Other electronics & components	5	3.65	22	11.06	2	2.35	45	15.00	74	10.26
Precision instruments	0	0.00	2	1.01	0	0.00	14	4.67	16	2.22
Automobile, auto parts	5	3.65	14	7.04	9	10.59	6	2.00	34	4.72
Other transportation equipments and parts	1	0.73	2	1.01	1	1.18	4	1.33	8	1.11
Others	24	17.52	10	5.03	24	28.24	25	8.33	83	11.51
Total	137		199		85		300		721	

2.3. Linkages: Sources of Information

This paper focuses on information linkages in an area, which consist of various networks in an area, including production, research, and human linkages. The production linkages are related to sources through market transactions such as purchasing and sales, and these linkages are divided into the following two categories: (i) forward and (ii) backward.[3] The former indicates that firms receive information from their upstream customers, whereas the latter indicates that firms receive information from their downstream suppliers. Research linkages indicate the information flow from universities or public research institutions and so on.

[3] Theoretical as well as empirical research has been conducted to establish fundamental theories or to identify such linkages. Among them, Javorcik (2004), and Blalock and Gertler (2008) found that backward linkage impacts productivity upgrading for upstream suppliers that occur from customers of MNCs. Most recently, Machikita and Ueki (2010a), (2010b) provided new evidence that the impact of knowledge flows through forward linkages as well as backward linkages. In the context of this paper, the main issue is to verify that firms with a greater variety of linkages achieve more innovations.

In order to identify the sources of information, we used the following questions for production linkages:

3. *Sources of knowledge and new technologies*

Production linkages

(a) Internal sources of information and own R&D efforts

(b) Cooperation with (technology transfer from) local firms (100% local capital)

(c) Cooperation with (technology transfer from) MNCs (100% non-local capital)

(d) Cooperation with (technology transfer from) from Joint Ventures (JVs)

Research linkages: new technologies and information

(e) Technical assistance by government/public agency

(f) Technical assistance by industrial/trade organizations

(g) Technical assistance by community organizations (NGOs or NPOs)

(h) Technical assistance by government owned financial institutions

(i) Cooperation with (assistance from) universities/higher educational institutions

(j) Cooperation with (assistance from) government or public research institutes

Human linkages: provided by support organizations such as seminar, lecture, training, or consultant/expert dispatched or hired by them

(k) University professors or researchers personally closed contracts with your firm

(l) Dispatch your engineers to universities/higher educational institutions

(m) Dispatch your engineers to government or public research institutes

(n) Recruitment of middle-ranking personnel or mid-carrier engineers

(o) Recruitment of senior engineers retired from MNCs, JVs, or large local firms

(p) Headhunt of top management from MNCs, JVs, or large local firms

Other sources

(q) Technical information obtainable from academic publication

(r) Technical information obtainable from patents

(s) Introduction of “foreign-made” equipments and software

(t) Reverse engineering

(u) Participation in conferences, trade fairs, exhibitions

(v) Licensing technologies from other firms

In our analysis below, we focus on which linkages are statistically significant to innovation performances.[4] In addition, this paper is also interested in the relevancy between the number of linkages and innovation, that is, we analyze if firms with a greater variety of linkages achieve more innovations.

2.4. Proximity to Information Linkages

This paper attempts to analyze whether and how information linkages contribute to innovation performances of respondents. In this context we are interested in how firms are connected with partners. In order to analyze this question, we asked about the frequency of communications and the distance between them. It is impossible to identify the contents of communications, but we take these two factors as proxy of intimate relationships. Here we are particularly concerned with the distance between firms and partners since it represents an intimate relationship.

In relation to question 3, we prepare with sub-questions asking the locations of sources attached to the sources, namely,

4. *In which are the sources located?*

(a) in the area

(b) in the country

(c) in other ASEAN

(d) in East Asia

---

[4] For more analysis of linkages, see, for instance, Amara and Landry (1999), Vega-Jurado, Gutiérrez-Gracia, Fernández-de-Lucio, and Manjarrés-Henríquez (2008), and Frenz and Ietto-Gillies (2009).For example, see Tsuji, Miyahara and Ueki (2008), Tsuji and Miyahara (2009), (2010).

(e) in other country

If firms reply “In the area,” this implies that sources are located closer to firms. These questions are fully utilized in the analysis below.

3. ESTIMATION OF PROXIMITY OF INFORMATION LINKAGES

Here we use rigorous econometric analysis to investigate the hypothesis that industrial clustering promotes innovation in the areas. In so doing, based on the framework explained in the previous sections, we identify the linkages that contribute to respondents’ innovation.

3.1. Methodology of Analysis

We chose research sites in cluster areas in four ASEAN economies, and the firms to which we sent questionnaire are considered to be located in the clusters. The usual methodology of this kind analysis is to choose two groups of firms inside and outside the clusters and then to compare their innovation achievements.[5] Since all firms surveyed are inside clusters, we cannot use this method, and thus we take the proximity of linkages, that is, geographical proximity between firms and sources, into consideration. The underlying hypothesis in this context is that if the linkages or the partners of innovation activities are closed to each other, then the information flow inside an area is “dense,” and this makes the area more innovative.

In order to accommodate the proximity into the estimation equations, we construct the variables related to sources as follows: Question 4 asks the exact location of sources, and each source takes values from one to five depending upon location of sources. If it is located “in the area,” the source takes five, and if it is “in the country,” it takes four, and so on. Because of the construction, if estimated coefficients take a positive sign,

[5] See Tsuji and Miyahara (2010a), for example.

then the sources are located close to respondents.

3.2. Estimation Models

(a) Dependent variables

The first estimation models are aimed to verify the relevance between proximity of the linkages and innovation. In so doing, we estimate three models based on the categories of innovations, namely, product and process innovation and total of these two. We take the number of innovation they achieved, that is, the number of "yes" in question 1 for product innovation and question 2 for process innovation. The sum of these two innovations is taken as a dependent variable in total innovation.

(b) Independent variables

As independent variables, we use following variables; (i) attributes of respondent such as year of establishment, size of firms in term of employment, and categories of industry; (ii) sources of information such as production linkages, research linkages, and human linkages; (iii) number of sources; and (iv) country dummies. "(iii) Number of sources" refer to linkages that a particular firm replies to have in question 3 ("Sources of knowledge and new technologies") in the previous section.

In actual estimation, we examine two kinds of models, that is, full and selected models; the former contains all sources as well as characteristics of firms, whereas the latter includes only a specific source in addition to firm characteristics. The reason for this is to focus on the particular source and to examine the robustness of estimates. Summary statistics are shown in Table 9.

Table 9 Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Dependent variables					
Number of product innovation	738	2.729	1.313	0	4
Number of process innovation	738	3.179	1.244	0	4
Total number of innovation	738	5.908	2.166	0	8
Significant change in packaging or appearance design	738	0.644	0.479	0	1
Significant improvement of an existing product/service	738	0.837	0.369	0	1
Development of a totally new product/service based on the existing technologies for your establishment	738	0.690	0.463	0	1
Development of a totally new product/service based on new technologies for your establishment	738	0.558	0.497	0	1
Characteristics					
Year of establishment	717	16.197	13.136	0	181
Number of full-time employees	735	325.306	499.268	10	2000
Textiles, Apparel, leather	738	0.102	0.302	0	1
Wood, Paper products	738	0.092	0.289	0	1
Coal, Chemical products	738	0.057	0.232	0	1
Iron, Metal products	738	0.126	0.332	0	1
Computers, Other electronics	738	0.121	0.326	0	1
Automobile, Other transportation	738	0.057	0.232	0	1
Proximity of sources (In the Area 6, In the country 5, In the ASEAN 4, In East Asia 3, In Europe or US 2, In other countries 1)					
(a) Internal sources of information and own R&D efforts	738	2.967	2.624	0	6
(b) Cooperation with local firms (100% local capital)	738	3.141	2.804	0	6
(c) Cooperation with MNCs (100% non-local capital)	738	1.699	2.109	0	6
(d) Cooperation with Joint Ventures	738	2.047	2.474	0	6
(e) Technical assistance financed/provided by government/public agency	738	1.911	2.644	0	6
(f) Technical assistance financed/provided by industrial/trade organizations	738	1.928	2.654	0	6
(g) Technical assistance financed/provided by community organizations (NGOs or NPOs)	738	1.744	2.631	0	6
(h) Technical assistance financed/provided by government owned financial institutions	738	1.453	2.497	0	6
(i) Cooperation with universities/higher educational institutions	738	1.520	2.512	0	6
(j) Cooperation with government or public research institutes	738	1.397	2.422	0	6
(k) University professors or researchers personally closed contracts with your firm	738	1.291	2.340	0	6
(l) Dispatch your engineers to universities/higher educational institutions	738	1.153	2.225	0	6
(m) Dispatch your engineers to government or public research institutes	738	0.970	2.093	0	6
(n) Recruitment of middle-ranking personnel or mid-carrier engineers	738	3.953	2.656	0	6
(o) Recruitment of senior engineers retired from MNCs, JVs, or large local firms	738	1.511	2.399	0	6
(p) Headhunt of top management from MNCs, JVs, or large local firms	738	1.220	2.112	0	6
(q) Technical information obtainable from academic publication	738	2.477	2.605	0	6
(r) Technical information obtainable from patents	738	2.175	2.563	0	6
(s) Introduction of "foreign-made" equipments and software	738	1.995	2.182	0	6
(t) Reverse engineering	738	1.172	2.107	0	6
(u) Participation in conferences, trade fairs, exhibitions	738	2.980	2.502	0	6
(v) Licensing technologies from other firms	738	1.725	2.421	0	6
Country dummy variables					
Dummy (Indonesia)	738	0.188	0.391	0	1
Dummy (Thai)	738	0.130	0.337	0	1
Dummy (Vietnam)	738	0.407	0.492	0	1

3.3. Result of Estimation I: Basic Models

Let us discuss the results of estimation. Table 10 provides the results of estimation of total innovation, product innovation and process innovation. As for total innovation, only two linkages, (g) "technical assistance by community organizations (NGOs or NPOs)" and (h) "technical assistance by government owned financial institutions," were found to be significant in both of full and selected models. Since the signs of these two sources are positive, firms utilize the neighboring linkages with these sources, such as community organizations (NGOs or NPOs) and government-owned financial institutions.

As for the estimation of product innovation, the same linkages are also significant, which implies they use linkages closer to them. In the estimation of process innovation, on the other hand, the production linkages of (b) "cooperation with (technology transfer from) local firms" and the human linkages such as of (o) "recruitment of senior engineers retired from MNCs, JVs, or large local firms" are significant. As for the proximity, since the former (latter) has a positive (negative) sign, firms connect to neighboring local firms for technology transfer, while they hire senior engineers from remote MNCs or other large local firms. These are consistent with realty, since MNCs or larger firms may locate themselves in remote industrial parks or estates.

In addition, in all three models, the number of linkages is significant, and the more linkages, the more innovation firms achieve. This is also consistent with reality.[6]

[6] In the estimation of the basic models, the variables with proximity are already explained, that is, they take values from one to five. We also constructed the variables in such a way that they take a value of one if they replied "yes" to "in the Area," whereas they take 0 otherwise. We differentiate depending upon locating in an area or not. The results are almost similar except (h) technical assistance by government owned financial institutions being not significant for product innovation, while (q) headhunt of top management from MNCs, JVs, or large local firms being significant for total and product innovation. There is no change in process innovation.

Table 10 Estimation Results of Basic Models

	Total innovation		Product innovation		Process innovation	
	Full	Selected	Full	Selected	Full	Selected
Age (establishment)			[*]		*	*
Number of full-time employees (logarithmic)	***	***	***	***	***	***
Textiles, Apparel, leather						
Wood, Paper products						
Coal, Chemical products			*	*		
Iron, Metal products	[*]	[*]	[***]	[***]		
Computers, Other electronics						
Automobile, Other transportation						
Production Linkage						
(a) Internal sources of information and own R&D efforts						
(b) Cooperation with (technology transfer from) local firms (100% local capital)					*	*
(c) Cooperation with (technology transfer from) MNCs (100% non-local capital)						
(d) Cooperation with (technology transfer from) from Joint Ventures (JVs)						
Research linkage						
(e) Technical assistance financed/provided by government/public agency						
(f) Technical assistance financed/provided by industrial/trade organizations						
(g) Technical assistance financed/provided by community organizations (NGOs or NPOs)	*	**	**	**		
(h) Technical assistance financed/provided by government owned financial institutions	**	**	**	**		
(i) Cooperation with universities/higher educational institutions						
(j) Cooperation with government or public research institutes						
Human linkage						
(k) University professors or researchers personally closed contracts with your firm						
(l) Dispatch your engineers to universities/higher educational institutions						
(m) Dispatch your engineers to government or public research institutes						
(n) Recruitment of middle-ranking personnel or mid-carrier engineers						
(o) Recruitment of senior engineers retired from MNCs, JVs, or large local firms					[**]	[*]
(p) Headhunt of top management from MNCs, JVs, or large local firms						
Number of Sources	***	***	**	***	***	***
Dummy variable (Indonesia)	***	***	**	**	***	***
Dummy variable (Thai)						
Dummy variable (Hanoi)						
Dummy variable (Ho Chi Minh)	***	***	***	***	***	***

Note 1: ***, ** and * indicate the significance level at the 1%, 5% and 10%

Note 2: [ ] indicates that the sign of a estimated coefficient is negative.

3.4. Result of Estimation II: Research and Human Linkages

In the previous estimation, the production linkages are found to be less significant except cooperation with local firms. In particular, the linkage with MNCs is not identified as significant, which is different from the results obtained in our previous papers, such as Tsuji and Miyahara (2009), (2010). Next, in order to focus more on research and human linkages, we estimate the same models in which the production linkages are removed. The results of these models are shown in Table 11. As for the result of total innovation, the research linkages of remote (a) government/public agencies and (h) neighboring government-owned financial institutions are found to be significant. Among the human linkages, (o) hiring senior engineers from remote MNCs and large firms proved significant. These firms are located rather in the remote areas.

Regarding the linkages of product and process innovation, (h) neighboring government-owned financial institutions again are significant in all the models. Clear differences between two innovations are such that product innovation is related to recruiting middle-ranked engineers from neighboring firms, whereas process innovation showed the significant linkages with (a) government/public agencies and (o) recruiting senior engineers from remote MNCs/large firms, which are located in the remote areas.

These results can be interpreted in the following way: product innovation requires middle-ranked engineers from neighboring firms, whereas process innovation requires senior engineers from remote larger firms such as MNCs.

In all of three models, the number of linkages is again significant, and the variety of the linkages promotes innovation.

Table 11 Estimation Results of Research Linkages

		Total innovation		Product innovation		Process innovation	
		Full	Selected	Full	Selected	Full	Selected
	Age (establishment)					***	***
	Number of full-time employees (logarithmic)	***	***	***	***	***	***
	Textiles, Apparel, leather						
	Wood, Paper products						
	Coal, Chemical products			**	*		
	Iron, Metal products	[**]	[**]	[***]	[***]		
	Computers, Other electronics						
	Automobile, Other transportation						
(e)	Technical assistance financed/provided by government/public agency	[**]	[***]	[*]		[**]	[**]
(f)	Technical assistance financed/provided by industrial/trade organizations						
(g)	Technical assistance financed/provided by community organizations (NGOs or NPOs)			*			
(h)	Technical assistance financed/provided by government owned financial institutions	***	***	***	***	**	**
(i)	Cooperation with universities/higher educational institutions						
(j)	Cooperation with government or public research institutes			[*]			
(k)	University professors or researchers personally closed contracts with your firm						
(l)	Dispatch your engineers to universities/higher educational institutions						
(m)	Dispatch your engineers to government or public research institutes						
(n)	Recruitment of middle-ranking personnel or mid-carrier engineers			*	*		
(o)	Recruitment of senior engineers retired from MNCs, JVs, or large local firms	[*]	[**]			[***]	[***]
(p)	Headhunt of top management from MNCs, JVs, or large local firms						
	Number of Sources	***	***	***	***	***	***
	Dummy variable (Indonesia)	**	***	**	**	***	***
	Dummy variable (Thai)						
	Dummy variable (Vietnam)	***	***	**	***	***	***

Note 1: ***, ** and * indicate the significance level at the 1%, 5% and 10%

Note 2: [ ] indicates that the sign of a estimated coefficient is negative.

3.5. Results of Estimation III: Innovation in Different Industries

Here we examine whether different linkages are identified in forms of different industries. Again we focus on the research and human linkages, and examine their proximity. In the industry-wise estimation, the number of samples in each industry is small, which makes the estimation of total innovation difficult. We conducted here only the selected model; that is, variables such as the firm attributes and a particular linkage are used.

The results of estimation are shown in Table 12 for innovation as a whole, in Table 13 for product innovation and in Table 14 for process innovation. It is rather difficult, however, to identify the some coherent trend concerning proximity in all industries, since even a single linkage has a different direction for a different industry. In Table 12, only government/public agency has all negative trends for significant industries such as (I) food, beverage and tobacco, (VI) iron and steel, and (VII) machinery. The automobile industry has all positive trends for (h) government owned financial institutions and (n) recruiting middle-ranked engineers. The number of the linkages is not significant for all industries, and in particular for industries related to natural resources.

As for product innovation, (I) food, beverage and tobacco and (IX) precision instruments, automobile, auto parts, other transportation equipment have only significant neighboring linkages, while (V) plastic, rubber products, other non-metallic mineral products and (VI) iron, steel, non-ferrous metals, metal products have rather remote linkages for innovation. In particular, food is a typical industry with local features, and natural resource industry has the same tendency as mentioned in total innovation. The number of linkages has the almost same tendency. The results of process innovation are summarized in Table 14, but it is rather difficult to draw conclusions with consistent interpretations.

Table 12 Research Linkages in Different Industry (Total innovation)

		I	II	III	IV	V	VI	VII	VIII	IX	X
	Age (establishment)						*			[**]	
	Number of full-time employees (logarithmic)		*			***	*	**	***	***	
(e)	Technical assistance financed/provided by government/public agency	[**]					[**]	[***]			
(f)	Technical assistance financed/provided by industrial/trade organizations					[***]					
(g)	Technical assistance financed/provided by community organizations (NGOs or NPOs)										*
(h)	Technical assistance financed/provided by government owned financial institutions									**	
(i)	Cooperation with universities/higher educational institutions					[*]					
(j)	Cooperation with government or public research institutes	*						[**]			
(k)	University professors or researchers personally closed contracts with your firm	[**]					*				
(l)	Dispatch your engineers to universities/higher educational institutions			[**]				**			
(m)	Dispatch your engineers to government or public research institutes							[**]			**
(n)	Recruitment of middle-ranking personnel or mid-carrier engineers						[**]			*	
(o)	Recruitment of senior engineers retired from MNCs, JVs, or large local firms				[**]		[*]	**			
(p)	Headhunt of top management from MNCs, JVs, or large local firms										
	Number of Sources	***	***	***		**		**	*		
	Dummy variable (Indonesia)									***	
	Dummy variable (Thai)			[**]				**		***	[*]
	Dummy variable (Vietnam)				*	***	***		***	***	

Note 1: I (Food, beverages, tobacco), II (Textiles, Apparel, leather), III (Wood, wood products, paper, paper products, printing), IV (Coal, petroleum products, chemicals, chemical products), V (Plastic, rubber products, other non-metallic mineral products), VI (Iron, steel, non-ferrous metals, metal products), VII (Machinery, equipment, tools), VIII (Computers & computer parts, other electronics & components), IX (Precision instruments, automobile, auto parts, other transportation equipments and parts), X (Others).

Note 2: ***, ** and * indicate the significance level at the 1%, 5% and 10%.

Note 3: [ ] indicates that the sign of an estimated coefficient is negative.

Table 13 Research Linkages in Different Industry (Product innovation)

		I	II	III	IV	V	VI	VII	VIII	IX	X
	Age (establishment)				[*]					[**]	
	Number of full-time employees (logarithmic)				**	***			***	**	**
(e)	Technical assistance financed/provided by government/public agency										
(f)	Technical assistance financed/provided by industrial/trade organizations	**			[*]	[***]					
(g)	Technical assistance financed/provided by community organizations (NGOs or NPOs)			*			**				**
(h)	Technical assistance financed/provided by government owned financial institutions							*		*	
(i)	Cooperation with universities/higher educational institutions					[**]					
(j)	Cooperation with government or public research institutes	**					[**]	[*]			
(k)	University professors or researchers personally closed contracts with your firm										
(l)	Dispatch your engineers to universities/higher educational institutions							*			
(m)	Dispatch your engineers to government or public research institutes				**			[***]			
(n)	Recruitment of middle-ranking personnel or mid-carrier engineers	**					[**]			**	
(o)	Recruitment of senior engineers retired from MNCs, JVs, or large local firms						[*]				
(p)	Headhunt of top management from MNCs, JVs, or large local firms										
	Number of Sources	***	***	**		*		**			
	Dummy variable (Indonesia)								[**]	*	
	Dummy variable (Thai)			[*]		[**]		**		*	
	Dummy variable (Vietnam)					***	***	*	**		

Note 1: I (Food, beverages, tobacco), II (Textiles, Apparel, leather), III (Wood, wood products, paper, paper products, printing), IV (Coal, petroleum products, chemicals, chemical products), V (Plastic, rubber products, other non-metallic mineral products), VI (Iron, steel, non-ferrous metals, metal products), VII (Machinery, equipment, tools), VIII (Computers & computer parts, other electronics & components), IX (Precision instruments, automobile, auto parts, other transportation equipments and parts), X (Others).

Note 2: ***, ** and * indicate the significance level at the 1%, 5% and 10%.

Note 3: [ ] indicates that the sign of an estimated coefficient is negative.

Table 14 Research Linkages in Different Industry (Process innovation)

		I	II	III	IV	V	VI	VII	VIII	IX	X
	Age (establishment)			*	*			**	*		
	Number of full-time employees (logarithmic)			**		***	**	**	***	***	
(e)	Technical assistance financed/provided by government/public agency	[*]					[**]	[***]			
(f)	Technical assistance financed/provided by industrial/trade organizations					[**]					
(g)	Technical assistance financed/provided by community organizations (NGOs or NPOs)										
(h)	Technical assistance financed/provided by government owned financial institutions									**	*
(i)	Cooperation with universities/higher educational institutions										
(j)	Cooperation with government or public research institutes								[***]		
(k)	University professors or researchers personally closed contracts with your firm	[***]					**				
(l)	Dispatch your engineers to universities/higher educational institutions			[**]				*			
(m)	Dispatch your engineers to government or public research institutes										**
(n)	Recruitment of middle-ranking personnel or mid-carrier engineers						[**]				
(o)	Recruitment of senior engineers retired from MNCs, JVs, or large local firms				[**]			**	[*]		
(p)	Headhunt of top management from MNCs, JVs, or large local firms					*					
	Number of Sources		**	**		**		**	**	[**]	
	Dummy variable (Indonesia)									**	
	Dummy variable (Thai)			[*]		*				***	[**]
	Dummy variable (Vietnam)	**			*	*			***	***	

Note 1: I (Food, beverages, tobacco), II (Textiles, Apparel, leather), III (Wood, wood products, paper, paper products, printing), IV (Coal, petroleum products, chemicals, chemical products), V (Plastic, rubber products, other non-metallic mineral products), VI (Iron, steel, non-ferrous metals, metal products), VII (Machinery, equipment, tools), VIII (Computers & computer parts, other electronics & components), IX (Precision instruments, automobile, auto parts, other transportation equipments and parts), X (Others).

Note 2: ***, ** and * indicate the significance level at the 1%, 5% and 10%.

Note 3: [ ] indicates that the sign of an estimated coefficient is negative.

4. CHARACTERIZATION OF INNOVATION PROCESS

The analysis of this paper is based on the cross-section data, but here some dynamic flavor will be introduced in this section.

4.1. Linkages Charactering the Level of Innovation

The categories of innovation related to product innovation are defined as (a) significant change in packaging or appearance design, (b) significant improvement of an existing product/service, (c) development of a totally new product/service based on the existing technologies, and (d) development of a totally new product/service based on new technologies. These categories can be viewed as the development from low to high level of innovation. In order to upgrade the level of innovation, we examine what kinds of linkages are required, and characterize these categories of innovation by utilizing probit analysis. The methodology is as follows: product innovations in each category are taken as dependent variables and information linkages as well as attributes of respondents as independent variables. Their relevancy is estimated.[7] The analysis is limited only to product innovation.[8] The results of the probit analysis are shown in Table 15.

[7] In general, by normalizing, some category is taken as standard. In the actual estimation, the normalizing method did not provide good results, and thus here we present estimations without normalization. Care should be taken for the interpretation of estimates, namely, the comparison of numerical values of estimates do not have any meaning, and we only compare signs and significance levels of estimates.
[8] As for process innovation listed in section 2.1., it is rather difficult to arrange them according to quality of innovation.

Table 15 Estimation Results of Characterization of Innovation

	Case (I)		Case (II)		Case (III)		Case (IV)	
	Full	Selected	Full	Selected	Full	Selected	Full	Selected
Age (establishment)				*				
Number of full-time employees (logarithmic)	***	***			***	***	***	***
Textiles, Apparel, leather								
Wood, Paper products								
Coal, Chemical products					**	*		*
Iron, Metal products	[***]	[***]	[**]	[***]		[*]	[*]	[**]
Computers, Other electronics							***	***
Automobile, Other transportation								
Production Linkage								
(a) Internal sources of information and own R&D efforts	[**]	[**]		*	[*]			
(b) Cooperation with local firms (100% local capital)								
(c) Cooperation with MNCs (100% non-local capital)	*	*					**	**
(d) Cooperation with Joint Ventures								
Research linkage								
(e) Technical assistance financed/provided by government/public agency		[**]					[**]	[***]
(f) Technical assistance financed/provided by industrial/trade organizations								
(g) Technical assistance financed/provided by community organizations (NGOs or NPOs)								*
(h) Technical assistance financed/provided by government owned financial institutions	***	***		**				
(i) Cooperation with universities/higher educational institutions	[**]	[**]						
(j) Cooperation with government or public research institutes							[***]	[***]
Human linkage								
(k) University professors or researchers personally closed contracts with your firm								
(l) Dispatch your engineers to universities/higher educational institutions	[*]							
(m) Dispatch your engineers to government or public research institutes	**	**						**
(n) Recruitment of middle-ranking personnel or mid-carrier engineers			*	***				
(o) Recruitment of senior engineers retired from MNCs, JVs, or large local firms								
(p) Headhunt of top management from MNCs, JVs, or large local firms							**	**
Number of Sources		**		***	**	***	*	**
Dummy variable (Indonesia)	*	**					**	**
Dummy variable (Thai)								
Dummy variable (Vietnam)	***	***	***	***	**	***		

Note 1: ***, ** and * indicate the significance level at the 1%, 5% and 10%

Note 2: [ ] indicates that the sign of an estimated coefficient is negative.

Note 3: Case (I): Significant change in packaging or appearance design.
Case (II): Significant improvement of an existing product/service.
Case (III): Development of a new product/service based on the existing technologies.
Case (IV): Development of a new product/service based on new technologies.

The interpretation of this result is as follows: firms with significant linkages tend to be more highly achieving of innovation in this category. In order to understand the aim of this estimation, let us take as an example (e) technical assistance by government/public agency, which is negatively significant for innovation category (a) change in packaging and category (d) development of new product with new technology. This implies that firms which own this linkage are more likely to be classified either as having the lowest or as the highest level of innovations. Again the negative sign implies that government/public agency is located in the remote area. Similarly, (i) the linkage with universities and public agencies is negatively significant, which indicates that firms with this neighboring linkages are more likely to be classified to achieve the level of category (a) innovation.

Thus, firms attempt to perform the lowest level of innovation category (a) require (e) technical assistance by remote government and public agencies, (h) technical assistance by government owned financial institutions, (i) tie with remote university and, (m) dispatch of engineers to neighboring government or public research institutes. As for the second level of category (b) innovation, (h) technical assistance by neighboring government-owned financial institutions, and (n) recruitment of middle-ranking personnel or mid-carrier engineers are identified. There are no sources identified for innovation category (c). Regarding the highest level of category (d) innovation, two remote sources such as (a) government/public agency for technical assistance are required, while neighboring linkages such as (m) government or public research institutes to which to dispatch engineers and (p) MNCs, large local firms for headhunting of top management, are also required.

In sum, firms classified as achieving the lowest level of innovation tend to have linkages such as (i) remote universities/higher education institutions, firms achieving as the second lowest own the neighboring linkages such as (n) recruiting mid-ranked engineers, and firms achieving the highest level of innovation tend to have neighboring linkages of MNC or large firms for headhunting of top management.

4.2. Linkages for Upgrading Innovation Level

The previous analysis characterizes the level of innovation by linkages, and in this section we attempt to identify which linkages are required for firms to evolve from the lowest to the highest level of innovation by using ordered logit analysis. The result of estimation is summarized in Table 16. According to this estimation, the following linkages are extracted as key factors:

- Production linkages:

  Neighboring MNCs

- Research linkages:

  Remote government/public agencies for technical assistance

  Remote government or public research institutions for cooperation

- Human linkages:

  Neighboring government or public research institutions for sending engineers

  Neighboring MNCs or large firms for headhunting top management

- Number of linkages

In order to focus more on the partners of the linkages, the followings are summarized as important:

MNCs or large firms (neighboring)

Government/public agencies (remote)

Government or public research institutions (neighboring and remote)

Table 16 Estimation Result of Upgrading Innovation

		Full	Selected
	Age (establishment)		
	Number of full-time employees (logarithmic)	***	***
	Textiles, Apparel, leather		
	Wood, Paper products		
	Coal, Chemical products	**	**
	Iron, Metal products	[**]	[**]
	Computers, Other electronics	***	***
	Automobile, Other transportation		
Production Linkage			
(a)	Internal sources of information and own R&D efforts		
(b)	Cooperation with local firms (100% local capital)		
(c)	Cooperation with MNCs (100% non-local capital)	**	**
(d)	Cooperation with Joint Ventures		
Research linkage			
(e)	Technical assistance financed/provided by government/public agency	[*]	[**]
(f)	Technical assistance financed/provided by industrial/trade organizations		
(g)	Technical assistance financed/provided by community organizations (NGOs or NPOs)		
(h)	Technical assistance financed/provided by government owned financial institutions		
(i)	Cooperation with universities/higher educational institutions		
(j)	Cooperation with government or public research institutes	[**]	[**]
Human linkage			
(k)	University professors or researchers personally closed contracts with your firm		
(l)	Dispatch your engineers to universities/higher educational institutions		
(m)	Dispatch your engineers to government or public research institutes	*	**
(n)	Recruitment of middle-ranking personnel or mid-carrier engineers		
(o)	Recruitment of senior engineers retired from MNCs, JVs, or large local firms		
(p)	Headhunt of top management from MNCs, JVs, or large local firms	*	**
	Number of Sources	***	***
	Dummy variable (Indonesia)	**	***
	Dummy variable (Thai)		
	Dummy variable (Vietnam)		***

Note 1: ***, ** and * indicate the significance level at the 1%, 5% and 10%
Note 2: [ ] indicates that the sign of an estimated coefficient is negative.

Thus MNCs or large firms that are located in the area provide technological information through market transactions as well as supplying managerial human resources for executives, while public agencies, whether they are located in neighbor or remote, contribute to innovation by technical assistance, consulting, joint research or training. Most of these are consistent with the realty, and these results can provide practical information for policy for promoting innovation.

5. CONCLUSION

Economic development in the East Asian economies called the “growth centers of the global economy” is achieved by the Factory of the World. If their economic growth is due to the increase in factors of production such as capita and labor, then sooner or later its growth will face the serious limit, as Krugman predicted. In order to maintain its sustainability, the economies have to transform in such a way that their growth is contributed by the total factor productivity which is realized by technological development. Thus innovation and upgrading are required for their further economic development. Using this framework, this paper sought to examine the current stage of innovation and upgrading of firms in four ASEAN economies (Indonesia, the Philippines, Thailand and Vietnam), and identify their causes and reasons. By making use of survey data, this paper attempted to identify linkages that provide necessary information to firms in the area. In contrast with our previous studies, this survey revealed quite active innovation activities in all economies, and that most of firms are achieving some categories of innovation. Since the four economies are different from one another in the stages of economic development and innovation, this variety makes the coherent results to be yield. The following results can be summarized by considering all estimation results in this paper:

(i) As for sources of information, among the production linkages, MNCs are also identified, which is the same conclusion drawn by other studies. Not only through market transactions but also MNCs are sources of supplying high-ranked management to firms in the area. The latter seems to be consistent with reality, since MNCs have advanced managerial systems and the experiences of working there provide high ability to managers.

Among the research linkages, the various estimation models extract government owned financial institutions as significant sources which provide not only financial but also technical assistance. Innovation and upgrading require funds for R&D activities, and this makes these sources indispensable. In addition, government/public agencies or government/public research intuitions are found to be significant. This seems natural, since in these economies, private or semi-public agencies such as business/trade or community organizations are less popular.

Forms of human linkages are recruiting managers as well as engineers from various sources such as MNCs, JVs or other large firms, which shows that personnel with professional skills are still scarce resources in these economies. Technology transfer to firms seems to be done through human resources rather than production networks.

(ii) The estimation results do not present consistent conclusion concerning proximity, and it is difficult to obtain a general hypothesis. One neighboring source is found significant in one estimation model, while the same source in the remote area becomes feasible in another model. Only government-owned financial institutions, however, are significant in the neighboring areas, and this is consistent with reality, as already mentioned. Remote government/public agencies or government/public research institutions are found to be significant, and the reason is that its number is not large and they are located in the capitals or other prioritized regions. University and higher educational institutions are not significant; the role of university should be reconsidered for making strategy of the local innovation system.

(iii) Not only the distance but also the frequency of communication between firms and partners of linkages is not significant in any models. Because of this reason this paper fully utilized responses to the proximity in the questionnaire as explained in section 3.3. The distance or frequency does not necessarily indicate the intimate relationships or contents of communications, but it seems to be difficult to definite results in this type of questionnaire.[9]

From these results, the directions of future research are suggested in order to make this approach fruitful.

(iv) This paper does not capture the importance of the production linkages as sources of innovation information. According to in-depth interviews conducted at the same time of the survey, it is reported widely that firms obtain valuable information from not only customers but also suppliers. They receive it not only from the formal but also informal channels and measures. The formal channels imply that MNCs, for example, accept trainees or send their engineers to firms, while informal measures indicate they learn by doing. Technology transfer takes various routes. Care should be taken to construct questionnaire in order to capture these complicated phenomena.

---

[9] Tsuji and Miyahara (2010a) also have the same problem about these subjects. Thus this paper concludes in this way.

The relevancy between agglomeration and innovation is an old research issue, but still one of the hot issues in this field. In particular, the transmission mechanism from information to innovation is an open question. This paper found some of linkages that contribute to innovation in the area, but this is only beginning of the research of endogenous innovation process in this area.

ACKNOWLEDGEMENT

This paper is based on research conducted under the international project “Fostering Production- and Science & Technology Linkages to Stimulate Innovation in ASEAN” that was sponsored by the Economic Research Institute for ASEAN and East Asia (ERIA) in FY 2009. This project also has been carried with cooperation from the Center for Strategic and International Studies (CSIS) of Indonesia, the Philippine Institute for Development Studies (PIDS), Sirindhorn International Institute of Technology (SIIT) of Thammasat University, Thailand, The Institute for Industry Policy and Strategy (IPSI), Ministry of Industry and Trade of Vietnam. This paper is indebted to their efforts to collect data from a survey. Thanks are also due to Dr. Y. Akematsu, research fellow of JSPS, who performed the perfect statistical analysis.

REFERENCES

Amara, N., and R. Landry (2005) "Sources of Information as Determinants of Novelty of Innovation in Manufacturing Firms: Evidence from the 1999 Statistics Canada Innovation Survey," *Technovation*, vol. 25, issue 3, pp. 245-59.

Blalock, G. and P. J. Gertler (2008) "Welfare Gains from Foreign Direct Investment through Technology Transfer to Local Suppliers," *Journal of International Economics*, Vol. 74, pp. 402-21.

Frenz, M., and G. Ietto-Gillies (2009) "The Impact on Innovation Performance of Different Sources of Knowledge: Evidence from the UK Community Innovation Survey," *Research Policy,* vol. 38, issue 7, pp. 1125-35.

Fujita, M., P. Krugman, and A. Venables (1999) *The Special Economy: Cities, Region, and International Trade*, Cambridge, MA, MIT Press.

Kuchiki, A. and M. Tsuji (2005) *Industrial Clusters in Asia: Analyses of their Competition and Cooperation*, Basingstroke, UK, Palgrave and Macmillan.

Kuchiki, A. and M. Tsuji (2008) *The Flowchart Approach to Industrial Cluster policy*, Basingstroke, UK, Palgrave and Macmillan.

Kuchiki, A. and M. Tsuji (2009) *From Agglomeration to Innovation*, Basingstroke, UK, Palgrave and Macmillan.

Krugman, P. (1991) *Geography and Trades*, Cambridge, MA, MIT Press.

Machikita, T. and Y. Ueki (2010a) "Linked Versus Non-linked Firms in Innovation: The Effects of Economies of Network in Agglomeration in East Asia," mimeo, Institute of Developing Economies.

Machikita, T. and Y. Ueki (2010b) "Impacts of Face-to-face and Frequent Interactions on Innovation: Evidence from Upstream-Downstream Relations," mimeo, Institute of Developing Economies.

Markusen, A. (1996) "Sticky Places in Slippery: A Typology of Industrial Districts," *Economic Geography*, Vol. 72, No. 3, pp. 293-313.

Porter, M. E. (1980) *The Competitive Advantage of Nations*, New York, Free Press.

Saxenian, A. L. (1994) *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*, Cambridge, MA, Harvard University Press.

Schumpeter, J. A. (1934) *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*, Harvard University Press.

Tsuji, M. and S. Miyahara (2009) "Development of Regional Production and Logistic Networks in East Asia: Econometric Analysis," paper submitted to ERIA.

Tsuji, M. and S. Miyahara (2010a) "Agglomeration and Local Innovation Networks in Japanese SMEs: Analysis of the Information Linkage," IDE-JETRO.

Tsuji, M. and S. Miyahara (2010b) "Empirical Analysis of Information Linkages and Capability in ASEAN Economies: Case of Indonesia, the Philippines, Thailand and Vietnam," paper submitted to ERIA.

Tsuji, M., S. Miyahara and Y. Ueki (2008) "Consolidated Multi-country Analysis of Agglomeration, Upgrading, and Innovation," Proceedings of EAEA (East Asian Economic Association) Conference (CD-ROM), Manila, Philippines.

APPENDIX

A1. Questionnaire

Innovations

1. What has your establishment achieved?

(a) Significant change in packaging or appearance design
(b) Significant improvement of an existing product/service
(c) Development of a totally new product/service based on the existing technologies for your establishment
(d) Development of a totally new product/service based on new technologies for your establishment

2. Has your establishment achieved substantial organizational changes in the following managerial systems?

(a) Sales and marketing
(b) Quality control
(c) Production control and management
(d) Inventory control and management

Sources

3. Please identify sources and their locations that provided new technologies and information for upgrading/innovation

(a) Internal sources of information and own R&D efforts
(b) Cooperation with (technology transfer from) local firms (100% local capital)
(c) Cooperation with (technology transfer from) MNCs (100% non-local capital)
(d) Cooperation with (technology transfer from) Joint Ventures(JVs)
(e) Technical assistance financed/provided by government/public agency
(f) Technical assistance financed/provided by industrial/trade organizations
(g) Technical assistance financed/provided by community organizations (NGOs or NPOs)
(h) Technical assistance financed/provided by government owned financial institutions
(i) Cooperation with (assistance from) universities/higher educational institutions
(j) Cooperation with (assistance from) government or public research institutes
(k) University professors or researchers/higher educational institutions
(l) Dispatch your engineers to universities/higher educational institutions
(m) Dispatch your engineers to government or public research institutes
(n) Recruitment of middle-ranking personnel or mid-carrier engineers
(o) Recruitment of senior engineers retired from MNCs, JVs, or large local firms
(p) Headhunt of top management from MNCs, JVs, or large local firms
(q) Technical information obtainable from academic publication
(r) Technical information obtainable from patents
(s) Introduction of "foreign-made" equipments and software
(t) Reverse engineering
(u) Participation in conferences, trade fairs, exhibitions
(v) Licensing technologies from other firms

Table A2 Estimation Results of Basic Models (Table 10)

	Total innovation					Product innovation				
	Full model	Selected model 1	Selected model 2	Selected model 3	Selected model 4	Full model	Selected model 1	Selected model 2	Selected model 3	Selected model 4
Age (establishment)	0.000	0.000	0.000	0.000	0.000	-0.009 *	-0.009	-0.009	-0.008	-0.009
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)
Number of full-time employees (logarithmic)	0.211 ***	0.212 ***	0.207 ***	0.204 ***	0.192 ***	0.207 ***	0.212 ***	0.216 ***	0.207 ***	0.188 ***
	(0.054)	(0.053)	(0.052)	(0.052)	(0.053)	(0.055)	(0.054)	(0.054)	(0.054)	(0.054)
Textiles, Apparel, leather	0.136	0.126	0.083	0.037	0.078	-0.010	-0.052	-0.064	-0.110	-0.052
	(0.250)	(0.246)	(0.244)	(0.246)	(0.246)	(0.252)	(0.247)	(0.246)	(0.247)	(0.247)
Wood, Paper products	-0.106	-0.120	-0.085	-0.079	-0.054	-0.010	-0.084	-0.036	-0.048	0.000
	(0.252)	(0.247)	(0.250)	(0.245)	(0.245)	(0.261)	(0.255)	(0.259)	(0.254)	(0.254)
Coal, Chemical products	0.375	0.322	0.374	0.303	0.305	0.590 *	0.520 *	0.574 *	0.508 *	0.511 *
	(0.309)	(0.302)	(0.304)	(0.301)	(0.302)	(0.320)	(0.311)	(0.309)	(0.308)	(0.310)
Iron, Metal products	-0.392 *	-0.377 *	-0.385 *	-0.390 *	-0.366 *	-0.649 ***	-0.645 ***	-0.627 ***	-0.664 ***	-0.631 ***
	(0.213)	(0.209)	(0.210)	(0.208)	(0.209)	(0.221)	(0.216)	(0.218)	(0.215)	(0.216)
Computers, Other electronics	-0.096	-0.058	-0.078	-0.063	-0.090	0.066	0.119	0.146	0.145	0.072
	(0.236)	(0.232)	(0.231)	(0.232)	(0.231)	(0.247)	(0.242)	(0.242)	(0.243)	(0.242)
Automobile, Other transportation	0.136	0.096	0.151	0.095	0.091	0.063	0.028	0.084	0.002	-0.009
	(0.327)	(0.326)	(0.328)	(0.328)	(0.330)	(0.323)	(0.318)	(0.321)	(0.320)	(0.322)
(a) Internal sources of information and own R&D efforts	-0.035	-0.032				-0.029	-0.018			
	(0.030)	(0.029)				(0.032)	(0.030)			
(b) Cooperation with local firms (100% local capital)	0.032	0.047				0.006	0.035			
	(0.031)	(0.029)				(0.032)	(0.031)			
(c) Cooperation with MNCs (100% non-local capital)	0.052	0.047				0.069	0.068			
	(0.041)	(0.040)				(0.043)	(0.041)			
(d) Cooperation with Joint Ventures	-0.052	-0.039				-0.044	-0.033			
	(0.037)	(0.036)				(0.038)	(0.037)			
(e) Technical assistance financed/provided by government/public agency	-0.019		-0.027			-0.001		-0.009		
	(0.033)		(0.031)			(0.034)		(0.032)		
(f) Technical assistance financed/provided by industrial/trade organizations	0.011		0.007			0.014		0.014		
	(0.031)		(0.030)			(0.032)		(0.031)		
(g) Technical assistance financed/provided by community organizations (NGOs or NPOs)	0.056 *		0.065 **			0.072 **		0.078 **		
	(0.032)		(0.031)			(0.033)		(0.033)		
(h) Technical assistance financed/provided by government owned financial institutions	0.078 **		0.072 **			0.083 **		0.073 **		
	(0.034)		(0.033)			(0.035)		(0.034)		
(i) Cooperation with universities/higher educational institutions	-0.037			-0.041		-0.029			-0.022	
	(0.036)			(0.035)		(0.037)			(0.036)	
(j) Cooperation with government or public research institutes	-0.024			0.003		-0.045			-0.010	
	(0.036)			(0.035)		(0.038)			(0.036)	

(k) University professors or researchers personally closed contracts with your firm	0.010			0.027		0.010			0.027	
	(0.038)			(0.037)		(0.038)			(0.037)	
(l) Dispatch your engineers to universities/higher educational institutions	-0.025			-0.016		-0.024			-0.012	
	(0.040)			(0.040)		(0.042)			(0.041)	
(m) Dispatch your engineers to government or public research institutes	0.038			0.045		0.032			0.051	
	(0.046)			(0.044)		(0.047)			(0.046)	
(n) Recruitment of middle-ranking personnel or mid-carrier engineers	0.021				0.023	0.042				0.049
	(0.034)				(0.031)	(0.035)				(0.032)
(o) Recruitment of senior engineers retired from MNCs, JVs, or large local firms	-0.034				-0.020	0.008				0.016
	(0.037)				(0.036)	(0.038)				(0.037)
(p) Headhunt of top management from MNCs, JVs, or large local firms	0.059				0.053	0.065				0.053
	(0.042)				(0.040)	(0.044)				(0.042)
Number of Sources	0.053 ***	0.066 ***	0.053 ***	0.069 ***	0.065 ***	0.039 **	0.061 ***	0.045 ***	0.064 ***	0.055 ***
	(0.015)	(0.013)	(0.013)	(0.014)	(0.013)	(0.016)	(0.014)	(0.014)	(0.014)	(0.014)
Dummy variable (Indonesia)	0.752 ***	0.680 ***	0.764 ***	0.688 ***	0.683 ***	0.681 **	0.498 **	0.602 **	0.488 **	0.550 **
	(0.250)	(0.235)	(0.238)	(0.235)	(0.237)	(0.263)	(0.246)	(0.249)	(0.246)	(0.248)
Dummy variable (Thai)	-0.094	-0.109	-0.081	-0.142	-0.158	-0.175	-0.278	-0.199	-0.292	-0.249
	(0.255)	(0.250)	(0.251)	(0.251)	(0.253)	(0.268)	(0.259)	(0.261)	(0.260)	(0.264)
Dummy variable (Hanoi)	-0.077	-0.038	-0.183	-0.031	-0.075	-0.130	-0.016	-0.176	0.011	-0.108
	(0.248)	(0.230)	(0.221)	(0.219)	(0.221)	(0.255)	(0.235)	(0.226)	(0.223)	(0.226)
Dummy variable (Ho Chi Minh)	1.829 ***	1.830 ***	1.850 ***	1.907 ***	1.854 ***	1.324 ***	1.285 ***	1.346 ***	1.379 ***	1.303 ***
	(0.264)	(0.232)	(0.219)	(0.220)	(0.227)	(0.272)	(0.236)	(0.220)	(0.221)	(0.230)
/cut1	-1.684	-1.671	-1.728	-1.714	-1.709	-0.693	-0.718	-0.716	-0.755	-0.721
	(0.361)	(0.357)	(0.356)	(0.355)	(0.358)	(0.330)	(0.326)	(0.325)	(0.324)	(0.327)
/cut2	-0.957	-0.946	-1.003	-0.989	-0.983	0.311	0.278	0.282	0.240	0.276
	(0.330)	(0.326)	(0.324)	(0.323)	(0.327)	(0.326)	(0.321)	(0.319)	(0.318)	(0.322)
/cut3	-0.434	-0.425	-0.480	-0.468	-0.462	1.369	1.316	1.329	1.271	1.312
	(0.318)	(0.314)	(0.312)	(0.311)	(0.315)	(0.330)	(0.324)	(0.323)	(0.321)	(0.326)
/cut4	0.216	0.220	0.168	0.173	0.180	2.576	2.490	2.519	2.442	2.488
	(0.313)	(0.308)	(0.306)	(0.305)	(0.309)	(0.338)	(0.332)	(0.332)	(0.329)	(0.334)
/cut5	0.879	0.873	0.826	0.821	0.827					
	(0.314)	(0.309)	(0.307)	(0.306)	(0.310)					
/cut6	1.469	1.454	1.410	1.401	1.406					
	(0.318)	(0.314)	(0.312)	(0.311)	(0.315)					
/cut7	2.274	2.246	2.206	2.194	2.197					
	(0.327)	(0.322)	(0.320)	(0.319)	(0.323)					
/cut8	3.347	3.299	3.268	3.245	3.248					
	(0.337)	(0.332)	(0.330)	(0.329)	(0.332)					
Number of observation	715	715	715	715	715	715	715	715	715	715
Log likelihood	-1256	-1265	-1261	-1266	-1266	-963	-975	-969	-976	-974
Pseudo R2	0.078	0.071	0.074	0.070	0.070	0.083	0.071	0.077	0.070	0.072

	Process innovation				
	Full model	Selected model 1	Selected model 2	Selected model 3	Selected model 4
Age (establishment)	0.013 *	0.012 *	0.013 *	0.013 *	0.013 *
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Number of full-time employees (logarithmic)	0.200 ***	0.186 ***	0.179 ***	0.183 ***	0.180 ***
	(0.062)	(0.061)	(0.060)	(0.061)	(0.061)
Textiles, Apparel, leather	0.024	0.055	0.016	-0.042	-0.051
	(0.275)	(0.271)	(0.269)	(0.269)	(0.269)
Wood, Paper products	-0.262	-0.241	-0.202	-0.193	-0.205
	(0.284)	(0.277)	(0.280)	(0.277)	(0.277)
Coal, Chemical products	-0.048	-0.018	-0.045	-0.074	-0.094
	(0.351)	(0.344)	(0.343)	(0.345)	(0.343)
Iron, Metal products	0.217	0.233	0.191	0.197	0.202
	(0.253)	(0.249)	(0.248)	(0.247)	(0.246)
Computers, Other electronics	-0.374	-0.374	-0.403	-0.392	-0.382
	(0.291)	(0.285)	(0.283)	(0.285)	(0.285)
Automobile, Other transportation	-0.054	-0.040	-0.033	-0.062	-0.085
	(0.377)	(0.371)	(0.373)	(0.371)	(0.373)
(a) Internal sources of information and own R&D efforts	-0.014	-0.016			
	(0.035)	(0.034)			
(b) Cooperation with local firms (100% local capital)	0.060 *	0.057 *			
	(0.036)	(0.035)			
(c) Cooperation with MNCs (100% non-local capital)	0.047	0.041			
	(0.046)	(0.045)			
(d) Cooperation with Joint Ventures	-0.057	-0.052			
	(0.044)	(0.043)			
(e) Technical assistance financed/provided by government/public agency	-0.023		-0.031		
	(0.037)		(0.034)		
(f) Technical assistance financed/provided by industrial/trade organizations	0.021		0.009		
	(0.037)		(0.035)		
(g) Technical assistance financed/provided by community organizations (NGOs or NPOs)	0.007		0.020		
	(0.040)		(0.039)		
(h) Technical assistance financed/provided by government owned financial institutions	0.047		0.049		
	(0.041)		(0.039)		
(i) Cooperation with universities/higher educational institutions	-0.041			-0.058	
	(0.041)			(0.039)	
(j) Cooperation with government or public research institutes	0.009			0.023	
	(0.042)			(0.040)	

(k) University professors or researchers personally closed contracts with your firm	0.016			0.024	
	(0.044)			(0.043)	
(l) Dispatch your engineers to universities/higher educational institutions	-0.019			-0.011	
	(0.047)			(0.046)	
(m) Dispatch your engineers to government or public research institutes	0.037			0.034	
	(0.052)			(0.051)	
(n) Recruitment of middle-ranking personnel or mid-carrier engineers	-0.023				-0.018
	(0.038)				(0.034)
(o) Recruitment of senior engineers retired from MNCs, JVs, or large local firms	-0.093 **				-0.072 *
	(0.043)				(0.041)
(p) Headhunt of top management from MNCs, JVs, or large local firms	0.056				0.052
	(0.049)				(0.046)
Number of Sources	0.048 ***	0.046 ***	0.042 ***	0.049 ***	0.057 ***
	(0.017)	(0.014)	(0.015)	(0.015)	(0.015)
Dummy variable (Indonesia)	0.779 ***	0.854 ***	0.877 ***	0.880 ***	0.773 ***
	(0.275)	(0.261)	(0.262)	(0.262)	(0.262)
Dummy variable (Thai)	0.092	0.162	0.166	0.140	0.045
	(0.274)	(0.267)	(0.268)	(0.269)	(0.270)
Dummy variable (Hanoi)	0.099	-0.006	-0.018	0.023	0.083
	(0.272)	(0.246)	(0.240)	(0.234)	(0.234)
Dummy variable (Ho Chi Minh)	2.546 ***	2.511 ***	2.542 ***	2.589 ***	2.570 ***
	(0.368)	(0.339)	(0.326)	(0.327)	(0.332)
/cut1	-0.551	-0.537	-0.613	-0.587	-0.645
	(0.360)	(0.356)	(0.352)	(0.351)	(0.355)
/cut2	-0.040	-0.030	-0.106	-0.081	-0.139
	(0.355)	(0.351)	(0.347)	(0.346)	(0.350)
/cut3	0.877	0.875	0.800	0.822	0.763
	(0.356)	(0.352)	(0.347)	(0.347)	(0.350)
/cut4	1.787	1.774	1.696	1.719	1.661
	(0.362)	(0.358)	(0.352)	(0.352)	(0.355)
Number of observation	715	715	715	715	715
Log likelihood	-760	-765	-766	-766	-766
Pseudo R2	0.100	0.095	0.094	0.094	0.094

Note 1: ***, ** and * indicate the significance level at the 1%, 5% and 10%

Note 2: Standard errors in parenthesis

Table A3 Estimation Results of Research Linkages (Table 11)

		Total innovation				Product innovation			
		Full model	Selected model 1	Selected model 2	Selected model 3	Full model	Selected model 1	Selected model 2	Selected model 3
		Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
	Age (establishment)	0.004	0.004	0.003	0.004	-0.006	-0.005	-0.006	-0.005
		(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
	Number of full-time employees (logarithmic)	0.255 ***	0.270 ***	0.267 ***	0.254 ***	0.251 ***	0.269 ***	0.261 ***	0.244 ***
		(0.053)	(0.052)	(0.052)	(0.053)	(0.055)	(0.054)	(0.053)	(0.054)
	Textiles, Apparel, leather	0.023	0.002	-0.055	-0.022	-0.097	-0.146	-0.183	-0.136
		(0.247)	(0.244)	(0.246)	(0.246)	(0.249)	(0.246)	(0.247)	(0.247)
	Wood, Paper products	-0.069	-0.131	-0.055	-0.048	-0.005	-0.079	-0.032	-0.005
		(0.247)	(0.245)	(0.242)	(0.242)	(0.258)	(0.256)	(0.253)	(0.252)
	Coal, Chemical products	0.457	0.441	0.349	0.334	0.643 **	0.600 *	0.527 *	0.527 *
		(0.305)	(0.302)	(0.300)	(0.299)	(0.314)	(0.307)	(0.308)	(0.309)
	Iron, Metal products	-0.419 **	-0.463 **	-0.408 **	-0.369 *	-0.694 ***	-0.720 ***	-0.711 ***	-0.670 ***
		(0.210)	(0.207)	(0.206)	(0.207)	(0.218)	(0.215)	(0.213)	(0.214)
	Computers, Other electronics	0.170	0.203	0.254	0.265	0.279	0.344	0.359	0.324
		(0.229)	(0.227)	(0.226)	(0.225)	(0.240)	(0.236)	(0.235)	(0.235)
	Automobile, Other transportation	0.179	0.160	0.121	0.148	0.099	0.095	0.019	0.026
		(0.330)	(0.326)	(0.325)	(0.326)	(0.325)	(0.322)	(0.320)	(0.321)
(e)	Technical assistance financed/provided by government/public agency	-0.079 **	-0.078 ***			-0.054 *	-0.050		
		(0.031)	(0.030)			(0.033)	(0.031)		
(f)	Technical assistance financed/provided by industrial/trade organizations	-0.013	-0.031			-0.010	-0.018		
		(0.030)	(0.029)			(0.031)	(0.030)		
(g)	Technical assistance financed/provided by community organizations (NGOs or NPOs)	0.034	0.026			0.055 *	0.051		
		(0.031)	(0.031)			(0.032)	(0.032)		
(h)	Technical assistance financed/provided by government owned financial institutions	0.104 ***	0.095 ***			0.105 ***	0.093 ***		
		(0.033)	(0.032)			(0.035)	(0.033)		
(i)	Cooperation with universities/higher educational institutions	-0.023		-0.043		-0.014		-0.025	
		(0.036)		(0.035)		(0.037)		(0.036)	
(j)	Cooperation with government or public research institutes	-0.056		-0.043		-0.068 *		-0.041	
		(0.036)		(0.035)		(0.037)		(0.036)	
(k)	University professors or researchers personally closed contracts with your firm	-0.033		-0.015		-0.025		-0.004	
		(0.037)		(0.036)		(0.037)		(0.037)	
(l)	Dispatch your engineers to universities/higher educational institutions	-0.034		-0.026		-0.029		-0.016	
		(0.040)		(0.040)		(0.042)		(0.041)	
(m)	Dispatch your engineers to government or public research institutes	0.073		0.069		0.061		0.065	
		(0.045)		(0.044)		(0.047)		(0.046)	

(n)	Recruitment of middle-ranking personnel or mid-carrier engineers	0.048			0.041	0.060 *			0.060 *
		(0.032)			(0.031)	(0.034)			(0.032)
(o)	Recruitment of senior engineers retired from MNCs, JVs, or large local firms	-0.071 *			-0.087 **	-0.023			-0.034
		(0.037)			(0.035)	(0.037)			(0.036)
(p)	Headhunt of top management from MNCs, JVs, or large local firms	0.049			0.049	0.057			0.052
		(0.043)			(0.040)	(0.044)			(0.042)
	Number of Sources	0.056 ***	0.046 ***	0.059 ***	0.053 ***	0.044 ***	0.042 ***	0.059 ***	0.048 ***
		(0.015)	(0.013)	(0.013)	(0.013)	(0.015)	(0.014)	(0.014)	(0.014)
	Dummy variable (Indonesia)	0.621 **	0.740 ***	0.733 ***	0.718 ***	0.567 **	0.615 **	0.538 **	0.591 **
		(0.241)	(0.236)	(0.233)	(0.235)	(0.255)	(0.248)	(0.246)	(0.248)
	Dummy variable (Thai)	-0.124	-0.023	-0.083	-0.104	-0.198	-0.147	-0.252	-0.219
		(0.253)	(0.248)	(0.248)	(0.249)	(0.265)	(0.259)	(0.259)	(0.261)
	Dummy variable (Vietnam)	0.819 ***	0.889 ***	0.986 ***	0.889 ***	0.536 **	0.646 ***	0.736 ***	0.609 ***
		(0.203)	(0.182)	(0.185)	(0.190)	(0.208)	(0.185)	(0.188)	(0.195)
	/cut1	-1.429	-1.461	-1.384	-1.335	-0.451	-0.484	-0.473	-0.395
		(0.359)	(0.357)	(0.355)	(0.357)	(0.328)	(0.325)	(0.322)	(0.324)
	/cut2	-0.702	-0.737	-0.657	-0.607	0.547	0.508	0.521	0.601
		(0.328)	(0.325)	(0.323)	(0.326)	(0.323)	(0.320)	(0.316)	(0.319)
	/cut3	-0.183	-0.219	-0.140	-0.088	1.564	1.516	1.520	1.601
		(0.316)	(0.313)	(0.311)	(0.314)	(0.328)	(0.324)	(0.320)	(0.324)
	/cut4	0.455	0.415	0.494	0.549	2.710	2.645	2.635	2.716
		(0.310)	(0.307)	(0.305)	(0.308)	(0.337)	(0.333)	(0.329)	(0.333)
	/cut5	1.097	1.052	1.127	1.183				
		(0.312)	(0.309)	(0.307)	(0.310)				
	/cut6	1.657	1.606	1.674	1.728				
		(0.316)	(0.313)	(0.311)	(0.314)				
	/cut7	2.391	2.325	2.388	2.440				
		(0.324)	(0.321)	(0.319)	(0.322)				
	/cut8	3.374	3.292	3.346	3.396				
		(0.334)	(0.330)	(0.328)	(0.332)				
	Number of observation	715	715	715	715	715	715	715	715
	Log likelihood	-1291	-1299	-1303	-1302	-983	-989	-994	-993
	Pseudo R2	0.052	0.047	0.044	0.044	0.064	0.058	0.053	0.054

		Process innovation							
		Full model		Selected		Selected		Selected	
		Coef.		Coef.		Coef.		Coef.	
	Age (establishment)	0.020	***	0.020	***	0.017	**	0.019	**
		(0.008)		(0.008)		(0.007)		(0.007)	
	Number of full-time employees (logarithmic)	0.250	***	0.251	***	0.257	***	0.249	***
		(0.061)		(0.060)		(0.060)		(0.061)	
	Textiles, Apparel, leather	-0.147		-0.103		-0.183		-0.202	
		(0.268)		(0.264)		(0.265)		(0.265)	
	Wood, Paper products	-0.243		-0.271		-0.193		-0.216	
		(0.274)		(0.272)		(0.267)		(0.267)	
	Coal, Chemical products	-0.001		0.019		-0.027		-0.081	
		(0.338)		(0.332)		(0.333)		(0.330)	
	Iron, Metal products	0.068		0.029		0.107		0.112	
		(0.243)		(0.240)		(0.240)		(0.239)	
	Computers, Other electronics	-0.059		-0.050		-0.003		0.022	
		(0.271)		(0.265)		(0.265)		(0.265)	
	Automobile, Other transportation	-0.009		0.001		-0.024		-0.025	
		(0.372)		(0.369)		(0.364)		(0.368)	
(e)	Technical assistance financed/provided by government/public agency	-0.080	**	-0.081	**				
		(0.034)		(0.033)					
(f)	Technical assistance financed/provided by industrial/trade organizations	-0.012		-0.036					
		(0.035)		(0.033)					
(g)	Technical assistance financed/provided by community organizations (NGOs or NPOs)	-0.024		-0.023					
		(0.037)		(0.036)					
(h)	Technical assistance financed/provided by government owned financial institutions	0.083	**	0.075	**				
		(0.039)		(0.038)					
(i)	Cooperation with universities/higher educational institutions	-0.030				-0.057			
		(0.040)				(0.039)			
(j)	Cooperation with government or public research institutes	-0.014				-0.018			
		(0.041)				(0.040)			
(k)	University professors or researchers personally closed contracts with your firm	-0.026				-0.020			
		(0.042)				(0.041)			
(l)	Dispatch your engineers to universities/higher educational institutions	-0.035				-0.027			
		(0.046)				(0.045)			
(m)	Dispatch your engineers to government or public research institutes	0.073				0.060			
		(0.052)				(0.051)			
(n)	Recruitment of middle-ranking personnel or mid-carrier engineers	0.011						0.001	
		(0.036)						(0.034)	
(o)	Recruitment of senior engineers retired from MNCs, JVs, or large local firms	-0.119	***					-0.127	***
		(0.041)						(0.040)	

(p)	Headhunt of top management from MNCs, JVs, or large local firms	0.051						0.051	
		(0.049)						(0.046)	
	Number of Sources	0.055	***	0.041	***	0.043	***	0.048	***
		(0.017)		(0.015)		(0.015)		(0.015)	
	Dummy variable (Indonesia)	0.732	***	0.892	***	0.955	***	0.852	***
		(0.270)		(0.262)		(0.262)		(0.263)	
	Dummy variable (Thai)	0.090		0.221		0.197		0.110	
		(0.274)		(0.268)		(0.269)		(0.270)	
	Dummy variable (Vietnam)	1.095	***	1.052	***	1.057	***	1.033	***
		(0.228)		(0.204)		(0.205)		(0.209)	
	/cut1	-0.264		-0.262		-0.162		-0.195	
		(0.355)		(0.353)		(0.351)		(0.354)	
	/cut2	0.242		0.240		0.341		0.308	
		(0.350)		(0.348)		(0.346)		(0.349)	
	/cut3	1.124		1.113		1.209		1.177	
		(0.350)		(0.348)		(0.346)		(0.349)	
	/cut4	1.969		1.947		2.034		2.006	
		(0.356)		(0.354)		(0.352)		(0.355)	
	Number of observation	715		715		715		715	
	Log likelihood	-794		-800		-803		-801	
	Pseudo R2	0.061		0.053		0.050		0.053	

Note 1: ***, ** and * indicate the significance level at the 1%, 5% and 10%

Note 2: Standard errors in parenthesis

Table A4 Research Linkages in Different Industry (Total Innovation) (Table 12)

	Food, beverages, tobacco			Textiles, Apparel, leather			Wood, wood products, Paper, paper products, printing		
	Selected model 1	Selected model 2	Selected model 3	Selected model 1	Selected model 2	Selected model 3	Selected model 1	Selected model 2	Selected model 3
Age (establishment)	0.007	-0.009	0.001	0.006	0.016	0.001	0.010	0.009	0.014
	(0.018)	(0.019)	(0.019)	(0.029)	(0.031)	(0.028)	(0.016)	(0.016)	(0.017)
Number of full-time employees (logarithmic)	0.216	0.219	0.217	0.297 *	0.327 *	0.282	0.293	0.319	0.271
	(0.172)	(0.187)	(0.175)	(0.171)	(0.178)	(0.173)	(0.193)	(0.195)	(0.194)
(e) Technical assistance financed/provided by	-0.238 **		0.119	-0.077			0.002		
government/public agency	(0.102)		(0.089)	(0.095)			(0.091)		
(f) Technical assistance financed/provided by	0.142		-0.165	-0.077			-0.094		
industrial/trade organizations	(0.093)		(0.126)	(0.103)			(0.104)		
(g) Technical assistance financed/provided by	-0.090		-0.027	0.005			0.076		
community organizations (NGOs or NPOs)	(0.101)		(0.131)	(0.101)			(0.126)		
(h) Technical assistance financed/provided by	0.118			0.085			0.031		
government owned financial institutions	(0.123)			(0.159)			(0.105)		
(i) Cooperation with universities/higher		0.020			-0.188			0.009	
educational institutions		(0.112)			(0.143)			(0.141)	
(j) Cooperation with government or public		0.230 *			0.090			-0.071	
research institutes		(0.128)			(0.129)			(0.102)	
(k) University professors or researchers		-0.278 **			-0.138			-0.056	
personally closed contracts with your firm		(0.132)			(0.133)			(0.141)	
(l) Dispatch your engineers to universities/higher		-0.157			0.101			-0.316 **	
educational institutions		(0.137)			(0.204)			(0.147)	
(m) Dispatch your engineers to government or		-0.036			-0.213			0.161	
public research institutes		(0.137)			(0.238)			(0.146)	
(n) Recruitment of middle-ranking personnel or						0.017			0.034
mid-carrier engineers						(0.114)			(0.102)
(o) Recruitment of senior engineers retired from						-0.203			-0.042
MNCs, JVs, or large local firms						(0.139)			(0.129)
(p) Headhunt of top management from MNCs,						0.081			-0.095
JVs, or large local firms						(0.154)			(0.165)
Number of Sources	0.124 ***	0.122 ***	0.118 ***	0.119 **	0.143 ***	0.131 ***	0.072 *	0.118 ***	0.082 **
	(0.035)	(0.040)	(0.036)	(0.049)	(0.047)	(0.046)	(0.038)	(0.041)	(0.037)
Dummy variable (Indonesia)	-0.185	-0.315	-0.032	0.834	0.912	0.819	0.754	0.241	0.743
	(0.534)	(0.544)	(0.539)	(0.789)	(0.798)	(0.773)	(0.691)	(0.744)	(0.689)
Dummy variable (Thai)	0.642	0.563	0.846	-0.289	0.624	-0.533	-1.652	-2.313 **	-1.685
	(1.126)	(1.183)	(1.098)	(1.123)	(1.243)	(1.195)	(1.050)	(1.144)	(1.038)

Dummy variable (Vietnam)	0.663	0.263	0.084	0.166	0.409	0.122	0.802	0.891	0.852
	(0.567)	(0.583)	(0.577)	(0.665)	(0.655)	(0.732)	(0.748)	(0.771)	(0.809)
/cut1	-2.520	-2.916	-2.233	-0.090	0.374	-0.018	-0.942	-1.153	-0.865
	(1.328)	(1.360)	(1.338)	(0.981)	(1.040)	(0.989)	(1.127)	(1.202)	(1.123)
/cut2	-1.364	-1.717	-1.080	0.265	0.746	0.346	-0.607	-0.812	-0.526
	(1.056)	(1.102)	(1.069)	(0.973)	(1.036)	(0.981)	(1.093)	(1.165)	(1.090)
/cut3	-0.579	-0.929	-0.300	0.544	1.040	0.636	-0.345	-0.548	-0.261
	(0.987)	(1.030)	(1.001)	(0.970)	(1.037)	(0.980)	(1.075)	(1.146)	(1.072)
/cut4	0.289	-0.060	0.546	1.100	1.634	1.205	0.491	0.318	0.587
	(0.958)	(0.995)	(0.974)	(0.977)	(1.050)	(0.989)	(1.046)	(1.115)	(1.044)
/cut5	1.311	0.978	1.536	1.549	2.106	1.650	0.961	0.813	1.063
	(0.970)	(1.000)	(0.984)	(0.986)	(1.061)	(0.997)	(1.043)	(1.111)	(1.042)
/cut6	1.712	1.389	1.922	1.941	2.516	2.039	2.050	1.973	2.148
	(0.984)	(1.009)	(0.994)	(0.994)	(1.072)	(1.006)	(1.061)	(1.125)	(1.061)
/cut7	2.360	2.025	2.538	2.874	3.499	2.962	2.835	2.817	2.918
	(1.009)	(1.026)	(1.015)	(1.027)	(1.118)	(1.043)	(1.094)	(1.153)	(1.093)
/cut8	3.549	3.185	3.666	3.603	4.247	3.689	3.924	3.966	3.984
	(1.042)	(1.055)	(1.048)	(1.052)	(1.147)	(1.068)	(1.143)	(1.198)	(1.139)
Number of observation	84	84	84	72	72	72	65	65	65
Log likelihood	-145.1	-144.6	-147.4	-125.8	-123.7	-125.5	-114.4	-111.3	-114.8
Pseudo R2	0.075	0.077	0.059	0.086	0.101	0.088	0.076	0.101	0.074

	Coal, petroleum products, Chemicals, chemical products			Plastic, rubber products, Other non-metallic mineral products			Iron, steel, Non-ferrous metals, Metal products		
	Selected model 1	Selected model 2	Selected model 3	Selected model 1	Selected model 2	Selected model 3	Selected model 1	Selected model 2	Selected model 3
Age (establishment)	0.009	-0.003	0.027	-0.010	-0.013	-0.010	0.030 *	0.017	0.029
	(0.028)	(0.029)	(0.033)	(0.021)	(0.022)	(0.020)	(0.018)	(0.019)	(0.018)
Number of full-time employees (logarithmic)	0.463	0.393	0.481	0.616 ***	0.748 ***	0.636 ***	0.150	0.142	0.283 *
	(0.316)	(0.335)	(0.353)	(0.207)	(0.211)	(0.207)	(0.146)	(0.159)	(0.147)
(e) Technical assistance financed/provided by government/public agency	-0.001			-0.054			-0.175 **		
	(0.136)			(0.104)			(0.088)		
(f) Technical assistance financed/provided by industrial/trade organizations	-0.139			-0.276 ***			0.076		
	(0.140)			(0.102)			(0.093)		
(g) Technical assistance financed/provided by community organizations (NGOs or NPOs)	0.157			0.025			0.115		
	(0.168)			(0.103)			(0.088)		
(h) Technical assistance financed/provided by government owned financial institutions	-0.005			0.120			-0.033		
	(0.234)			(0.099)			(0.089)		
(i) Cooperation with universities/higher educational institutions		0.103			-0.309 *			0.003	
		(0.375)			(0.167)			(0.099)	
(j) Cooperation with government or public research institutes		-0.161			-0.048			-0.183	
		(0.294)			(0.129)			(0.112)	
(k) University professors or researchers personally closed contracts with your firm		-0.188			0.075			0.194 *	
		(0.222)			(0.159)			(0.110)	
(l) Dispatch your engineers to universities/higher educational institutions		-0.203			0.080			-0.005	
		(0.183)			(0.168)			(0.101)	
(m) Dispatch your engineers to government or public research institutes		0.614			0.066			-0.086	
		(0.394)			(0.146)			(0.113)	
(n) Recruitment of middle-ranking personnel or mid-carrier engineers			-0.143			0.048			-0.206 **
			(0.143)			(0.098)			(0.082)
(o) Recruitment of senior engineers retired from MNCs, JVs, or large local firms			-0.377 **			-0.145			-0.176 *
			(0.152)			(0.120)			(0.100)
(p) Headhunt of top management from MNCs, JVs, or large local firms			0.134			0.153			0.012
			(0.179)			(0.150)			(0.110)
Number of Sources	0.039	-0.010	0.080	0.097 **	0.099 *	0.054	0.004	0.013	0.058
	(0.074)	(0.078)	(0.067)	(0.046)	(0.056)	(0.053)	(0.046)	(0.041)	(0.039)
Dummy variable (Indonesia)	-0.476	0.342	-0.393	1.214	0.388	0.290	0.776	0.878	0.428
	(1.381)	(1.275)	(1.312)	(0.953)	(1.010)	(0.952)	(0.906)	(0.816)	(0.809)
Dummy variable (Thai)	-0.668	-0.332	-0.705	-0.607	-1.043	-0.737	0.268	0.112	0.122
	(1.009)	(0.921)	(0.963)	(0.836)	(0.992)	(0.912)	(0.678)	(0.671)	(0.697)

Dummy variable (Vietnam)	0.478	1.376	1.690 *	1.693 ***	1.304 **	1.316 **	1.609 ***	1.531 ***	2.243 ***
	(1.009)	(0.960)	(0.986)	(0.610)	(0.639)	(0.571)	(0.532)	(0.538)	(0.539)
/cut1	-0.618	-1.331	-0.493	0.420	1.154	0.694	-2.930	-3.180	-2.613
	(1.741)	(1.954)	(1.889)	(0.977)	(0.992)	(0.966)	(1.223)	(1.248)	(1.224)
/cut2	0.128	-0.574	0.433	1.459	2.254	1.748	-1.487	-1.756	-1.152
	(1.673)	(1.885)	(1.813)	(0.949)	(0.974)	(0.938)	(0.871)	(0.906)	(0.873)
/cut3	0.925	0.261	1.428	1.972	2.802	2.270	-0.595	-0.855	-0.254
	(1.633)	(1.831)	(1.760)	(0.955)	(0.987)	(0.944)	(0.790)	(0.824)	(0.792)
/cut4	1.723	1.127	2.380	2.401	3.244	2.688	0.109	-0.127	0.457
	(1.636)	(1.815)	(1.768)	(0.969)	(1.008)	(0.958)	(0.765)	(0.794)	(0.765)
/cut5	2.212	1.660	2.926	3.098	3.898	3.305	1.151	0.906	1.521
	(1.660)	(1.832)	(1.800)	(1.006)	(1.047)	(0.989)	(0.781)	(0.798)	(0.779)
/cut6	3.200	2.693	3.898	3.290	4.063	3.463	1.914	1.678	2.291
	(1.700)	(1.873)	(1.856)	(1.017)	(1.056)	(0.998)	(0.816)	(0.828)	(0.816)
/cut7				4.251	4.912	4.314	2.655	2.467	3.048
				(1.067)	(1.098)	(1.040)	(0.847)	(0.860)	(0.852)
/cut8				5.296	5.896	5.302	3.747	3.585	4.188
				(1.113)	(1.144)	(1.085)	(0.873)	(0.887)	(0.888)
Number of observation	41	41	41	75	75	75	93	93	93
Log likelihood	-66.4	-65.1	-64.0	-128.3	-130.6	-132.0	-174.6	-173.7	-172.5
Pseudo R2	0.056	0.075	0.091	0.117	0.101	0.091	0.059	0.063	0.070

		Machinery, equipment, tools			Computers & computer parts, Other electronics & components			Precision instruments, Automobile, auto parts, Other transportation equipments and parts		
		Selected model 1	Selected model 2	Selected model 3	Selected model 1	Selected model 2	Selected model 3	Selected model 1	Selected model 2	Selected model 3
	Age (establishment)	0.017	0.036	0.038	0.016	-0.021	0.012	-0.050 **	-0.055 **	-0.038
		(0.037)	(0.035)	(0.034)	(0.028)	(0.031)	(0.028)	(0.024)	(0.025)	(0.025)
	Number of full-time employees (logarithmic)	0.337	0.468	0.603 **	0.560 ***	0.566 ***	0.631 ***	0.634 ***	0.618 ***	0.574 ***
		(0.282)	(0.285)	(0.295)	(0.181)	(0.186)	(0.187)	(0.217)	(0.211)	(0.215)
(e)	Technical assistance financed/provided by government/public agency	-0.388 ***			0.192			-0.016		
		(0.142)			(0.119)			(0.114)		
(f)	Technical assistance financed/provided by industrial/trade organizations	-0.189			0.018			0.003		
		(0.122)			(0.111)			(0.116)		
(g)	Technical assistance financed/provided by community organizations (NGOs or NPOs)	-0.032			-0.081			0.019		
		(0.130)			(0.088)			(0.129)		
(h)	Technical assistance financed/provided by government owned financial institutions	0.169			0.065			0.320 **		
		(0.131)			(0.093)			(0.160)		
(i)	Cooperation with universities/higher educational institutions		-0.097			-0.092			-0.007	
			(0.156)			(0.128)			(0.124)	
(j)	Cooperation with government or public research institutes		-0.302 **			-0.192			0.058	
			(0.148)			(0.127)			(0.161)	
(k)	University professors or researchers personally closed contracts with your firm		-0.115			-0.072			0.042	
			(0.125)			(0.113)			(0.130)	
(l)	Dispatch your engineers to universities/higher educational institutions		0.339 **			0.043			0.100	
			(0.169)			(0.162)			(0.142)	
(m)	Dispatch your engineers to government or public research institutes		-0.572 **			-0.116			0.272	
			(0.287)			(0.180)			(0.178)	
(n)	Recruitment of middle-ranking personnel or mid-carrier engineers			-0.018			0.115			0.265 *
				(0.242)			(0.126)			(0.152)
(o)	Recruitment of senior engineers retired from MNCs, JVs, or large local firms			0.265 **			-0.160			-0.074
				(0.133)			(0.106)			(0.192)
(p)	Headhunt of top management from MNCs, JVs, or large local firms			0.128			0.167			0.158
				(0.196)			(0.140)			(0.202)
	Number of Sources	0.196 **	0.232 **	-0.020	0.010	0.120 *	0.022	-0.044	-0.093	-0.056
		(0.096)	(0.100)	(0.092)	(0.052)	(0.062)	(0.053)	(0.050)	(0.058)	(0.052)
	Dummy variable (Indonesia)	15.259	14.639	17.256	0.174	-0.791	-0.087	3.097 **	3.349 **	4.097 ***
		(1112)	(1263)	(814)	(0.970)	(0.987)	(0.991)	(1.356)	(1.343)	(1.566)
	Dummy variable (Thai)	3.296 **	2.341	2.918 *	0.627	-0.516	1.051	2.795 ***	2.712 ***	2.895 ***
		(1.644)	(2.137)	(1.701)	(0.882)	(1.037)	(0.911)	(0.946)	(0.907)	(0.933)

Dummy variable (Vietnam)	1.214	0.794	1.652	2.237 ***	1.649 ***	1.768 ***	2.025 ***	1.878 ***	1.190
	(0.967)	(0.925)	(1.221)	(0.615)	(0.581)	(0.643)	(0.698)	(0.667)	(0.752)
/cut1	-1.041	0.230	0.352	-0.123	-0.439	0.409	-0.327	-0.838	0.132
	(1.717)	(1.655)	(1.680)	(1.509)	(1.533)	(1.501)	(1.278)	(1.260)	(1.336)
/cut2	0.243	1.518	1.642	1.745	1.459	2.293	0.514	-0.031	0.951
	(1.536)	(1.494)	(1.508)	(1.208)	(1.236)	(1.200)	(1.203)	(1.183)	(1.266)
/cut3	1.606	2.936	2.978	2.350	2.071	2.914	1.516	0.980	1.913
	(1.518)	(1.519)	(1.526)	(1.192)	(1.221)	(1.187)	(1.185)	(1.157)	(1.251)
/cut4	1.994	3.322	3.324	2.823	2.552	3.408	2.052	1.536	2.455
	(1.530)	(1.541)	(1.543)	(1.202)	(1.228)	(1.201)	(1.204)	(1.172)	(1.269)
/cut5	2.897	4.087	4.022	3.409	3.138	4.018	2.710	2.213	3.109
	(1.568)	(1.583)	(1.581)	(1.226)	(1.246)	(1.233)	(1.233)	(1.196)	(1.290)
/cut6	3.850	5.005	4.826	4.082	3.787	4.690	3.795	3.348	4.162
	(1.604)	(1.638)	(1.620)	(1.260)	(1.275)	(1.276)	(1.268)	(1.228)	(1.309)
/cut7	5.041	6.203	5.895	5.596	5.250	6.157	4.643	4.204	5.011
	(1.643)	(1.694)	(1.667)	(1.327)	(1.329)	(1.342)	(1.300)	(1.259)	(1.344)
Number of observation	50	50	50	87	87	87	57	57	57
Log likelihood	-72.4	-73.6	-76.8	-127.0	-127.1	-127.3	-88.5	-88.2	-88.3
Pseudo R2	0.178	0.164	0.128	0.101	0.101	0.099	0.122	0.124	0.123

		Others		
		Selected model 1	Selected model 2	Selected model 3
	Age (establishment)	0.000	0.009	0.004
		(0.009)	(0.009)	(0.009)
	Number of full-time employees (logarithmic)	0.191	0.016	0.101
		(0.141)	(0.149)	(0.142)
(e)	Technical assistance financed/provided by government/public agency	-0.101		
(f)	Technical assistance financed/provided by industrial/trade organizations	0.049		
(g)	Technical assistance financed/provided by community organizations (NGOs or NPOs)	0.180 *		
(h)	Technical assistance financed/provided by government owned financial institutions	0.132		
(i)	Cooperation with universities/higher educational institutions		-0.110	
			(0.103)	
(j)	Cooperation with government or public research institutes		0.000	
			(0.110)	
(k)	University professors or researchers personally closed contracts with your firm		0.058	
			(0.099)	
(l)	Dispatch your engineers to universities/higher educational institutions		0.031	
			(0.118)	
(m)	Dispatch your engineers to government or public research institutes		0.261 **	
			(0.123)	
(n)	Recruitment of middle-ranking personnel or mid-carrier engineers			0.130
				(0.087)
(o)	Recruitment of senior engineers retired from MNCs, JVs, or large local firms			-0.068
				(0.120)
(p)	Headhunt of top management from MNCs, JVs, or large local firms			0.076
				(0.124)
	Number of Sources	-0.011	-0.003	0.025
		(0.034)	(0.035)	(0.037)
	Dummy variable (Indonesia)	-0.129	-0.297	-0.298
		(0.666)	(0.670)	(0.701)
	Dummy variable (Thai)	-0.934	-1.286 *	-1.344 *
		(0.703)	(0.697)	(0.766)

Dummy variable (Vietnam)	-0.223	-0.041	-0.427
	(0.649)	(0.653)	(0.738)
/cut1	-3.199	-4.079	-3.198
	(1.069)	(1.121)	(1.093)
/cut2	-2.470	-3.353	-2.461
	(0.943)	(0.999)	(0.969)
/cut3	-1.860	-2.737	-1.843
	(0.881)	(0.939)	(0.911)
/cut4	-1.440	-2.303	-1.422
	(0.855)	(0.912)	(0.887)
/cut5	-0.693	-1.536	-0.699
	(0.837)	(0.890)	(0.870)
/cut6	-0.054	-0.893	-0.086
	(0.840)	(0.888)	(0.869)
/cut7	0.823	-0.028	0.750
	(0.858)	(0.897)	(0.883)
/cut8	1.935	1.065	1.802
	(0.879)		(0.897)
Number of observation	91	91	91
Log likelihood	-161.2	-161.2	-164.1
Pseudo R2	0.046	0.045	0.028

Note 1: ***, ** and * indicate the significance level at the 1%, 5% and 10%

Note 2: Standard errors in parenthesis

Table A5 Research Linkages in Different Industry (Product Innovation) (Table 13)

	Food, beverages, tobacco			Textiles, Apparel, leather			Wood, wood products, Paper, paper products, printing		
	Selected model 1	Selected model 2	Selected model 3	Selected model 1	Selected model 2	Selected model 3	Selected model 1	Selected model 2	Selected model 3
Age (establishment)	0.000	-0.019	0.004	-0.006	0.000	-0.013	-0.003	-0.002	0.000
	(0.020)	(0.021)	(0.020)	(0.030)	(0.033)	(0.030)	(0.017)	(0.017)	(0.018)
Number of full-time employees (logarithmic)	0.185	0.127	0.120	0.248	0.283	0.227	0.077	0.017	0.046
	(0.183)	(0.194)	(0.186)	(0.167)	(0.175)	(0.168)	(0.199)	(0.199)	(0.199)
(e) Technical assistance financed/provided by government/public agency	-0.174			-0.057			-0.016		
	(0.108)			(0.097)			(0.099)		
(f) Technical assistance financed/provided by industrial/trade organizations	0.190 **			-0.047			-0.110		
	(0.095)			(0.106)			(0.115)		
(g) Technical assistance financed/provided by community organizations (NGOs or NPOs)	-0.050			-0.011			0.270 *		
	(0.110)			(0.103)			(0.154)		
(h) Technical assistance financed/provided by government owned financial institutions	0.182			0.074			0.033		
	(0.133)			(0.164)			(0.112)		
(i) Cooperation with universities/higher educational institutions		-0.091			-0.095			-0.014	
		(0.123)			(0.143)			(0.138)	
(j) Cooperation with government or public research institutes		0.334 **			0.058			-0.117	
		(0.138)			(0.128)			(0.105)	
(k) University professors or researchers personally closed contracts with your firm		-0.032			-0.157			0.091	
		(0.137)			(0.133)			(0.142)	
(l) Dispatch your engineers to universities/higher educational institutions		-0.236			0.027			-0.173	
		(0.160)			(0.204)			(0.150)	
(m) Dispatch your engineers to government or public research institutes		-0.044			-0.150			0.121	
		(0.154)			(0.239)			(0.154)	
(n) Recruitment of middle-ranking personnel or mid-carrier engineers			0.193 **			0.072			0.009
			(0.096)			(0.117)			(0.102)
(o) Recruitment of senior engineers retired from MNCs, JVs, or large local firms			-0.179			-0.184			0.058
			(0.143)			(0.138)			(0.144)
(p) Headhunt of top management from MNCs, JVs, or large local firms			0.269			0.071			-0.059
			(0.166)			(0.149)			(0.183)
Number of Sources	0.162 ***	0.188 ***	0.142 ***	0.120 **	0.150 ***	0.133 ***	0.037	0.077 **	0.057
	(0.040)	(0.048)	(0.040)	(0.051)	(0.049)	(0.048)	(0.038)	(0.039)	(0.036)
Dummy variable (Indonesia)	-0.496	-0.711	-0.356	0.446	0.265	0.331	0.628	0.293	0.536
	(0.594)	(0.608)	(0.599)	(0.848)	(0.859)	(0.834)	(0.660)	(0.723)	(0.655)
Dummy variable (Thai)	-0.266	-0.462	-0.239	-0.661	0.015	-1.099	-1.427	-1.944 *	-1.630 *
	(1.091)	(1.108)	(1.080)	(1.128)	(1.255)	(1.204)	(0.973)	(1.027)	(0.969)

Dummy variable (Vietnam)	0.070	-0.306	-0.408	0.111	0.268	-0.206	1.056	1.067	0.989
	(0.594)	(0.621)	(0.620)	(0.704)	(0.671)	(0.765)	(0.716)	(0.753)	(0.772)
/cut1	-0.616	-1.330	-0.524	-0.009	0.364	0.005	-1.548	-1.904	-1.552
	(1.062)	(1.088)	(1.053)	(0.948)	(1.001)	(0.953)	(1.066)	(1.145)	(1.076)
/cut2	0.841	0.134	0.957	0.968	1.386	0.996	-0.421	-0.743	-0.417
	(1.059)	(1.074)	(1.053)	(0.947)	(1.006)	(0.955)	(1.028)	(1.098)	(1.037)
/cut3	2.019	1.357	2.140	1.877	2.334	1.902	0.866	0.578	0.861
	(1.093)	(1.101)	(1.084)	(0.965)	(1.032)	(0.974)	(1.026)	(1.090)	(1.033)
/cut4	3.006	2.344	3.097	2.893	3.382	2.932	1.983	1.667	1.918
	(1.115)	(1.118)	(1.103)	(0.994)	(1.069)	(1.005)	(1.051)	(1.110)	(1.057)
Number of observation	84	84	84	72	72	72	65	65	65
Log likelihood	-103.8	-103.3	-103.7	-99.2	-97.5	-98.6	-87.6	-88.3	-89.8
Pseudo R2	0.137	0.141	0.137	0.090	0.105	0.095	0.106	0.098	0.084

		Coal, petroleum products, Chemicals, chemical products			Plastic, rubber products, Other non-metallic mineral products			Iron, steel, Non-ferrous metals, Metal products		
		Selected model 1	Selected model 2	Selected model 3	Selected model 1	Selected model 2	Selected model 3	Selected model 1	Selected model 2	Selected model 3
	Age (establishment)	-0.038 (0.031)	-0.062 * (0.037)	-0.037 (0.035)	-0.005 (0.022)	-0.004 (0.022)	-0.004 (0.021)	0.023 (0.018)	0.022 (0.020)	0.026 (0.019)
	Number of full-time employees (logarithmic)	0.784 ** (0.362)	0.995 ** (0.467)	0.802 ** (0.363)	0.461 ** (0.206)	0.618 *** (0.211)	0.508 ** (0.204)	0.148 (0.153)	0.080 (0.158)	0.240 (0.152)
(e)	Technical assistance financed/provided by government/public agency	-0.215 (0.155)			-0.065 (0.110)			-0.065 (0.089)		
(f)	Technical assistance financed/provided by industrial/trade organizations	-0.284 * (0.150)			-0.285 *** (0.108)			0.022 (0.098)		
(g)	Technical assistance financed/provided by community organizations (NGOs or NPOs)	0.081 (0.178)			-0.008 (0.108)			0.186 ** (0.091)		
(h)	Technical assistance financed/provided by government owned financial institutions	0.216 (0.262)			0.131 (0.104)			-0.029 (0.091)		
(i)	Cooperation with universities/higher educational institutions		-0.269 (0.464)			-0.383 ** (0.166)			0.070 (0.102)	
(j)	Cooperation with government or public research institutes		-0.059 (0.353)			0.025 (0.129)			-0.222 ** (0.110)	
(k)	University professors or researchers personally closed contracts with your firm		-0.173 (0.222)			-0.012 (0.153)			0.084 (0.110)	
(l)	Dispatch your engineers to universities/higher educational institutions		-0.237 (0.199)			0.161 (0.169)			-0.123 (0.101)	
(m)	Dispatch your engineers to government or public research institutes		1.181 ** (0.541)			-0.002 (0.145)			0.006 (0.112)	
(n)	Recruitment of middle-ranking personnel or mid-carrier engineers			-0.077 (0.161)			0.016 (0.103)			-0.180 ** (0.086)
(o)	Recruitment of senior engineers retired from MNCs, JVs, or large local firms			-0.153 (0.143)			-0.033 (0.119)			-0.186 * (0.100)
(p)	Headhunt of top management from MNCs, JVs, or large local firms			-0.057 (0.203)			0.036 (0.153)			0.094 (0.111)
	Number of Sources	0.097 (0.081)	-0.068 (0.108)	0.113 (0.074)	0.090 * (0.048)	0.109 * (0.059)	0.035 (0.054)	-0.004 (0.049)	0.054 (0.043)	0.064 (0.039)
	Dummy variable (Indonesia)	-0.394 (1.451)	1.965 (1.732)	0.486 (1.388)	1.270 (0.998)	0.376 (0.989)	0.618 (0.978)	1.159 (0.966)	0.455 (0.846)	0.386 (0.802)
	Dummy variable (Thai)	-0.514 (1.110)	0.469 (1.119)	-0.466 (1.056)	-1.479 * (0.874)	-2.090 ** (1.059)	-1.255 (0.947)	0.355 (0.713)	0.264 (0.709)	0.138 (0.737)

Dummy variable (Vietnam)	0.315	1.049	0.491	1.869 ***	1.397 **	1.389 **	2.200 ***	2.255 ***	2.808 ***
	(1.084)	(1.095)	(0.966)	(0.619)	(0.639)	(0.580)	(0.570)	(0.585)	(0.589)
/cut1	-0.755	-0.434	0.158	0.740	1.754	1.165	0.198	-0.059	0.434
	(2.003)	(2.224)	(1.934)	(0.955)	(0.974)	(0.929)	(0.835)	(0.833)	(0.820)
/cut2	2.143	2.373	2.833	1.810	2.786	2.125	1.353	1.125	1.590
	(1.900)	(2.124)	(1.867)	(0.972)	(1.003)	(0.946)	(0.852)	(0.840)	(0.835)
/cut3	3.440	3.723	4.068	2.916	3.862	3.118	2.632	2.495	2.894
	(1.933)	(2.182)	(1.934)	(1.022)	(1.060)	(0.988)	(0.892)	(0.879)	(0.879)
/cut4				3.985	4.907	4.087	3.986	3.867	4.309
				(1.074)	(1.117)	(1.035)	(0.934)	(0.925)	(0.933)
Number of observation	41	41	41	75	75	75	93	93	93
Log likelihood	-38.8	-38.1	-41.0	-96.4	-97.6	-100.9	-132.6	-131.3	-131.0
Pseudo R2	0.204	0.219	0.159	0.147	0.137	0.107	0.099	0.108	0.109

	Machinery, equipment, tools			Computers & computer parts, Other electronics & components			Precision instruments, Automobile, auto parts, Other transportation equipments and parts		
	Selected model 1	Selected model 2	Selected model 3	Selected model 1	Selected model 2	Selected model 3	Selected model 1	Selected model 2	Selected model 3
Age (establishment)	-0.018 (0.038)	0.010 (0.037)	0.008 (0.035)	-0.003 (0.030)	-0.043 (0.032)	-0.006 (0.029)	-0.052 ** (0.025)	-0.060 ** (0.025)	-0.037 (0.025)
Number of full-time employees (logarithmic)	0.300 (0.308)	0.406 (0.307)	0.408 (0.294)	0.577 *** (0.190)	0.584 *** (0.193)	0.638 *** (0.196)	0.390 ** (0.197)	0.372 * (0.196)	0.378 * (0.205)
(e) Technical assistance financed/provided by government/public agency	-0.227 (0.138)			0.173 (0.124)			0.072 (0.115)		
(f) Technical assistance financed/provided by industrial/trade organizations	-0.201 (0.125)			0.085 (0.118)			0.038 (0.119)		
(g) Technical assistance financed/provided by community organizations (NGOs or NPOs)	-0.051 (0.134)			-0.073 (0.094)			0.016 (0.130)		
(h) Technical assistance financed/provided by government owned financial institutions	0.260 * (0.139)			0.077 (0.102)			0.262 * (0.156)		
(i) Cooperation with universities/higher educational institutions		-0.116 (0.169)			-0.118 (0.134)			0.032 (0.129)	
(j) Cooperation with government or public research institutes		-0.326 * (0.167)			-0.176 (0.134)			0.097 (0.153)	
(k) University professors or researchers personally closed contracts with your firm		-0.088 (0.137)			-0.119 (0.120)			0.035 (0.129)	
(l) Dispatch your engineers to universities/higher educational institutions		0.394 * (0.205)			0.078 (0.170)			0.041 (0.139)	
(m) Dispatch your engineers to government or public research institutes		-0.850 *** (0.311)			-0.165 (0.203)			0.080 (0.172)	
(n) Recruitment of middle-ranking personnel or mid-carrier engineers			0.240 (0.260)			-0.010 (0.135)			0.414 ** (0.170)
(o) Recruitment of senior engineers retired from MNCs, JVs, or large local firms			0.160 (0.130)			-0.048 (0.111)			-0.166 (0.218)
(p) Headhunt of top management from MNCs, JVs, or large local firms			-0.011 (0.188)			0.152 (0.144)			0.222 (0.239)
Number of Sources	0.106 (0.099)	0.250 ** (0.115)	-0.041 (0.093)	-0.041 (0.059)	0.100 (0.065)	-0.019 (0.058)	-0.023 (0.050)	-0.034 (0.061)	-0.050 (0.054)
Dummy variable (Indonesia)	16.907 -1233	14.616 -1019	17.262 -917	-1.339 (1.114)	-2.888 ** (1.124)	-1.753 (1.127)	1.827 (1.383)	2.190 (1.338)	3.099 * (1.624)
Dummy variable (Thai)	3.508 ** (1.681)	3.277 (2.008)	2.931 * (1.733)	1.427 (1.050)	-0.037 (1.125)	1.445 (1.074)	0.986 (0.885)	1.260 (0.854)	1.791 * (0.916)

Dummy variable (Vietnam)	1.747 *	1.306	1.234	1.509 **	0.800	1.264 *	0.727	0.623	-0.235
	(1.025)	(1.041)	(1.146)	(0.632)	(0.614)	(0.675)	(0.642)	(0.622)	(0.764)
/cut1	-0.034	1.315	1.164	0.329	-0.002	0.566	-1.712	-2.125	-0.973
	(1.702)	(1.723)	(1.607)	(1.319)	(1.342)	(1.303)	(1.290)	(1.298)	(1.399)
/cut2	0.591	2.092	1.840	1.486	1.209	1.733	0.036	-0.352	0.927
	(1.712)	(1.774)	(1.639)	(1.281)	(1.286)	(1.267)	(1.149)	(1.137)	(1.292)
/cut3	2.399	4.387	3.545	1.847	1.570	2.098	1.433	1.043	2.391
	(1.738)	(1.884)	(1.668)	(1.280)	(1.281)	(1.269)	(1.139)	(1.117)	(1.292)
/cut4	3.981	6.015	4.897	4.019	3.713	4.209	2.515	2.077	3.544
	(1.778)	(1.945)	(1.707)	(1.339)	(1.331)	(1.332)	(1.169)	(1.143)	(1.334)
Number of observation	50	50	50	87	87	87	57	57	57
Log likelihood	-56.6	-54.1	-60.7	-89.3	-89.1	-91.2	-72.7	-73.9	-69.6
Pseudo R2	0.170	0.207	0.110	0.114	0.115	0.095	0.093	0.078	0.132

	Others		
	Selected model 1	Selected model 2	Selected model 3
Age (establishment)	-0.009	-0.001	-0.003
	(0.009)	(0.010)	(0.009)
Number of full-time employees (logarithmic)	0.336 **	0.224	0.271 *
	(0.151)	(0.155)	(0.150)
(e) Technical assistance financed/provided by government/public agency	-0.091		*
	(0.095)		
(f) Technical assistance financed/provided by industrial/trade organizations	0.094		
	(0.086)		
(g) Technical assistance financed/provided by community organizations (NGOs or NPOs)	0.237 **		
	(0.098)		
(h) Technical assistance financed/provided by government owned financial institutions	0.048		
	(0.093)		
(i) Cooperation with universities/higher educational institutions		-0.097	
		(0.108)	
(j) Cooperation with government or public research institutes		-0.006	
		(0.113)	
(k) University professors or researchers personally closed contracts with your firm		0.059	
		(0.098)	
(l) Dispatch your engineers to universities/higher educational institutions		0.191	
		(0.126)	
(m) Dispatch your engineers to government or public research institutes		0.161	
		(0.128)	
(n) Recruitment of middle-ranking personnel or mid-carrier engineers			0.164
			(0.091)
(o) Recruitment of senior engineers retired from MNCs, JVs, or large local firms			-0.023
			(0.129)
(p) Headhunt of top management from MNCs, JVs, or large local firms			-0.025
			(0.135)
Number of Sources	-0.045	-0.039	-0.008
	(0.036)	(0.036)	(0.038)
Dummy variable (Indonesia)	-0.377	-0.522	-0.512
	(0.733)	(0.725)	(0.757)
Dummy variable (Thai)	-0.706	-1.069	-1.031
	(0.771)	(0.751)	(0.816)

Dummy variable (Vietnam)	-0.781	-0.700	-0.916
	(0.709)	(0.705)	(0.793)
/cut1	-1.466	-2.098	-1.242
	(0.926)	(0.964)	(0.955)
/cut2	-0.807	-1.441	-0.596
	(0.910)	(0.946)	(0.939)
/cut3	-0.143	-0.787	0.041
	(0.908)	(0.940)	(0.935)
/cut4	1.352	0.703	1.458
	(0.914)	(0.938)	(0.943)
Number of observation	91	91	91
Log likelihood	-119.5	-119.9	-122.9
Pseudo R2	0.070	0.067	0.043

Note 1: ***, ** and * indicate the significance level at the 1%, 5% and 10%

Note 2: Standard errors in parenthesis

Table A6 Research Linkages in Different Industry (Process Innovation) (Table 14)

	Food, beverages, tobacco			Textiles, Apparel, leather			Wood, wood products, Paper, paper products, printing		
	Selected model 1	Selected model 2	Selected model 3	Selected model 1	Selected model 2	Selected model 3	Selected model 1	Selected model 2	Selected model 3
Age (establishment)	0.022	0.012	0.014	0.003	0.017	0.003	0.034	0.031	0.036 *
	(0.022)	(0.020)	(0.021)	(0.030)	(0.031)	(0.029)	(0.021)	(0.020)	(0.021)
Number of full-time employees (logarithmic)	0.312	0.349	0.293	0.236	0.242	0.257	0.486 **	0.559 **	0.410 *
	(0.209)	(0.224)	(0.214)	(0.176)	(0.183)	(0.177)	(0.238)	(0.232)	(0.219)
(e) Technical assistance financed/provided by government/public agency	-0.206 *			-0.067			0.030		
	(0.107)			(0.104)			(0.102)		
(f) Technical assistance financed/provided by industrial/trade organizations	0.032			-0.060			-0.036		
	(0.102)			(0.113)			(0.117)		
(g) Technical assistance financed/provided by community organizations (NGOs or NPOs)	-0.103			0.030			-0.158		
	(0.117)			(0.113)			(0.144)		
(h) Technical assistance financed/provided by government owned financial institutions	0.001			0.032			0.023		
	(0.129)			(0.189)			(0.118)		
(i) Cooperation with universities/higher educational institutions		0.080			-0.344 *			0.026	
		(0.125)			(0.179)			(0.155)	
(j) Cooperation with government or public research institutes		0.135			0.125			0.092	
		(0.143)			(0.158)			(0.119)	
(k) University professors or researchers personally closed contracts with your firm		-0.375 ***			-0.122			-0.218	
		(0.136)			(0.155)			(0.157)	
(l) Dispatch your engineers to universities/higher educational institutions		0.037			0.261			-0.373 **	
		(0.150)			(0.229)			(0.175)	
(m) Dispatch your engineers to government or public research institutes		-0.041			-0.317			0.196	
		(0.144)			(0.253)			(0.182)	
(n) Recruitment of middle-ranking personnel or mid-carrier engineers			0.047			-0.111			0.070
			(0.095)			(0.130)			(0.110)
(o) Recruitment of senior engineers retired from MNCs, JVs, or large local firms			-0.169			-0.191			-0.168
			(0.132)			(0.161)			(0.150)
(p) Headhunt of top management from MNCs, JVs, or large local firms			-0.093			0.063			-0.091
			(0.141)			(0.168)			(0.180)
Number of Sources	0.046	0.012	0.046	0.116 *	0.159 **	0.142 **	0.103 **	0.122 **	0.097 **
	(0.038)	(0.043)	(0.040)	(0.059)	(0.061)	(0.059)	(0.044)	(0.048)	(0.042)
Dummy variable (Indonesia)	0.438	0.587	0.463	0.983	1.230	0.976	0.405	0.242	0.442
	(0.595)	(0.635)	(0.613)	(0.845)	(0.859)	(0.797)	(0.757)	(0.807)	(0.746)
Dummy variable (Thai)	0.793	0.664	0.688	0.495	2.023	0.517	-1.937 *	-2.040	-1.677
	(1.084)	(1.090)	(1.071)	(1.426)	(1.755)	(1.461)	(1.175)	(1.256)	(1.131)
Dummy variable (Vietnam)	1.592 **	1.241 *	0.920	-0.076	0.197	0.328	0.264	0.624	0.301
	(0.729)	(0.705)	(0.678)	(0.720)	(0.754)	(0.769)	(0.813)	(0.885)	(0.919)

/cut1	-0.231	-0.313	-0.169	-0.014	0.440	0.066	0.754	0.845	0.527
	(1.113)	(1.165)	(1.149)	(1.016)	(1.079)	(1.009)	(1.289)	(1.306)	(1.198)
/cut2	0.186	0.159	0.248	0.407	0.874	0.494	0.971	1.078	0.745
	(1.096)	(1.147)	(1.131)	(1.022)	(1.088)	(1.016)	(1.283)	(1.300)	(1.192)
/cut3	1.177	1.208	1.181	1.101	1.628	1.215	2.052	2.254	1.856
	(1.094)	(1.139)	(1.120)	(1.039)	(1.110)	(1.034)	(1.285)	(1.299)	(1.192)
/cut4	2.055	2.070	2.014	2.063	2.703	2.200	3.599	3.986	3.435
	(1.117)	(1.157)	(1.137)	(1.056)	(1.141)	(1.057)	(1.335)	(1.372)	(1.249)
Number of observation	84	84	84	72	72	72	65	65	65
Log likelihood	-94.24	-93.28	-95.65	-79.64	-75.97	-78.91	-70.53	-66.41	-70.26
Pseudo R2	0.069	0.079	0.055	0.103	0.144	0.111	0.110	0.162	0.113

	Coal, petroleum products, Chemicals, chemical products			Plastic, rubber products, Other non-metallic mineral products			Iron, steel, Non-ferrous metals, Metal products		
	Selected model 1	Selected model 2	Selected model 3	Selected model 1	Selected model 2	Selected model 3	Selected model 1	Selected model 2	Selected model 3
Age (establishment)	0.040	0.030	0.067 *	-0.008	-0.004	0.006	0.029	0.015	0.024
	(0.031)	(0.031)	(0.037)	(0.024)	(0.025)	(0.025)	(0.023)	(0.026)	(0.023)
Number of full-time employees (logarithmic)	0.381	0.240	0.409	0.667 **	0.837 ***	0.834 ***	0.190	0.305 *	0.377 **
	(0.338)	(0.353)	(0.391)	(0.258)	(0.251)	(0.267)	(0.167)	(0.183)	(0.177)
(e) Technical assistance financed/provided by government/public agency	0.146			-0.036			-0.217 **		
	(0.162)			(0.120)			(0.093)		
(f) Technical assistance financed/provided by industrial/trade organizations	0.081			-0.249 **			0.097		
	(0.156)			(0.124)			(0.104)		
(g) Technical assistance financed/provided by community organizations (NGOs or NPOs)	0.063			0.047			0.021		
	(0.182)			(0.118)			(0.101)		
(h) Technical assistance financed/provided by government owned financial institutions	-0.290			0.146			-0.011		
	(0.252)			(0.114)			(0.102)		
(i) Cooperation with universities/higher educational institutions		0.130			-0.117			-0.100	
		(0.393)			(0.213)			(0.110)	
(j) Cooperation with government or public research institutes		-0.161			-0.133			-0.071	
		(0.306)			(0.172)			(0.121)	
(k) University professors or researchers personally closed contracts with your firm		-0.187			0.272			0.276 **	
		(0.251)			(0.207)			(0.134)	
(l) Dispatch your engineers to universities/higher educational institutions		-0.217			-0.137			0.118	
		(0.186)			(0.205)			(0.121)	
(m) Dispatch your engineers to government or public research institutes		0.393			0.183			-0.150	
		(0.384)			(0.176)			(0.135)	
(n) Recruitment of middle-ranking personnel or mid-carrier engineers			-0.200			0.004			-0.226 **
			(0.162)			(0.118)			(0.096)
(o) Recruitment of senior engineers retired from MNCs, JVs, or large local firms			-0.404 **			-0.190			-0.134
			(0.159)			(0.138)			(0.112)
(p) Headhunt of top management from MNCs, JVs, or large local firms			0.190			0.393 *			-0.061
			(0.197)			(0.226)			(0.119)
Number of Sources	0.056	0.017	0.106	0.134 **	0.090	0.087	0.008	-0.027	0.054
	(0.079)	(0.077)	(0.076)	(0.061)	(0.063)	(0.066)	(0.050)	(0.047)	(0.046)
Dummy variable (Indonesia)	-0.536	-0.391	-1.335	1.246	0.673	0.707	-0.073	0.744	-0.044
	(1.430)	(1.320)	(1.420)	(1.094)	(1.186)	(1.083)	(1.023)	(0.968)	(0.944)
Dummy variable (Thai)	-0.588	-0.676	-1.026	2.118	2.222	2.359 *	-0.137	-0.470	-0.096
	(1.089)	(1.011)	(1.045)	(1.292)	(1.407)	(1.396)	(0.774)	(0.784)	(0.787)
Dummy variable (Vietnam)	0.741	1.460	2.155 *	1.126 *	0.913	1.085 *	0.433	0.081	0.891
	(1.114)	(1.097)	(1.130)	(0.665)	(0.686)	(0.636)	(0.584)	(0.588)	(0.568)

/cut1	0.592	-1.037	0.311	2.110	2.845	3.019	-1.797	-1.625	-1.304
	(1.783)	(1.995)	(1.978)	(1.153)	(1.177)	(1.194)	(0.976)	(1.024)	(0.979)
/cut2	1.373	-0.246	1.298	2.942	3.693	3.841	-1.018	-0.831	-0.516
	(1.741)	(1.940)	(1.917)	(1.183)	(1.214)	(1.225)	(0.932)	(0.983)	(0.936)
/cut3	1.742	0.122	1.753	3.518	4.233	4.382	0.049	0.198	0.522
	(1.734)	(1.923)	(1.902)	(1.219)	(1.252)	(1.260)	(0.917)	(0.971)	(0.928)
/cut4	3.115	1.494	3.262	4.588	5.210	5.417	1.005	1.135	1.476
	(1.779)	(1.939)	(1.964)	(1.276)	(1.308)	(1.327)	(0.918)	(0.972)	(0.937)
Number of observation	41	41	41	75	75	75	93	93	93
Log likelihood	-45.58	-45.22	-42.53	-77.53	-78.47	-77.99	-106.6	-106.1	-105.4
Pseudo R2	0.073	0.080	0.135	0.173	0.162	0.168	0.048	0.053	0.059

	Machinery, equipment, tools			Computers & computer parts, Other electronics & components			Precision instruments, Automobile, auto parts, Other transportation equipments and parts		
	Selected model 1	Selected model 2	Selected model 3	Selected model 1	Selected model 2	Selected model 3	Selected model 1	Selected model 2	Selected model 3
Age (establishment)	0.147 *	0.167 **	0.095	0.079 *	0.021	0.048	-0.036	-0.031	-0.023
	(0.077)	(0.079)	(0.059)	(0.046)	(0.045)	(0.042)	(0.032)	(0.036)	(0.037)
Number of full-time employees (logarithmic)	0.322	0.586	0.968 **	0.512 **	0.667 **	0.730 ***	0.999 ***	0.983 **	0.738 **
	(0.381)	(0.391)	(0.414)	(0.239)	(0.265)	(0.261)	(0.367)	(0.380)	(0.314)
(e) Technical assistance financed/provided by government/public agency	-0.652 ***			0.074			-0.074		
	(0.245)			(0.128)			(0.163)		
(f) Technical assistance financed/provided by industrial/trade organizations	-0.039			-0.047			-0.094		
	(0.182)			(0.139)			(0.169)		
(g) Technical assistance financed/provided by community organizations (NGOs or NPOs)	0.008			-0.112			-0.068		
	(0.210)			(0.125)			(0.180)		
(h) Technical assistance financed/provided by government owned financial institutions	-0.083			0.159			0.560 **		
	(0.186)			(0.140)			(0.257)		
(i) Cooperation with universities/higher educational institutions		-0.217			-0.028			-0.111	
		(0.204)			(0.154)			(0.158)	
(j) Cooperation with government or public research institutes		-0.350			-0.473 ***			-0.247	
		(0.237)			(0.182)			(0.271)	
(k) University professors or researchers personally closed contracts with your firm		-0.272			0.055			-0.214	
		(0.168)			(0.173)			(0.197)	
(l) Dispatch your engineers to universities/higher educational institutions		0.617 *			0.006			0.051	
		(0.341)			(0.250)			(0.204)	
(m) Dispatch your engineers to government or public research institutes		-0.056			-0.021			5.661	
		(0.352)			(0.284)			(719)	
(n) Recruitment of middle-ranking personnel or mid-carrier engineers			-0.308			0.203			0.006
			(0.302)			(0.142)			(0.211)
(o) Recruitment of senior engineers retired from MNCs, JVs, or large local firms			0.388 **			-0.299 *			-0.101
			(0.178)			(0.153)			(0.219)
(p) Headhunt of top management from MNCs, JVs, or large local firms			0.536			0.201			0.235
			(0.346)			(0.204)			(0.242)
Number of Sources	0.367 **	0.289 **	0.055	0.032	0.171 **	0.042	-0.110 *	-0.142 **	-0.092
	(0.142)	(0.123)	(0.126)	(0.065)	(0.083)	(0.071)	(0.064)	(0.071)	(0.064)
Dummy variable (Indonesia)	11.831	13.321	19.413	16.865	19.354	18.004	3.273 **	3.177 *	3.778 **
	(2367)	(2401)	(5087)	(975)	(1017)	(1159)	(1.596)	(1.810)	(1.629)
Dummy variable (Thai)	17.932	18.397	19.172	0.568	-0.542	1.567	5.364 ***	4.745 ***	4.826 ***
	(2936)	(3204)	(6196)	(0.960)	(1.196)	(1.133)	(1.806)	(1.727)	(1.678)
Dummy variable (Vietnam)	0.642	0.708	1.775	3.171 ***	3.080 ***	2.863 ***	3.535 ***	3.504 ***	2.848 ***
	(1.165)	(1.161)	(1.344)	(0.805)	(0.846)	(0.842)	(1.072)	(1.020)	(1.084)

/cut1	0.897	2.730	2.228	3.177	3.938	4.560	2.451	2.005	1.791
	(1.954)	(1.928)	(1.830)	(1.577)	(1.701)	(1.651)	(1.680)	(1.693)	(1.634)
/cut2	1.821	3.752	3.273	3.331	4.094	4.719	2.759	2.307	2.060
	(1.912)	(1.917)	(1.810)	(1.579)	(1.703)	(1.653)	(1.698)	(1.707)	(1.644)
/cut3	4.266	5.764	5.435	4.287	5.100	5.782	4.177	3.823	3.307
	(1.955)	(2.018)	(1.882)	(1.615)	(1.740)	(1.707)	(1.840)	(1.829)	(1.730)
/cut4	5.153	6.414	6.097	5.264	6.150	6.835	4.787	4.545	3.862
	(2.022)	(2.064)	(1.930)	(1.666)	(1.799)	(1.772)	(1.888)	(1.878)	(1.762)
Number of observation	50	50	50	87	87	87	57	57	57
Log likelihood	-34.05	-36.83	-37.00	-70.88	-68.19	-68.86	-41.41	-37.26	-44.12
Pseudo R2	0.347	0.294	0.290	0.215	0.244	0.237	0.231	0.308	0.181

		Others		
		Selected model 1	Selected model 2	Selected model 3
	Age (establishment)	0.017	0.016	0.016
		(0.018)	(0.014)	(0.016)
	Number of full-time employees (logarithmic)	-0.033	-0.200	-0.093
		(0.157)	(0.162)	(0.153)
(e)	Technical assistance financed/provided by government/public agency	0.013		
		(0.107)		
(f)	Technical assistance financed/provided by industrial/trade organizations	-0.071		
		(0.099)		
(g)	Technical assistance financed/provided by community organizations (NGOs or NPOs)	0.004		
		(0.115)		
(h)	Technical assistance financed/provided by government owned financial institutions	0.217 *		
		(0.119)		
(i)	Cooperation with universities/higher educational institutions		-0.009	
			(0.122)	
(j)	Cooperation with government or public research institutes		-0.034	
			(0.131)	
(k)	University professors or researchers personally closed contracts with your firm		0.033	
			(0.123)	
(l)	Dispatch your engineers to universities/higher educational institutions		-0.167	
			(0.143)	
(m)	Dispatch your engineers to government or public research institutes		0.323 **	
			(0.161)	
(n)	Recruitment of middle-ranking personnel or mid-carrier engineers			0.092
				(0.095)
(o)	Recruitment of senior engineers retired from MNCs, JVs, or large local firms			-0.125
				(0.126)
(p)	Headhunt of top management from MNCs, JVs, or large local firms			0.164
				(0.133)
	Number of Sources	0.026	0.030	0.051
		(0.040)	(0.040)	(0.042)
	Dummy variable (Indonesia)	0.087	0.040	-0.009
		(0.752)	(0.757)	(0.782)
	Dummy variable (Thai)	-1.335 *	-1.537 **	-1.650 **
		(0.774)	(0.783)	(0.818)
	Dummy variable (Vietnam)	0.377	0.566	0.051
		(0.773)	(0.772)	(0.847)

/cut1	-2.940	-3.791	-2.968
	(1.032)	(1.094)	(1.036)
/cut2	-2.059	-2.905	-2.073
	(0.959)	(1.021)	(0.964)
/cut3	-0.875	-1.676	-0.882
	(0.918)	(0.970)	(0.926)
/cut4	-0.163	-0.944	-0.179
	(0.913)	(0.959)	(0.920)
Number of observation	91	91	91
Log likelihood	-97.39	-96.68	-98.12
Pseudo R2	0.070	0.077	0.063

Note 1: ***, ** and * indicate the significance level at the 1%, 5% and 10%

Note 2: Standard errors in parenthesis

Table A7 Estimation Results of Characterization of Innovation (Table 15)

	Significant change in packaging or appearance design					Significant improvement of an existing product/service				
	Full model	Selected model 1	Selected model 2	Selected model 3	Selected model 4	Full model	Selected model 1	Selected model 2	Selected model 3	Selected model 4
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
Age (establishment)	-0.001	-0.002	-0.001	-0.002	-0.001	0.018	0.014	0.017	0.018 *	0.017
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Number of full-time employees (logarithmic)	0.211 ***	0.201 ***	0.207 ***	0.208 ***	0.191 ***	0.082	0.101	0.115	0.105	0.067
	(0.066)	(0.064)	(0.064)	(0.064)	(0.064)	(0.087)	(0.084)	(0.083)	(0.083)	(0.084)
Textiles, Apparel, leather	-0.056	-0.088	-0.057	-0.169	-0.104	0.320	0.285	0.217	0.210	0.254
	(0.299)	(0.292)	(0.290)	(0.293)	(0.290)	(0.386)	(0.378)	(0.372)	(0.374)	(0.379)
Wood, Paper products	0.187	0.179	0.139	0.230	0.216	0.071	0.070	0.024	0.057	0.147
	(0.329)	(0.313)	(0.318)	(0.314)	(0.311)	(0.391)	(0.381)	(0.383)	(0.379)	(0.382)
Coal, Chemical products	0.304	0.177	0.215	0.170	0.161	1.055	0.946	0.971	0.957	1.017
	(0.393)	(0.380)	(0.375)	(0.380)	(0.374)	(0.647)	(0.637)	(0.632)	(0.633)	(0.637)
Iron, Metal products	-0.760 ***	-0.704 ***	-0.721 ***	-0.648 **	-0.618 **	-0.754 **	-0.743 **	-0.873 ***	-0.820 ***	-0.753 **
	(0.274)	(0.262)	(0.264)	(0.262)	(0.259)	(0.313)	(0.304)	(0.304)	(0.300)	(0.302)
Computers, Other electronics	0.187	0.281	0.271	0.302	0.328	0.538	0.646	0.589	0.596	0.601
	(0.315)	(0.307)	(0.308)	(0.309)	(0.307)	(0.468)	(0.460)	(0.451)	(0.454)	(0.457)
Automobile, Other transportation	0.150	0.070	0.132	0.110	0.114	0.816	0.791	0.723	0.754	0.787
	(0.387)	(0.373)	(0.382)	(0.376)	(0.376)	(0.579)	(0.572)	(0.572)	(0.569)	(0.573)
(a) Internal sources of information and own R&D efforts	-0.087 **	-0.080 **				0.056	0.083 *			
	(0.039)	(0.036)				(0.049)	(0.047)			
(b) Cooperation with local firms (100% local capital)	0.010	0.022				0.040	0.061			
	(0.040)	(0.038)				(0.052)	(0.049)			
(c) Cooperation with MNCs (100% non-local capital)	0.092 *	0.092 *				0.075	0.058			
	(0.054)	(0.052)				(0.076)	(0.073)			
(d) Cooperation with Joint Ventures	-0.065	-0.055				-0.028	-0.002			
	(0.049)	(0.047)				(0.067)	(0.065)			
(e) Technical assistance financed/provided by government/public agency	-0.060		-0.077 **			-0.012		0.024		
	(0.042)		(0.039)			(0.057)		(0.053)		
(f) Technical assistance financed/provided by industrial/trade organizations	0.003		-0.015			0.003		0.006		
	(0.041)		(0.039)			(0.056)		(0.053)		
(g) Technical assistance financed/provided by community organizations (NGOs or NPOs)	-0.008		-0.008			0.008		0.001		
	(0.044)		(0.042)			(0.063)		(0.060)		
(h) Technical assistance financed/provided by government owned financial institutions	0.172 ***		0.156 ***			0.115		0.128 **		
	(0.049)		(0.046)			(0.070)		(0.065)		
(i) Cooperation with universities/higher educational institutions	-0.104 **			-0.108 **		0.041			0.050	
	(0.047)			(0.044)		(0.063)			(0.060)	

(j)	Cooperation with government or public research institutes	0.004			0.022		0.042			0.087	
		(0.049)			(0.045)		(0.066)			(0.063)	
(k)	University professors or researchers personally closed contracts with your firm	-0.036			-0.037		-0.046			-0.023	
		(0.048)			(0.046)		(0.068)			(0.065)	
(l)	Dispatch your engineers to universities/higher educational institutions	-0.099 *			-0.069		-0.045			-0.033	
		(0.053)			(0.050)		(0.071)			(0.069)	
(m)	Dispatch your engineers to government or public research institutes	0.130 **			0.126 **		-0.080			-0.064	
		(0.059)			(0.057)		(0.074)			(0.071)	
(n)	Recruitment of middle-ranking personnel or mid-carrier engineers	0.052				0.029	0.096 *				0.126 ***
		(0.041)				(0.037)	(0.050)				(0.046)
(o)	Recruitment of senior engineers retired from MNCs, JVs, or large local firms	-0.029				-0.027	-0.105				-0.099
		(0.049)				(0.045)	(0.064)				(0.062)
(p)	Headhunt of top management from MNCs, JVs, or large local firms	0.018				0.005	0.057				0.040
		(0.055)				(0.051)	(0.076)				(0.071)
	Number of Sources	0.028	0.027 *	0.017	0.037 **	0.027 *	0.033	0.033 *	0.034 *	0.049 **	0.050 ***
		(0.018)	(0.015)	(0.016)	(0.016)	(0.015)	(0.021)	(0.019)	(0.019)	(0.020)	(0.019)
	Dummy variable (Indonesia)	0.545 *	0.624 **	0.606 **	0.550 **	0.604 **	0.072	0.177	0.185	0.072	0.018
		(0.294)	(0.274)	(0.278)	(0.274)	(0.275)	(0.356)	(0.337)	(0.334)	(0.331)	(0.334)
	Dummy variable (Thai)	-0.444	-0.406	-0.399	-0.507 *	-0.452	-0.174	-0.143	-0.129	-0.142	-0.212
		(0.310)	(0.295)	(0.296)	(0.298)	(0.297)	(0.378)	(0.363)	(0.361)	(0.358)	(0.363)
	Dummy variable (Vietnam)	1.529 ***	1.431 ***	1.355 ***	1.456 ***	1.275 ***	1.156 ***	1.210 ***	1.457 ***	1.510 ***	1.227 ***
		(0.286)	(0.248)	(0.230)	(0.232)	(0.233)	(0.377)	(0.335)	(0.316)	(0.317)	(0.324)
	Constant	-1.118 ***	-1.027 ***	-1.075 ***	-1.136 ***	-1.144 ***	-0.322	-0.247	-0.151	-0.143	-0.161
		(0.381)	(0.373)	(0.371)	(0.370)	(0.372)	(0.474)	(0.471)	(0.461)	(0.460)	(0.462)
	Number of observation	715	715	715	715	715	715	715	715	715	715
	Log likelihood	-398.1	-413.5	-410.6	-411.0	-417.4	-266.9	-273.5	-274.5	-275.8	-273.1
	Pseudo R2	0.142	0.109	0.115	0.114	0.101	0.145	0.124	0.120	0.116	0.125

	Development of a totally new product/service based on the existing technologies for your establishment					Development of a totally new product/service based on new technologies for your establishment				
	Full model	Selected model 1	Selected model 2	Selected model 3	Selected model 4	Full model	Selected model 1	Selected model 2	Selected model 3	Selected model 4
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
Age (establishment)	-0.008	-0.008	-0.008	-0.008	-0.008	-0.010	-0.009	-0.008	-0.010	-0.009
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Number of full-time employees (logarithmic)	0.245 ***	0.258 ***	0.258 ***	0.250 ***	0.239 ***	0.245 ***	0.250 ***	0.253 ***	0.256 ***	0.239 ***
	(0.067)	(0.066)	(0.066)	(0.066)	(0.066)	(0.064)	(0.062)	(0.062)	(0.062)	(0.062)
Textiles, Apparel, leather	-0.012	-0.051	-0.081	-0.076	-0.068	-0.321	-0.339	-0.356	-0.394	-0.350
	(0.305)	(0.301)	(0.299)	(0.299)	(0.300)	(0.287)	(0.279)	(0.278)	(0.279)	(0.276)
Wood, Paper products	-0.210	-0.246	-0.236	-0.217	-0.196	-0.008	-0.097	-0.049	-0.040	-0.033
	(0.318)	(0.309)	(0.310)	(0.307)	(0.308)	(0.302)	(0.291)	(0.295)	(0.293)	(0.290)
Coal, Chemical products	0.931 **	0.866 *	0.873 *	0.861 *	0.877 *	0.637	0.575	0.681 *	0.599	0.622 *
	(0.460)	(0.454)	(0.452)	(0.453)	(0.452)	(0.388)	(0.374)	(0.374)	(0.372)	(0.374)
Iron, Metal products	-0.437	-0.466 *	-0.450 *	-0.448 *	-0.412	-0.491 *	-0.505 **	-0.468 *	-0.508 **	-0.450 *
	(0.269)	(0.264)	(0.264)	(0.262)	(0.263)	(0.263)	(0.253)	(0.252)	(0.252)	(0.252)
Computers, Other electronics	-0.358	-0.337	-0.290	-0.294	-0.311	0.820 ***	0.878 ***	0.911 ***	0.966 ***	0.871 ***
	(0.297)	(0.291)	(0.289)	(0.290)	(0.290)	(0.306)	(0.297)	(0.298)	(0.297)	(0.296)
Automobile, Other transportation	-0.085	-0.143	-0.092	-0.106	-0.094	-0.171	-0.165	-0.071	-0.186	-0.217
	(0.391)	(0.385)	(0.386)	(0.385)	(0.387)	(0.368)	(0.356)	(0.359)	(0.357)	(0.358)
(a) Internal sources of information and own R&D efforts	-0.070 *	-0.058				-0.018	-0.028			
	(0.038)	(0.036)				(0.036)	(0.034)			
(b) Cooperation with local firms (100% local capital)	0.043	0.058				0.022	0.027			
	(0.039)	(0.038)				(0.037)	(0.035)			
(c) Cooperation with MNCs (100% non-local capital)	0.029	0.026				0.111 **	0.114 **			
	(0.055)	(0.054)				(0.051)	(0.049)			
(d) Cooperation with Joint Ventures	-0.004	0.004				0.007	0.018			
	(0.049)	(0.048)				(0.046)	(0.044)			
(e) Technical assistance financed/provided by government/public agency	0.000		0.002			-0.084 **		-0.098 ***		
	(0.042)		(0.039)			(0.039)		(0.036)		
(f) Technical assistance financed/provided by industrial/trade organizations	0.004		0.002			0.008		0.001		
	(0.041)		(0.039)			(0.038)		(0.036)		
(g) Technical assistance financed/provided by community organizations (NGOs or NPOs)	0.034		0.028			0.054		0.067 *		
	(0.044)		(0.042)			(0.040)		(0.038)		
(h) Technical assistance financed/provided by government owned financial institutions	0.041		0.045			0.066		0.053		
	(0.046)		(0.043)			(0.042)		(0.039)		
(i) Cooperation with universities/higher educational institutions	0.024			0.031		-0.019			-0.032	
	(0.048)			(0.046)		(0.045)			(0.042)	

(j) Cooperation with government or public research institutes	-0.025			-0.018		-0.144 ***			-0.118 ***	
	(0.048)			(0.046)		(0.047)			(0.043)	
(k) University professors or researchers personally closed contracts with your firm	-0.033			-0.028		0.028			0.048	
	(0.048)			(0.047)		(0.045)			(0.043)	
(l) Dispatch your engineers to universities/higher educational institutions	-0.003			0.006		-0.014			0.003	
	(0.054)			(0.053)		(0.050)			(0.048)	
(m) Dispatch your engineers to government or public research institutes	0.000			0.009		0.090			0.108 **	
	(0.058)			(0.057)		(0.056)			(0.054)	
(n) Recruitment of middle-ranking personnel or mid-carrier engineers	0.060				0.057	0.036				0.032
	(0.041)				(0.038)	(0.040)				(0.036)
(o) Recruitment of senior engineers retired from MNCs, JVs, or large local firms	-0.026				-0.016	-0.035				-0.037
	(0.048)				(0.046)	(0.045)				(0.043)
(p) Headhunt of top management from MNCs, JVs, or large local firms	0.008				0.001	0.115 **				0.126 **
	(0.056)				(0.053)	(0.054)				(0.051)
Number of Sources	0.046 **	0.052 ***	0.044 ***	0.056 ***	0.053 ***	0.029 *	0.033 **	0.045 ***	0.052 ***	0.036 **
	(0.018)	(0.016)	(0.016)	(0.017)	(0.016)	(0.018)	(0.015)	(0.016)	(0.016)	(0.015)
Dummy variable (Indonesia)	0.448	0.437	0.528 *	0.447	0.473	0.638 **	0.669 **	0.493 *	0.572 **	0.617 **
	(0.302)	(0.286)	(0.286)	(0.284)	(0.288)	(0.299)	(0.279)	(0.279)	(0.278)	(0.281)
Dummy variable (Thai)	-0.081	-0.102	-0.062	-0.108	-0.095	-0.003	0.044	0.051	-0.024	-0.019
	(0.311)	(0.303)	(0.303)	(0.303)	(0.306)	(0.313)	(0.300)	(0.300)	(0.302)	(0.302)
Dummy variable (Vietnam)	0.698 **	0.797 ***	0.875 ***	0.924 ***	0.786 ***	-0.375	-0.203	-0.180	-0.068	-0.077
	(0.274)	(0.246)	(0.226)	(0.228)	(0.235)	(0.267)	(0.234)	(0.213)	(0.215)	(0.222)
Constant	-1.195 ***	-1.145 ***	-1.195 ***	-1.158 ***	-1.240 ***	-1.402 ***	-1.414 ***	-1.359 ***	-1.406 ***	-1.441 ***
	(0.386)	(0.382)	(0.379)	(0.376)	(0.380)	(0.374)	(0.364)	(0.360)	(0.360)	(0.363)
Number of observation	715	715	715	715	715	715	715	715	715	715
Log likelihood	-401.3	-404.1	-405.2	-406.1	-405.3	-432.8	-446.8	-446.4	-445.8	-447.7
Pseudo R2	0.096	0.089	0.087	0.085	0.087	0.118	0.090	0.090	0.092	0.088

Note 1: ***, ** and * indicate the significance level at the 1%, 5% and 10%

Note 2: Standard errors in parenthesis

Table A8 Estimation Result of Upgrading Innovation (Table 16)

		Full model		Selected model 1		Selected model 2		Selected model 3		Selected model 4	
		Coef.		Coef.		Coef.		Coef.		Coef.	
	Age (establishment)	-0.006		-0.006		-0.005		-0.005		-0.005	
		(0.006)		(0.006)		(0.006)		(0.006)		(0.006)	
	Number of full-time employees (logarithmic)	0.243	***	0.259	***	0.264	***	0.264	***	0.245	***
		(0.060)		(0.058)		(0.059)		(0.058)		(0.059)	
	Textiles, Apparel, leather	-0.189		-0.240		-0.255		-0.276		-0.243	
		(0.258)		(0.253)		(0.252)		(0.253)		(0.252)	
	Wood, Paper products	0.101		0.002		0.059		0.064		0.090	
		(0.278)		(0.272)		(0.274)		(0.272)		(0.271)	
	Coal, Chemical products	0.884	**	0.798	**	0.874	**	0.813	**	0.837	**
		(0.372)		(0.360)		(0.357)		(0.359)		(0.360)	
	Iron, Metal products	-0.488	**	-0.513	**	-0.506	**	-0.533	**	-0.469	**
		(0.232)		(0.226)		(0.226)		(0.224)		(0.226)	
	Computers, Other electronics	0.795	***	0.859	***	0.888	***	0.918	***	0.855	***
		(0.298)		(0.293)		(0.293)		(0.293)		(0.292)	
	Automobile, Other transportation	-0.062		-0.062		-0.021		-0.112		-0.113	
		(0.344)		(0.334)		(0.339)		(0.337)		(0.336)	
(a)	Internal sources of information and own R&D efforts	-0.004		-0.007							
		(0.033)		(0.031)							
(b)	Cooperation with local firms (100% local capital)	0.014		0.024							
		(0.034)		(0.033)							
(c)	Cooperation with MNCs (100% non-local capital)	0.096	**	0.097	**						
		(0.047)		(0.046)							
(d)	Cooperation with Joint Ventures	-0.008		0.004							
		(0.041)		(0.040)							
(e)	Technical assistance financed/provided by government/public agency	-0.070	*			-0.073	**				
		(0.036)				(0.033)					
(f)	Technical assistance financed/provided by industrial/trade organizations	0.012				0.007					
		(0.034)				(0.033)					
(g)	Technical assistance financed/provided by community organizations (NGOs or NPOs)	0.045				0.050					
		(0.036)				(0.035)					
(h)	Technical assistance financed/provided by government owned financial institutions	0.058				0.051					
		(0.038)				(0.036)					
(i)	Cooperation with universities/higher educational institutions	-0.020						-0.033			
		(0.041)						(0.039)			
(j)	Cooperation with government or public research institutes	-0.097	**					-0.077	**		
		(0.040)						(0.038)			

		(1)	(2)	(3)	(4)	(5)
(k)	University professors or researchers personally closed contracts with your firm	0.014			0.033	
		(0.041)			(0.040)	
(l)	Dispatch your engineers to universities/higher educational institutions	-0.019			-0.003	
		(0.045)			(0.044)	
(m)	Dispatch your engineers to government or public research institutes	0.086 *			0.100 **	
		(0.051)			(0.050)	
(n)	Recruitment of middle-ranking personnel or mid-carrier engineers	0.057				0.053
		(0.037)				(0.034)
(o)	Recruitment of senior engineers retired from MNCs, JVs, or large local firms	-0.038				-0.035
		(0.042)				(0.039)
(p)	Headhunt of top management from MNCs, JVs, or large local firms	0.091 *				0.096 **
		(0.051)				(0.048)
	Number of Sources	0.046 ***	0.050 ***	0.058 ***	0.066 ***	0.053 ***
		(0.017)	(0.014)	(0.015)	(0.015)	(0.015)
	Dummy variable (Indonesia)	0.698 **	0.736 ***	0.612 **	0.633 **	0.689 **
		(0.282)	(0.268)	(0.267)	(0.267)	(0.270)
	Dummy variable (Thai)	0.087	0.119	0.132	0.056	0.076
		(0.293)	(0.284)	(0.285)	(0.286)	(0.288)
	Dummy variable (Vietnam)	0.303	0.423 *	0.461 **	0.553 ***	0.460 **
		(0.242)	(0.215)	(0.198)	(0.201)	(0.209)
	/cut1	-0.332	-0.310	-0.362	-0.323	-0.273
		(0.352)	(0.346)	(0.343)	(0.341)	(0.344)
	/cut2	-0.258	-0.236	-0.288	-0.249	-0.199
		(0.351)	(0.345)	(0.342)	(0.340)	(0.343)
	/cut3	0.957	0.964	0.911	0.952	1.003
		(0.350)	(0.344)	(0.340)	(0.339)	(0.343)
	/cut4	2.062	2.040	1.987	2.028	2.077
		(0.357)	(0.350)	(0.347)	(0.345)	(0.349)
	Number of observation	715	715	715	715	715
	Log likelihood	-769.69	-781.20	-780.93	-780.60	-781.01
	Pseudo R2	0.080	0.067	0.067	0.067	0.067

Note 1: ***, ** and * indicate the significance level at the 1%, 5% and 10%

Note 2: Standard errors in parenthesis

9

Learning and Innovation in Upstream-Downstream Relations: Mutual Knowledge Exchanges and Types of Transferred Technologies*

Tomohiro Machikita and Yasushi Ueki

Abstract

This paper presents a simple model of knowledge creation as a result of face-to-face communication between upstream-downstream relations. This also serves to be an empirical investigation of mutual knowledge exchanges' impacts of knowledge production function in a survey of manufacturing firms in East Asia—Indonesia, Thailand, Philippines, and Vietnam. Evidence from inter-connected firms in developing economies suggests that firms which mutually exchange engineers with customers achieved more innovations than other firms. However, one-way flow of knowledge with supplier is effective for product innovation but not for mutual exchanges of engineers. We find that managerial experience with foreign firms is an important technology for knowledge creation. Technology transfer needs not only one-way face-to-face communication but also mutual exchanges of knowledge.

1. INTRODUCTION

This paper constructs a new framework linking product and process innovations and explicit knowledge exchanges between firms in developing economies. We assume that detailed evidences of production linkages provide the information of knowledge exchanges between own firms and their partners (customer and supplier). Identifying

* This paper is grateful for the comments and suggestions of Haryo Aswicahyono, Truong Chi Binh, Masahisa Fujita, Patarapong Intarakumnerd, Fukunari Kimura, Satoru Kumagai, Kazunobu Hayakawa, Mari-Len Macasaquit, Avvari V. Mohan, Sothea Oum, Masatsugu Tsuji, So Umezaki, and Mariko Watanabe. This paper is based on a research conducted under the international project "Fostering Production- and Science and Technology Linkages to Stimulate Innovation in ASEAN" sponsored by the Economic Research Institute for ASEAN and East Asia (ERIA) in FY 2009. This project also has been carried with cooperation from the Center for Strategic and International Studies (CSIS) of Indonesia, the Philippine Institute for Development Studies (PIDS), Sirindhorn International Institute of Technology (SIIT) of Thammasat University, Thailand, The Institute for Industry Policy and Strategy (IPSI), Ministry of Industry and Trade of Vietnam.

detailed evidences of linkages opens a black-box of knowledge creation and learning process among firms that deeply involves internal and international production chains. A canonical model of knowledge exchanges of engineers between own firms and partners has been identified. It also investigates the empirical implications of this mechanism using the data gathered from manufacturing firms in five megacities in East Asia. The five cities come from Indonesia, Philippines, Thailand and Vietnam. Data collection through mail surveys and field interviews include product and process innovations, mutual knowledge exchanges between upstream-downstream firms, detailed information on technology transfer of linkages between production and information, and respondent firms' own characteristics.

This paper was able to outline a methodology in determining linkage impact of innovation and mutual knowledge exchanges between upstream-downstream relations in industrial development. Microeconometric evidences suggest that mutual knowledge exchanges drives innovation as well as one-way flow of information from partners after controlling self-selection (i.e., "teachers" achieve more innovation than "students"). Some evidences are robust to conclude that mutual knowledge exchanges matter. The theoretical background of this paper explains a model of learning and knowledge creation through face-to-face communication among different types of agents as described by Berliant and Fujita (2008, 2009), Fujita (2007), and Berliant, Reed, and Wang (2006). The central concern of these models is how diversity of knowledge among members could affect the decision on collaboration and its outcome. Their fundamental modeling approach has been applied to the question how cultural background of members affects city system (Ottaviano and Prarolo 2009). In that sense, diversity of knowledge among firms and exchange of knowledge between firms could have aggregate implications like city system as well as agglomerations of firms.

However, it has been difficult to capture and quantify the information flow between agents—one of growing field in development, labor, and industrial organization—specifically the study of network impact of productivity growth. The following identified some factors that contribute to such difficulty like Conley and Udry (2010) study in development economics which associated input use of informational neighbors for pineapple farmers in Ghana as well as their geographic neighbors as affecting growth. Another is Bandiera, Barankay, and Rasul (2009) study in labor economics where the social and workplace level connections among fruit pickers affect the changing payment system on productivity. Goyal (2007), Jackson (2008), and Easley and Kleinberg (2010) showed the measuring and theoretical framework of information diffusion through network. Productivity growth could differ between firms depending on the types of production or intellectual linkages that they have. It is also true that productivity changes on entry or exit especially when the hub-firm is located central to the production network. Given this situation, the dense network in East Asia could provide a new insight on causes and consequences of information diffusion among local firms. This paper aims to study the innovation impacts of mutual knowledge exchanges among inter-connected firms in the field of industrial development. This paper is also related to the field of international technology diffusion and international knowledge production. Keller (2000) gave an overview of the cause and consequences of technology diffusion across countries. Kerr (2008, 2010) and Kerr and Lincoln (2010) studied the role of ethnic scientific communities on technology diffusion to match ethnic scientist name with individual patent records.

A testable hypothesis considers the mutual exchange impacts of product and process innovations using interfirm connectivity network data. The data uncovers not only innovation impacts of mutual exchange between connected firms, but also motivation from direct information flow of upstream to downstream or vice versa. Findings also show that manufacturing firms are more likely to achieve product innovations upon mutually exchanging engineers with specific customers, especially for new product development using technologies for a new market. This entails close collaboration with the primary existing customer. On the other hand, connected firms are less likely to achieve improvement of existing machines and development of new product after the mutual exchange with their main supplier. Mutual knowledge exchanges with the supplier do not seem to fit existing machines and technologies. Further, evidence shows that product and process innovations experienced by a manager with foreign firms (including joint venture firms) are an important technology of innovations. Experience of foreign firms plays a key role on new knowledge to local firms.

The next section provides the theoretical framework. Section 3 describes the data collected. Section 4 presents the results of innovation impacts of mutual knowledge exchanges. Robustness checks are also shown here. Section 5 explains the determinants of mutual knowledge exchanges. Section 6 is the conclusion.

2. THEORETICAL FRAMEWORK

2.1. Matching, Transfer of Technologies, and Mutual Knowledge Exchanges with Partners

Interfirm linkages take various forms of guidance and learning like the exchange of engineers. Interfirm guidance and learning may exist in controlling quality, costs, delivery, and environment management (QCDE) within the firm as well as within the (international) production chain. Total quality management plays an important role in knowledge exchanges between upstream-downstream firms. Not only the customer but also the supplier takes guidance from the partner firm. That is, firms learn about specific product demand from their customers. They also gain technical information from their suppliers faced with the new demand. It is assumed that each firm requires information spillovers through backward and forward linkages to meet the demand. Therefore, information exchanges between demand and technologies spillover within the (international) production chain. Information exchanges are not always in “encoded” form (Polanyi 1966, 1967). Communication between firms and their partners are not well-facilitated when demand and technologies become complicated. The same is with knowledge production in the academic field. First, team production achieves more cited research than individuals do (Wuchty, Jones, and Uzzi, 2007) across all fields of natural science, social science, and arts-humanities. Second, teamwork in science is done by not only multi-university collaborations but also stratified groups (Jones, Wuchty, and Uzzi, 2008). Rosenblat and Mobius (2004) studied the impacts of rising Internet on international collaboration the similar field.

This paper focuses on the dynamics of two-way information flow from downstream to upstream (backward linkage) and from upstream to downstream (forward linkage) instead of examining of a one-way process. If engineers are sent out to share their professional knowledge about the production process, then accepting engineers from partners is more of learning the activities for the respondent firms. Dispatching engineers to partners seem to be teaching the activities for the firms. If these firms were able to gain professional knowledge through partners, then aforementioned strategy is a better choice. To identify which flows become learning or teaching, direct information from the “teachers” and “students” are helpful. Due to the limitations of this paper, it was assumed that the “teacher” receives benefits from “students”. On the other hand, “students” learn new production processes, materials, and market from “teachers”. This has been tested to determine the implication to upstream-downstream relations.

2.2. Experiences of Foreign Firms as Technology of Innovations

Bloom and van Reenen (2007, 2010a, 2010b) emphasize that differences in management practices play a crucial role in productivity dispersion within a country and across countries. Bloom, Eifert, Mahajan, McKenzie, and Roberts (2010) also provides the experimental evidence of modern management practices on productivity upgrading among the Indian textile factories. Finding showed that treated factories achieve not only product upgrading but also profitability than control factories. It is difficult to identify the impact of adoption of modern management practices as well as changing managerial abilities of managers. This was subjected to further testing focus on the background of top management.

Hortacsu and Syverson (2009) suggested the importance of intangible inputs like managerial oversight within the firm to show vertical ownership is not usually used to facilitate transfers of goods in the production chain. They concluded that the central motivation of owning production chains is the more efficient transfer of knowledge of production and information on markets. This motivation is closely related to the concept of “adaptive organization” A la Dessein and Santos (2006) theoretically analyzes the complementarities between the level of adaptation to a changing environment, coordination, and the extent of specialization. Production chains within firms help the firm to collect information on market and use it for production and vice versa. Therefore, since managerial abilities have centralized local information, these abilities play a key role as a technology of product and process innovations within the firm.

One concrete example is that the industrial development impacts of immigrant technologist as shown in Kerr (2008, 2010) and Kerr and Lincoln (2010). Experiences in foreign firms or countries are as an important technology of innovations. Experience of foreign firms plays a key role of new knowledge to local firms. This implication is also directly derived from Berliant and Fujita (2008, 2009).

3. DATA

3.1. Sampling

The sample industries primarily involved in the manufacturing (and exporting for some firms) sector are currently operating in East Asia. The dataset used came from the Establishment Survey on Innovation and Production Network for selected manufacturing firms in four countries in East Asia. In December 2009, a dataset was created in Indonesia, Philippines, Thailand, and Vietnam. The sample population is restricted to selected manufacturing hubs in each country (JABODETABEK area, i.e., Jakarta, Bogor, Depok, Tangerang and Bekasi for Indonesia, CALABARZON area, i.e., Cavite, Laguna, Batangas, Rizal, and Quezon for the Philippines, Greater Bangkok area for Thailand, and Hanoi and Ho Chi Minh area for Vietnam). A total of 864 firms agreed to participate in the survey: (1) 183 firms in Indonesia; (2) 203 firms in the Philippines; (3) 178 firms in Thailand; and (4) 300 firms in Vietnam. The sample industries consist of 17 manufacturers for each country.

3.2. Firm Characteristics

Table 1 presents a summary of firm characteristics. The average existence of a firm is 16.8 years, with a standard deviation of 13.9 years. Firm size is much dispersed averaging 340 employees with a standard deviation of 499. Since the sampling strategy covers the whole of manufacturing in each country, some firms have more than 2,000 employees while others are as small as having less than 20 employees. Of the total number surveyed, approximately 67.5 percent are local firms; 14.5 percent, joint-venture firms; and 17 percent, Multinational Enterprises (MNEs). Firm function is classified into one of nine categories. Seventeen percent of the firms produce raw materials. Forty-two percent of the firms process raw materials. Thirty-six percent produce components and parts while 63 percent produce final goods. In addition to

Table 1, a total of 19 percent procure raw materials while 24 percent carry out logistics. Only two percent of the firms has information technologies department. Twenty percent of firms have sales while 40 percent carry out marketing activities.

Table 1 Summary Statistics of Firm Characteristics

	Mean	Std. Dev.
R&D activities (1 if Yes, 0 otherwise)	0.501	0.500
Age	16.796	13.922
Full-time Employees	340.198	514.347
Local Firms	0.675	0.469
Joint Venture Firms	0.145	0.352
Food	0.111	0.314
Textiles	0.053	0.225
Apparel	0.053	0.225
Wood	0.043	0.203
Paper	0.051	0.220
Chemical	0.049	0.215
Plastic	0.080	0.271
Nonmetal	0.015	0.122
Iron	0.047	0.213
Metal	0.063	0.242
Machinery	0.063	0.242
Computers	0.023	0.150
Electronics	0.095	0.293
Precision	0.019	0.135
Auto	0.058	0.234
Transport	0.009	0.096
Production (raw material)	0.176	0.381
Production (processing)	0.427	0.495
Production (components and parts)	0.345	0.476
Production (final products)	0.589	0.492
Size of domestic sales	27.833	25.770
Years of product life cycle	2.973	2.254
Number of product types	6.962	4.234
Top management have a master degree	0.284	0.451
Top management was engineer	0.578	0.494
Top management have an experience for MNC/JV	0.459	0.499
Ratio of high school graduates among blue-collar workers	58.191	27.665
Ratio of technical college graduates among engineers	50.453	36.371
Indonesia	0.212	0.409
Philippines	0.235	0.424
Thailand	0.206	0.405
Hanoi	0.174	0.379
Ho Chi Minh City	0.174	0.379

The average size of domestic sales is calculated by the average number of local customers. That is, on the average 27.8 customer firms with standard deviation of 25.7

that respondent firm has. There is quite larger dispersion in shipping across respondent firms. The average years of product life cycle are 2.9 years with a standard error of 2.2 years. There is also a larger dispersion of years in product life cycle. The average number of product types is 6.9 with a standard error of 4.2. There are firms with many types of products while others have single product only.

Now, with regard to the characteristics of top management and worker characteristics within the firm, 28.4 percent of the employees are holding a master degree or higher. Almost 57.8 percent of top managers rise from the engineering ranks. Moreover, 45.9 percent of top management have multinational or joint venture experience. The ratio of high school graduates among blue-collar workers is 58.1 percent while the ratio of technical college graduates among engineers is 50.4 percent.

3.3. Dependent Variables

To keep pace with the domestic demand and stay on top of international competition, the firms adopt new technologies, acquire new organizational forms to adapt to market changes, create new markets, find new inputs to improve product quality and cost efficiency, and introduce new products. Table 2 shows the main interests—product and process innovation. Innovative activities reflect several dimensions of industry upgrading. There is large distinction on the firm's policy for industry upgrading. Three different groups of measures were identified—(1) introduction of new goods, (2) adoption of new technologies and facilities, and (3) changes in organizational structures.

An approximately 64 percent of the sample firms are able to change the design of their existing products. More than 80 percent of the firms improve their existing products. Almost 70 percent of the firms develop new products based on existing technologies while 57 percent utilized new technologies. These suggest that it is more difficult to achieve product innovation combined with new technologies. Eighty-five percent of firms are able to sell new products to the existing market while 71 percent of firms are able to sell new products to new market. These also imply that creation of new market is difficult and costly.

Table 2 Summary Statistics of Product and Process Innovations

	Mean	Std. Dev.
Product Innovations		
(1) Change Design	0.639	0.481
(2) Improvement of Existing Product	0.841	0.365
(3) Development of New Product based on Existing Technologies	0.692	0.462
(4) Development of New Product based on New Technologies	0.573	0.495
(5) New Product to Existing Market	0.845	0.362
(6) New Product to New Market	0.712	0.453
Production Process Innovations		
(1) Bought New Machines	0.656	0.475
(2) Improved Existing Machines	0.831	0.375
(3) Introduced New Know-how on Production Methods	0.704	0.457
Change in Production Process		
(1) Change Quality Control	0.789	0.408
(2) Change Production Control	0.840	0.367
(3) Change Cost Control	0.801	0.400
(4) Change Marketing	0.745	0.436
(5) Change Inventory Control	0.699	0.459
(6) Change Domestic Procurement	0.495	0.500
(7) Change International Procurement	0.701	0.458
(8) Change Domestic Delivery	0.360	0.480
(9) Change International Delivery	0.635	0.482
Changes in Management Practices		
(1) Change Accounting System	0.780	0.414
(2) Change HRMP	0.753	0.431
(3) Change Environment Management	0.671	0.470
(4) Adopt New ISO	0.503	0.500
Upgrading Production Process		
(1) Decrease in Defection	0.727	0.446
(2) Decrease in Inventories	0.580	0.494
(3) Decrease in Materials	0.506	0.500
(4) Reduce Labor Inputs	0.334	0.472
(5) Improve Quality	0.838	0.369
(6) Reduce Lead-time	0.503	0.500
(7) Increase in Domestic Market	0.606	0.489
(8) Increase in Abroad Market	0.350	0.477
(9) Reduce Pollution	0.612	0.488
(10) Meet Regulation	0.825	0.380

How about process innovations? More than 83 percent of the firms are able to buy new machines. Seventy percent of firms improved their existing machines. Likewise, 71 percent of firms introduced new know-how in production methods. There are several types of changes in production process, for example, quality, production, cost controls in terms of plant operation, marketing, inventory, procurement, and delivery controls through shipping. These firms tend to change production processes more than shipping processes. There are also several types of changes in management practices, that is, accounting system, human resource management practices (HRMP), environment management, and adoption of International Organization for Standardization (ISO). Changes in accounting system and HRMP within firm is popular than meeting with regulation and global standardization.

Information collected are not only changes in production processes but also actual upgrading; (1) decrease in defection (72%); (2) decrease in inventories (58%); (3) decrease in materials (50%); (4) reduce the labor input (33%); (5) improve quality (84%); (6) reduce lead-time (50%); (7) increase in domestic market (60%); (8) increase in abroad market (35%); (9) reduce pollution (61%); (10) meet regulation (82%).

3.4. Independent Variables--Forms of Guidance, Transferred Technology, and Partner's Characteristics

Firms utilize knowledge exchange among production partners (own customers and suppliers) for upgrading purposes. Adaption of new technologies and improvement of organizational practices, particularly technology transfer, are more likely to happen in response to the demands of the external environment. What occurs in the knowledge flows among customers? There are three dimensions of technology transfer: (1) quality control; (2) cost control; (3) delivery control. Environment management is also important in technology transfer between customers and suppliers in East Asia especially in exporting firms. Only 1 percent of the firms have received environment management from the main customer.

First, proxies exist in mutual knowledge flows between own firm and customer. Learning and teaching create mutual knowledge flows. Knowledge flows refer to the exchange of engineers from customer to own firm as well as engineers from own firm to customer. Thirty-seven percent of firms do mutual exchange of engineers between own firm and customer. Fifty-four percent of firms adopt the engineers from their main customer (i.e., customer dispatch engineers). Forty-three percent of firms dispatch engineers to their main customer. Total quality management is one of the incentives of mutual knowledge flows between firms. Twenty-eight percent of firms are provided quality control by their customer. Customer provides cost control for 7 percent of firms. Customer provides delivery control for 9 percent of firms. Forty-seven firms provide quality controls to customer. On the other hand, 4.6 percent of firms provide cost controls as well as 14.6 percent of firms provide delivery control. Thirty percent of firms are granted license by their customer. Thirty-six percent of firms grant license to their customers. Forty-three percent firms are required to have ISO by their customers. Almost thirty-five percent of firms require ISO to customer. Fifty-five percent of firms form JIT with their customer while the average distance to customer is 448 km with a standard deviation of 702 km (Table 3a).

Second, relationship with supplier has different figures compared to the relationship with customer. Thirty-five percent of firms do mutual exchange of engineers between own firm and supplier. Forty-seven percent of firms adopt the engineers from their main supplier (i.e., supplier dispatch engineers). Forty-five percent of firms dispatch engineers to their main supplier. Total quality management is also one incentive for mutual knowledge flows between firms and suppliers. Thirty-seven percent of firms are provided quality control by their supplier. Thirty-five percent of firms received quality control from their supplier. Almost eight percent of firms received cost control from their supplier while 6.5 percent of firms provide delivery control to their suppliers. On the other hand, 18.2 percent of firms receive delivery controls from their suppliers as well as 12.5 percent of firms provide delivery control to their supplier. Thirty percent of firms in the sample are granted license from their supplier. Twenty-eight percent of firms grant license to their suppliers. Thirty-three percent of firms required to have ISO by their suppliers. Almost 44 percent of firms require ISO to supplier. Fifty percent of firms form JIT with their supplier while the average distance to customer is 524 km with a standard deviation of 750 km.

Table 3a Summary Statistics of Relationship with Customer

	Mean	Std. Dev.
Relationship with Customer		
Customer dispatch engineers*Dispatch engineers to customer	0.372	0.483
Customer dispatch engineers	0.541	0.499
Dispatch engineers to customer	0.432	0.496
Customer provides quality control	0.278	0.448
Provide customer quality control	0.473	0.500
Customer provides cost control	0.074	0.262
Provide customer cost control	0.046	0.210
Customer provides delivery control	0.093	0.290
Provide customer delivery control	0.146	0.353
Customer grants license	0.299	0.458
Grants license to customer	0.365	0.482
Customer requires ISO	0.433	0.496
Requires ISO to customer	0.348	0.477
JIT with customer	0.553	0.497
Distance to customer	448.736	702.893
Same industry with customer	0.317	0.466
Customer is local	0.600	0.490
Customer is joint-venture	0.161	0.368
Capital tie up with customer	0.406	0.491
Years of duration with customer	6.699	3.605
Customer's Production (raw material)	0.066	0.248
Customer's Production (processing)	0.054	0.227
Customer's Production (components and parts)	0.133	0.340
Customer's Production (final products)	0.433	0.496

Table 3b Summary Statistics of Relationship with Supplier

	Mean	Std. Dev.
Relationship with Supplier		
Supplier dispatch engineers*Dispatch engineers to supplier	0.359	0.480
Supplier dispatch engineers	0.476	0.500
Dispatch engineers to supplier	0.459	0.499
Supplier provides quality control	0.358	0.480
Provide supplier quality control	0.332	0.471
Supplier provides cost control	0.079	0.269
Provide supplier cost control	0.065	0.246
Supplier provides delivery control	0.182	0.386
Provide supplier delivery control	0.125	0.331
Supplier grants license	0.314	0.464
Grants license to supplier	0.287	0.453
Supplier requires ISO	0.328	0.470
Requires ISO to supplier	0.442	0.497
JIT with supplier	0.507	0.500
Distance to supplier	524.855	750.251
Same industry with supplier	0.361	0.481
Supplier is local	0.538	0.499
Supplier is joint-venture	0.193	0.395
Capital tie up with supplier	0.389	0.488
Years of duration with supplier	6.485	3.541
Supplier's Production (raw material)	0.454	0.498
Supplier's Production (processing)	0.134	0.341
Supplier's Production (components and parts)	0.156	0.363
Supplier's Production (final products)	0.115	0.319

3.5. Exchanges of Engineers by Firm and Partner’s Characteristics

Table 4 presents the exchanges of engineers by types of respondent firms and their partners. Respondents are classified as: local firms; joint venture (JVs) firms; and foreign-owned firms (Multinational Corporations or MNCs). Findings showed that among the various types of firms, JVs and MNCs mostly practiced dispatching of engineers to their customers compared to local firms.

With regard to dispatching engineers to their customer, less than half (49%) are practiced by local firms and more than half are practiced by JVs (56%) and MNCs (71%). Similarly, in dispatching engineers to supplier, both JVs and MNCs are more than 50 percent. In the overall, among the types of firms, dispatching engineers to customer is more often the practice than dispatching engineers to supplier. This is another strong empirical finding.

Now, what about accepting engineers from their partners? MNCs (60%) accept engineers from their main customer and supplier compared to JVs (52%) and local firms (37%). On the other hand, 52 percent of MNCs accept engineers from their main supplier, 49 percent for JVs and 43 percent for local firms. At this point, it is the local firms which accept more engineers from supplier than accepting engineers from customer.

Table 4 also shows the results of exchanges of engineer with their main partner. MNCs often engage in exchanging engineers with partners more than JVs and local firms. Local firms do not engage in mutual exchanging, unlike JVs.

The inside patterns of dispatching and accepting are different from the above findings. As depicted in the middle of Table 4, there are more complex characteristics about dispatching engineers to main partners and accepting engineers from main partners. If MNCs had local customers, then there are more MNCs which send their engineers to their local customers than JVs or local firms. For example, 80 percent of MNCs dispatch engineers to local customers while 73 percent of MNCs dispatch their engineers to MNC customers. The situation of accepting engineers from a customer is different from dispatching engineers to them. If MNCs have local customers, then it is difficult for any other local customers to dispatch engineers to MNCs. It becomes the choice of the MNCs on which customer they would take engineers compared to the case of MNCs' customer being MNCs. This is true not only for MNCs but also to local firms and JVs. It is difficult for a local customer to dispatch their engineers to local firms and JVs. For example, only one third of the local firms accept engineers from local customers (33.7% of local customers dispatch engineers) as well as 48.6% of local customer dispatch engineers to JVs. Therefore, there is a strong connection between local customers and MNCs in terms of dispatching engineers from MNCs in upstream to downstream local customers. There is also significant connection between MNCs customer and every type of firms. Downstream MNCs tend to dispatch engineers to upstream firms compared to downstream JVs or local firms.

As depicted in the third range of Table 4, 70 percent of MNCs dispatch engineers to MNCs suppliers, and 65 percent of MNCs dispatch their engineers to local supplier. On the other hand, 56 percent of MNCs accept engineers from local suppliers as well as 52 percent of MNCs accept engineers from MNCs suppliers.

These results suggest that: (1) interconnection from downstream MNCs to upstream MNCs is stronger than from downstream MNCs to upstream local firms; (2) interconnection from upstream local firms to downstream MNCs is stronger than from upstream MNCs to downstream MNCs. These results are true for local firms.

Table 4 Summary Statistics of Exchange of Engineers by Firm and Partner's Type

Types of respondent firms		Local			JVs			MNCs	
No. observation		583			125			152	
Dispatch engineers to customer		0.492			0.560			0.717	
Dispatch engineers to supplier		0.413			0.544			0.664	
Customer dispatch engineer		0.370			0.528			0.599	
Supplier dispatch engineer		0.436			0.496			0.526	
Exchange engineer with customer		0.317			0.408			0.559	
Exchange engineer with supplier		0.328			0.376			0.474	
No. observation of respondents		563			118			148	
Respondents' customer types	Local	JVs	MNCs	Local	JVs	MNCs	Local	JVs	MNCs
No. observation	451	60	52	37	51	30	27	28	93
Dispatch engineers to customer	0.479	0.700	0.519	0.514	0.627	0.567	0.815	0.643	0.731
Dispatch engineers to supplier	0.410	0.583	0.385	0.595	0.588	0.467	0.667	0.679	0.677
Customer dispatch engineer	0.337	0.583	0.538	0.486	0.549	0.633	0.593	0.464	0.667
Supplier dispatch engineer	0.437	0.533	0.481	0.541	0.569	0.400	0.444	0.607	0.538
Exchange engineer with customer	0.293	0.517	0.404	0.351	0.471	0.467	0.593	0.393	0.624
Exchange engineer with supplier	0.333	0.417	0.308	0.432	0.412	0.333	0.370	0.500	0.505
No. observation of respondents		546			119			145	
Respondents' supplier types	Local	JVs	MNCs	Local	JVs	MNCs	Local	JVs	MNCs
No. observation	411	76	59	29	60	30	23	30	92
Dispatch engineers to customer	0.479	0.671	0.610	0.448	0.583	0.667	0.826	0.633	0.750
Dispatch engineers to supplier	0.416	0.487	0.492	0.517	0.583	0.533	0.652	0.667	0.707
Customer dispatch engineer	0.377	0.395	0.492	0.517	0.517	0.600	0.652	0.500	0.641
Supplier dispatch engineer	0.440	0.539	0.525	0.483	0.533	0.467	0.565	0.600	0.522
Exchange engineer with customer	0.316	0.342	0.475	0.345	0.417	0.500	0.565	0.400	0.641
Exchange engineer with supplier	0.324	0.408	0.441	0.414	0.383	0.367	0.478	0.500	0.489

4. RESULTS

The results of exchanges of workers and technology transfer on innovations are described in this section. The internal effects of the determinant of product and process innovations are discussed in order to understand the knowledge flow through upstream-downstream production linkages. First, exchanging engineers, trainers, and trainees could stimulate knowledge flow based on face-to-face communication. Such approach seems to be a "vehicle" of knowledge flows. This experience validates the importance of face-to-face communication. On the other hand, motivation of technology transfer is silent. Technology transfer could require the opportunity for face-to-face communication between suppliers and customers. Since this paper aimed to focus on tacit knowledge exchange impacts of product and process innovations, direct information flow through upstream-downstream linkages to product and process innovations is considered. This paper also was able to detect the firm's knowledge production function using the estimated equation as follows:

$$\Pr(y_i = 1) = \alpha Exchange\_Engineer_i + \beta Manager_i + \gamma x_i + u_i ,$$

where y means the outcome of innovation and upgrading for each firm i located in each country c, the variable *Exchange_Engineer* serves as proxy for information and knowledge flows between firms (forms of guidance through exchanging engineers, trainers, trainees and incidence of receiving technical assistances), x for other controls (i.e., R&D, age, size, capital structure, industry, function of operation, years of product life cycle, number of product types, ratio of high school workers, ratio of college graduates engineer, and country dummy variables) as depicted in Table 1. A cross-sectional error term is shown by u. To simply regress innovation outcome to covariates, focus is given on the estimated coefficient of *Exchange_Engineer* as the degree of innovation management technology across firms.

4.1. Product Innovations

Table 5 shows the effects of exchanges of engineers between own firms and partners (main customers and suppliers) regarding the introduction of new products. The dependent variable is equal to one if each firm achieves product innovations. We have six different types of product innovations, namely: (1) change design; (2) improvement of existing product; (3) development of new product based on existing technologies; (4) development of new product based on new technologies; (5) new product to existing market; and (6) new product to new market. The independent variable, R&D activities covering expenditure and country dummy variables are also shown. The variable of customer (supplier) dispatch engineers is equal to one if each firm accepts engineers from their main customer (supplier). The variable dispatch engineers and trainees to customer (supplier) is equal to one if each firm dispatches engineers and trainees to their main customer (supplier). This paper focuses on the interaction of customer (supplier) dispatch engineers and dispatch engineers to customer (supplier) with the role of mutual knowledge exchanges impacts. The theoretical framework suggests that such mutual knowledge exchanges with their partners could stimulate learning and innovation processes for each firm utilizing the production linkages. The marginal effects are presented in Table 5.

As reported in Table 5, the coefficient for R&D activities for development of new product based on existing technologies is .156 with a standard error of .048. This is statistically significant at 1 percent level (column 3). R&D activities dummy variable has also large impact on new product to new market (column 6), the coefficient being .137 with standard error of .066, also statistically significant at 5 percent level. Thus, firms doing R&D are likely to experience a significantly higher probability of product innovation than firms that do not engage in R&D at all.

With regard to the coefficient for the interaction between *customer dispatch engineers* and *dispatch engineers to customer,* development of new product based on new technologies has a coefficient of .230, with standard error of .129 (column 4), and statistically significant at 10 percent level. On the other hand, new product to new market is .271, with standard error of .129 (column 6), and statistically significant at 5 percent level.

The second main result of Table 4 is the coefficient for the interaction term between *supplier dispatch engineers* and *dispatch engineers to supplier*. The coefficient of this interaction also shows the impacts of mutual knowledge exchange with supplier. For improvement of existing product, a coefficient -.154 with standard error of .085 (column 2), is statistically significant at 10 percent level. On development of new product based on new technologies a coefficient -.267 with standard error of .127 (column 4), is statistically significant at 10 percent level. These results suggest that mutual knowledge exchanges with their main suppliers negatively affect product innovations especially on improvement of existing product and introducing new product based on existing technologies.

Table 5 Exchanges of Engineers and Product Innovations

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variables: Product Innovations (Yes/No)	Change Design	Improvement of Existing Product	Development of New Product based on Existing Technologies	Development of New Product based on New Technologies	New Product to Existing Market	New Product to New Market
R&D dummy (Yes/No)	0.001	0.015	0.156**	0.037	0.072	0.137*
	[0.045]	[0.024]	[0.048]	[0.053]	[0.045]	[0.066]
Customer dispatch engineers*Dispatch engineers to customer	0.103	0.032	0.038	0.230+	0.084	0.271*
	[0.104]	[0.052]	[0.125]	[0.129]	[0.097]	[0.129]
Customer dispatch engineers	-0.161*	0.018	0.062	-0.196*	-0.037	0.013
	[0.064]	[0.043]	[0.087]	[0.085]	[0.075]	[0.110]
Dispatch engineers to customer	-0.117	-0.016	-0.140	-0.162	-0.039	-0.334**
	[0.084]	[0.040]	[0.102]	[0.116]	[0.091]	[0.115]
Supplier dispatch engineers*Dispatch engineers to supplier	0.030	-0.154+	-0.129	-0.267*	-0.143	-0.145
	[0.113]	[0.085]	[0.118]	[0.127]	[0.132]	[0.170]
Supplier dispatch engineers	0.062	0.091+	0.076	0.178+	0.062	0.100
	[0.083]	[0.052]	[0.089]	[0.099]	[0.074]	[0.115]
Dispatch engineers to supplier	0.036	0.072	0.097	0.288**	0.128	0.237*
	[0.081]	[0.050]	[0.091]	[0.099]	[0.080]	[0.110]
Size of domestic sales	0.002*	0.000	-0.001	0.001	0.000	0.001
	[0.001]	[0.000]	[0.001]	[0.001]	[0.001]	[0.001]
Years of product life cycle	-0.013	-0.009+	-0.003	-0.005	-0.008	0.020
	[0.010]	[0.005]	[0.011]	[0.013]	[0.009]	[0.014]
Number of product types	0.004	0.002	0.009	0.008	0.020**	0.017*
	[0.005]	[0.003]	[0.006]	[0.007]	[0.005]	[0.007]
Top management have a master degree	-0.057	-0.003	0.032	0.090	0.057	-0.143*
	[0.050]	[0.024]	[0.054]	[0.056]	[0.043]	[0.071]
Top management was engineer	0.100+	0.026	-0.004	0.061	-0.023	-0.010
	[0.055]	[0.030]	[0.058]	[0.065]	[0.050]	[0.074]
Top management have an experience for MNC/JV	0.076+	-0.033	0.015	0.149**	0.100*	0.057
	[0.046]	[0.024]	[0.051]	[0.056]	[0.047]	[0.071]
Ratio of high school graduates among blue-collar workers	0.001	0.001	0.000	0.000	0.001	0.000
	[0.001]	[0.000]	[0.001]	[0.001]	[0.001]	[0.001]
Ratio of technical college graduates among engineers	0.000	0.000	0.000	-0.002*	0.000	-0.002*
	[0.001]	[0.000]	[0.001]	[0.001]	[0.001]	[0.001]
Indonesia	0.095+	0.012	0.049	-0.041	0.156**	-0.053
	[0.054]	[0.033]	[0.086]	[0.104]	[0.032]	[0.102]
Philippines	0.042	-0.025	0.018	-0.028	0.039	-0.222*
	[0.061]	[0.038]	[0.080]	[0.089]	[0.058]	[0.090]
Hanoi	0.113+	0.028	0.035	-0.122	0.177**	0.188*
	[0.062]	[0.033]	[0.100]	[0.118]	[0.037]	[0.094]
Ho Chi Minh	0.514**	0.114**	0.141+	0.091		
	[0.041]	[0.030]	[0.084]	[0.101]		
Observations	483	483	483	483	338	338

Notes: Other control variables are: age, size, local firms, joint venture, industry, and function dummies.
Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%
Reference country is Thailand.

4.2. Process Innovations

Process innovations are composed of six different types of changing production processes: (1) improved existing machines; (2) bought new machines; (3) introduction of new know-how on production methods; (4) changes in quality control; (5) changes in production control; (6) changes in cost control. The primary variables include R&D, mutual knowledge exchange with customer, and mutual knowledge with supplier.

As reported in Table 6, the coefficient of R&D activities on having bought new machines is .115 with a standard error of .045, and statistically significant at 5 percent level (column 2). The coefficient for R&D activities on introduction of new know-how on production methods is .179 with standard error of .044, and statistically significant at 1 percent level. Thus, firms that are involved in R&D are likely to experience a significantly higher probability of production process innovation than firms that no R&D expenditures. In addition to the contributions of R&D activities within the firm, Table 6 shows the impacts of mutual knowledge exchanges with their main supplier. The coefficient on buying new machines is -.390 with standard error of .119 (column 2), and statistically significant at 1 percent level. On the other hand, the coefficient for accepting engineers from supplier is .160 on buying new machines with a standard error of .055, and statistically significant at 10 percent level in this specification. The coefficient for accepting engineers from supplier is .162 on changing production control with standard error of .074, and statistically significant at 5 percent level. The coefficient for accepting engineers from supplier (i.e., supplier dispatch engineers) has positive impact on buying new machines (column 3) and changing production control (column 5). Dispatching engineers to their main supplier also have large and positively significant impacts on buying new machines (column 3) and changing production control (column 5).

Table 6 Exchanges of Engineers and Process Innovations

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variables: Process Innovations (Yes/No)	Improved Existing Machines	Bought New Machines	Introduced New-Know How on Production Methods	Change Quality Control	Change Producti on Control	Change Cost Control
R&D dummy (Yes/No)	0.005	**0.115***	**0.179****	-0.004	0.051	0.019
	[0.026]	**[0.045]**	**[0.044]**	[0.029]	[0.034]	[0.040]
Customer dispatch engineers*Dispatch engineers to customer	0.067	0.030	0.044	0.067	0.101	0.205*
	[0.058]	[0.113]	[0.098]	[0.067]	[0.074]	[0.092]
Customer dispatch engineers	0.002	-0.051	0.059	-0.063	-0.077	-0.078
	[0.048]	[0.073]	[0.074]	[0.047]	[0.053]	[0.061]
Dispatch engineers to customer	-0.022	0.123	-0.042	-0.047	**-0.116+**	**-0.166***
	[0.046]	[0.098]	[0.083]	[0.056]	**[0.063]**	**[0.081]**
Supplier dispatch engineers*Dispatch engineers to supplier	-0.016	**-0.390****	-0.165	-0.025	**-0.216***	-0.150
	[0.067]	**[0.119]**	[0.111]	[0.078]	**[0.101]**	[0.105]
Supplier dispatch engineers	0.020	**0.160+**	0.102	0.091	**0.162***	0.092
	[0.052]	**[0.092]**	[0.084]	[0.069]	**[0.074]**	[0.078]
Dispatch engineers to supplier	0.029	**0.203***	0.085	0.012	**0.132***	0.025
	[0.044]	**[0.088]**	[0.075]	[0.051]	**[0.066]**	[0.075]
Size of domestic sales	0.000	0.001	0.001	0.001	0.001	0.001
	[0.000]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Years of product life cycle	-0.006	-0.002	-0.008	-0.008	-0.007	-0.010
	[0.006]	[0.011]	[0.010]	[0.007]	[0.008]	[0.009]
Number of product types	-0.001	0.006	0.005	-0.001	0.001	0.005
	[0.003]	[0.005]	[0.005]	[0.004]	[0.004]	[0.005]
Top management have a master degree	-0.002	0.082+	0.046	-0.003	0.050	0.045
	[0.026]	[0.044]	[0.042]	[0.035]	[0.033]	[0.040]
Top management was engineer	0.054	-0.013	0.006	0.043	0.060	0.057
	[0.034]	[0.053]	[0.049]	[0.037]	[0.045]	[0.048]
Top management have an experience for MNC/JV	0.004	0.026	0.129**	0.020	0.000	-0.016
	[0.029]	[0.049]	[0.045]	[0.032]	[0.035]	[0.043]
Ratio of high school graduates among blue-collar workers	0.000	-0.001	0.000	0.000	0.000	0.000
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Ratio of technical college graduates among engineers	-0.001	0.000	-0.001	0.001	0.001	0.001*
	[0.000]	[0.001]	[0.001]	[0.000]	[0.000]	[0.001]
Indonesia	0.039	-0.016	-0.037	0.085**	0.064	0.110*
	[0.030]	[0.088]	[0.084]	[0.032]	[0.045]	[0.047]
Philippines	0.028	0.028	0.111+	-0.071	0.000	0.020
	[0.034]	[0.071]	[0.058]	[0.060]	[0.053]	[0.061]
Hanoi	0.074**	0.016	-0.002	-0.122	-0.048	-0.048
	[0.026]	[0.093]	[0.089]	[0.099]	[0.082]	[0.090]
Ho Chi Minh	0.123**	0.149*	0.239**	0.125**	0.193**	0.214**
	[0.032]	[0.075]	[0.054]	[0.044]	[0.044]	[0.050]
Observations	467	483	483	473	473	483

Notes: Other control variables are: age, size, local firms, joint venture, industry, and function dummies.
Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%
Reference country is Thailand.

4.3. Sales, Procurement, and Management Practices

Process innovation does not emerge from production processes alone but also in shipping phases (sales and procurement stages) and other managerial operation stages. Table 7 has 10 different organizational reforms within firms, namely: (1) change in marketing; (2) change in inventory control; (3) change in domestic procurement; (4) change in international procurement; (5) change in domestic delivery; (6) change in international delivery; (7) change in accounting system; (8) change in HRMP (human resource management practices); (9) change in environment management; and (10) adoption in ISO. The coefficients for the mutual knowledge exchanges on these organizational reforms could be interpreted as technologies of learning and teaching processes with upstream-downstream partners.

The coefficients for the R&D dummy variables are significantly effective for changing in international delivery (column 6), changing accounting system (column 7), and changing HRMP (column 8), being statistically significant at the 1 percent level. Since these organizational reforms have seemed to be costly activities, only firms with R&D activities can achieve the said reforms compared to firms without R&D activities. The coefficient for the mutual knowledge exchange with customer is .263 on changing environment management with standard error of .115, and statistically significant at 5 percent level. This suggests that firms which received the benefits of mutual knowledge flows from their main customer could have 26.3 percent larger probability of changing environment management than firms which no benefits from mutual knowledge flows. In addition to the mutual knowledge exchanges with customer, the coefficient is -.295 on changing inventory control (column 2) with standard error of .118, and statistically significant at 5 percent level. This is also true for changing international delivery (column 6) and changing HRMP (column 8). Since the coefficients for accepting engineers from supplier are always positive, firms accepting engineers naturally gain benefits.

Table 7 Exchanges of Engineers and Upgrading in Sales, Procurement, and Management Practices

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent variables: Upgrading in Sales, Procurement, and Management Practices (Yes/No)	Change Marketing	Change Inventory Control	Change Domestic Procurement	Change International Procurement	Change Domestic Delivery	Change International Delivery	Change Accounting System	Change HRMP	Change Environment Management	Adopt New ISO
R&D dummy (Yes/No)	-0.044	0.007	0.048	0.066	0.053	0.148**	0.156**	0.152**	0.054	-0.002
	[0.038]	[0.038]	[0.049]	[0.057]	[0.047]	[0.050]	[0.054]	[0.043]	[0.051]	[0.055]
Customer dispatch engineers*Dispatch engineers to customer	0.027	0.114	-0.127	0.161	-0.027	0.142	0.116	0.065	0.263*	0.176
	[0.092]	[0.091]	[0.118]	[0.137]	[0.119]	[0.137]	[0.137]	[0.099]	[0.115]	[0.134]
Customer dispatch engineers	0.019	-0.079	0.162+	-0.133	0.038	-0.193*	-0.006	-0.083	-0.089	-0.071
	[0.066]	[0.061]	[0.087]	[0.087]	[0.081]	[0.097]	[0.095]	[0.064]	[0.082]	[0.090]
Dispatch engineers to customer	-0.104	-0.111	-0.013	-0.089	-0.059	-0.051	-0.131	-0.045	-0.068	0.02
	[0.076]	[0.078]	[0.093]	[0.118]	[0.099]	[0.119]	[0.116]	[0.083]	[0.108]	[0.122]
Supplier dispatch engineers*Dispatch engineers to supplier	-0.035	-0.295*	-0.110	-0.111	-0.094	-0.222+	0.018	-0.296*	-0.16	-0.007
	[0.091]	[0.118]	[0.113]	[0.132]	[0.111]	[0.119]	[0.129]	[0.117]	[0.118]	[0.128]
Supplier dispatch engineers	0.061	0.235*	0.027	0.209*	0.025	0.276**	0.099	0.163+	0.101	-0.067
	[0.072]	[0.092]	[0.086]	[0.101]	[0.081]	[0.090]	[0.099]	[0.087]	[0.092]	[0.098]
Dispatch engineers to supplier	0.033	0.098	0.075	0.009	0.040	0.146	-0.015	0.108	0.014	-0.03
	[0.069]	[0.072]	[0.084]	[0.094]	[0.084]	[0.101]	[0.102]	[0.079]	[0.093]	[0.102]
Size of domestic sales	0.000	0.001	0.001	0.001	0.004**	0.000	0.001	0.001	0.002+	-0.001
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Years of product life cycle	-0.015+	0.003	-0.019+	-0.022+	-0.015	-0.007	-0.021	-0.016+	-0.033**	-0.039**
	[0.009]	[0.009]	[0.011]	[0.013]	[0.010]	[0.012]	[0.013]	[0.009]	[0.012]	[0.013]
Number of product types	0.006	0.001	0.000	0.004	-0.002	-0.008	0.001	0.005	0.004	0.001
	[0.004]	[0.004]	[0.006]	[0.007]	[0.005]	[0.007]	[0.007]	[0.005]	[0.007]	[0.007]
Top management have a master degree	0.080*	0.012	0.015	0.156**	0.026	0.060	0.044	0.047	-0.004	0.143*
	[0.035]	[0.041]	[0.052]	[0.060]	[0.048]	[0.057]	[0.059]	[0.042]	[0.055]	[0.057]
Top management was engineer	0.002	0.062	-0.020	-0.016	0.064	0.114*	-0.048	0.03	0.093	0.136*
	[0.043]	[0.047]	[0.054]	[0.068]	[0.054]	[0.058]	[0.064]	[0.050]	[0.060]	[0.065]
Top management have an experience for MNC/JV	0.084*	0.069+	0.030	0.038	0.008	-0.015	-0.039	0.025	0.107*	0.144**
	[0.040]	[0.040]	[0.052]	[0.061]	[0.050]	[0.055]	[0.057]	[0.044]	[0.053]	[0.056]
Ratio of high school graduates among blue-collar workers	-0.001	-0.001	-0.002*	-0.002	-0.001	0.000	0	-0.001	0.001	0
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Ratio of technical college graduates among engineers	0.001	0.000	0.000	0.001	-0.001	-0.001	0	0.001	0	0.002**
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Indonesia	0.054	-0.092	0.034	-0.029	0.002	-0.106	0.181+	0.085	0.016	0.068
	[0.056]	[0.088]	[0.079]	[0.101]	[0.081]	[0.092]	[0.095]	[0.055]	[0.096]	[0.097]
Philippines	-0.041	-0.070	-0.056	0.045	-0.195*	-0.049	-0.049	0.031	0.011	-0.042
	[0.059]	[0.067]	[0.077]	[0.091]	[0.084]	[0.087]	[0.093]	[0.060]	[0.088]	[0.091]
Hanoi	0.146**	-0.195+	-0.021	0.199*	0.013	0.067	0.174+	0.049	-0.015	0.093
	[0.036]	[0.110]	[0.100]	[0.093]	[0.095]	[0.114]	[0.103]	[0.074]	[0.115]	[0.110]
Ho Chi Minh	0.272**	0.239**	0.322**	0.513**	0.287**	0.013	-0.273**	0.288**	-0.098	0.055
	[0.042]	[0.048]	[0.059]	[0.062]	[0.056]	[0.100]	[0.102]	[0.048]	[0.106]	[0.104]
Observations	483	483	483	483	483	483	483	483	483	483

Notes: Other control variables are: age, size, local firms, joint venture, industry, and function dummies. Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Reference country is Thailand.

4.4. Total Quality Management and Production Processes

Table 8 revealed ten different upgrading proxies, namely: (1) decrease in defection; (2) decrease in inventories; (3) decrease in materials; (4) decrease in labor inputs; (5) improve quality; (6) reduce lead time; (7) increase domestic market; (8) increase in abroad market; (9) reduce pollution; and (10) meet regulation. The coefficients for R&D is positively significant for estimating improved quality (column 5), reduce lead time (column 6), increase in domestic market (column 7), increase in abroad market (column 8), and meet regulation (column 10).

The coefficient for mutual knowledge exchange with customer on increasing abroad market is .234 with standard error of .133, and statistically significant at 10 percent level. The coefficients for one-way knowledge flows from customer where impacts of accepting engineers from customer are effective in reducing labor input (column 4), increase in domestic market (column 7), and reduced pollution (column 9). There is no significant effect of the mutual knowledge exchanges with supplier as well as the one-way knowledge flows to and from the supplier.

Table 8 Exchanges of Engineers and Upgrading in Total Quality of Management and Production Process

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent variables: Upgrading Total Quality of Management and Production Process (Yes/No)	Decrease in Defection	Decrease in Inventories	Decrease in Materials	Reduce Labor Inputs	Improve Quality	Reduce Lead-time	Increase in Domestic Market	Increase in Abroad Market	Reduce Pollution	Meet Regulation
R&D dummy (Yes/No)	-0.017	0.007	0.064	0.038	**0.056+**	**0.094+**	**0.110***	**0.166****	0.064	**0.074***
	[0.044]	[0.054]	[0.054]	[0.049]	**[0.032]**	**[0.054]**	**[0.054]**	**[0.051]**	[0.052]	**[0.032]**
Customer dispatch engineers*Dispatch engineers to customer	0.061	0.282*	-0.070	-0.160	0.013	-0.092	-0.171	**0.234+**	-0.099	0.005
	[0.112]	[0.121]	[0.139]	[0.115]	[0.074]	[0.138]	[0.129]	**[0.133]**	[0.128]	[0.069]
Customer dispatch engineers	0.009	**-0.177***	-0.035	**0.144+**	0.001	-0.036	**0.274****	-0.041	**0.221***	-0.015
	[0.076]	**[0.083]**	[0.095]	**[0.077]**	[0.058]	[0.092]	**[0.089]**	[0.092]	**[0.093]**	[0.047]
Dispatch engineers to customer	-0.013	-0.095	0.034	0.135	-0.013	**0.211+**	0.11	-0.135	0.151	0.051
	[0.098]	[0.110]	[0.121]	[0.096]	[0.061]	**[0.118]**	[0.105]	[0.117]	[0.109]	[0.061]
Supplier dispatch engineers*Dispatch engineers to supplier	0.034	-0.131	0.008	-0.016	-0.076	0.126	-0.022	-0.016	0.012	-0.067
	[0.104]	[0.129]	[0.127]	[0.114]	[0.085]	[0.126]	[0.127]	[0.124]	[0.118]	[0.078]
Supplier dispatch engineers	0.012	-0.023	-0.077	-0.013	0.114+	-0.142	0.082	-0.022	-0.049	0.096
	[0.084]	[0.098]	[0.098]	[0.087]	[0.067]	[0.099]	[0.102]	[0.098]	[0.092]	[0.064]
Dispatch engineers to supplier	-0.073	0.141	0.147	0.021	0.035	-0.006	-0.069	0.088	0.023	-0.007
	[0.079]	[0.097]	[0.100]	[0.087]	[0.058]	[0.102]	[0.087]	[0.094]	[0.096]	[0.047]
Size of domestic sales	-0.001	-0.002+	-0.002+	-0.001	-0.001	-0.001	0.002*	-0.002*	0	-0.001
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Years of product life cycle	-0.022*	-0.010	-0.001	0.009	0.001	0.002	-0.023+	-0.038**	-0.013	-0.012+
	[0.011]	[0.012]	[0.013]	[0.011]	[0.008]	[0.013]	[0.013]	[0.013]	[0.012]	[0.007]
Number of product types	0.001	0.008	-0.001	-0.008	-0.006	0.017*	0.003	0.007	-0.002	-0.001
	[0.005]	[0.006]	[0.007]	[0.006]	[0.004]	[0.007]	[0.006]	[0.007]	[0.007]	[0.003]
Top management have a master degree	0.073	0.067	0.020	0.090	0.080*	0.085	-0.031	-0.018	0.079	0.009
	[0.047]	[0.057]	[0.058]	[0.055]	[0.032]	[0.060]	[0.058]	[0.058]	[0.055]	[0.035]
Top management was engineer	0.037	0.082	0.177**	0.037	0.037	0.165**	-0.055	0.065	0.058	0.036
	[0.053]	[0.063]	[0.062]	[0.058]	[0.039]	[0.063]	[0.063]	[0.061]	[0.061]	[0.037]
Top management have an experience for MNC/JV	-0.057	0.028	-0.035	0.036	-0.028	0.041	0.119*	0.055	0.078	0.046
	[0.049]	[0.056]	[0.058]	[0.053]	[0.034]	[0.059]	[0.056]	[0.055]	[0.058]	[0.033]
Ratio of high school graduates among blue-collar workers	0.001	-0.002*	-0.001	0.000	0.002**	0	0.002	-0.001	0	0
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Ratio of technical college graduates among engineers	0.001	0.001	0.002**	0.000	0.000	0.001	-0.001	0.001	0.001	0.001**
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.000]
Indonesia	0.206**	-0.054	-0.091	0.105	0.106**	0.476**	0.290**	0.107	0.178*	0.091**
	[0.041]	[0.099]	[0.106]	[0.097]	[0.029]	[0.050]	[0.049]	[0.107]	[0.078]	[0.025]
Philippines	0.218**	0.107	0.074	0.253**	0.085+	0.411**	0.167*	0.156	0.334**	0.082*
	[0.056]	[0.080]	[0.089]	[0.086]	[0.044]	[0.077]	[0.080]	[0.097]	[0.066]	[0.040]
Hanoi	0.215**	0.015	-0.024	-0.091	0.028	0.243*	0.203*	0.049	0.012	-0.107
	[0.049]	[0.110]	[0.118]	[0.090]	[0.058]	[0.105]	[0.079]	[0.120]	[0.110]	[0.094]
Ho Chi Minh	0.185**	0.364**	-0.184+	-0.285**	0.046	0.313**	0.462**	0.241*	-0.053	0.115*
	[0.066]	[0.073]	[0.101]	[0.068]	[0.058]	[0.097]	[0.058]	[0.108]	[0.101]	[0.046]
Observations	483	473	483	483	483	483	483	483	483	483

Notes: Other control variables are: age, size, local firms, joint venture, industry, and function dummies. Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Reference country is Thailand.

4.5. Robustness Checks

One concern arise regarding the above findings wherein engineer exchange with partner matters for product and process innovations. This means management practice with the main partner is the key reason for upgrading. If these findings simply reflect the *characteristics* of partners not the *practice* embedded with the partnership, then there may risk of misleading facts. The characteristics of partners—local firms, JVs, and MNCs—could affect the firm's upgrading through bypassing the exchange of engineers. Since Table 4 has suggested that MNCs dispatch engineers to their partners compared to JVs and local firms as well as there is more MNCs which accept engineers from their partners, MNCs could affect firm's upgrading through transactions without exchanges of engineers. To check the robustness of results, whether MNCs and JVs partnership do not simply affect product and process innovation compared to local firms was examined.

We regress product and process innovation outcome to the four dummy variables of types of partners—customer is MNCs, customer is JVs, supplier is MNCs, and supplier is JVs. The benchmark is the local firms. Since firms often send and accept engineers if they connect with MNCs customer, the expected coefficients of customers are MNCs and JVs are insignificant. Each column in Table 9 suggests that MNCs and JVs customer do not have significant impact on product innovations. On the other hand, the coefficient of JVs supplier means that firms achieve several types of product innovations in terms of development of new product based on existing technologies and new technologies as well as new product to existing market. Table 10 shows the process innovation impacts of MNCs and JVs partner. MNCs and JVs customer do not have significant impact on process innovations except for buying new machines as a process innovation.

On the other hand, MNCs and JVs partner solely affect the organizational reforms and changing of total quality of management. As shown in Table 11, if firms had connected with MNCs or JVs customer, then they achieve less change in marketing, domestic delivery, and account system compared to firms which sell to local customer. If firms had connected with MNCs or JVs supplier, they achieve more change in marketing, domestic delivery, international delivery, and adoption of ISO compared to firms which buy from local supplier. Table 12 shows that if firms had connected with MNCs customer, then inventories decreased. If firms had connected with MNCs or JVs customer, then they fail to reduce labor inputs or lead-time, to increase in domestic market, and to reduce pollution. If firms had connected with MNCs or JVs supplier, then they are able to increase domestic market, decrease inventories.

In summary, robustness in the main results is especially supported in terms of product innovations. Main results of process innovations, other organizational reforms, and changing of total quality of management are partially supported by above robustness check.

Table 9 Robustness Checks; Product Innovations Impacts of Partner's Types and Own Capabilities

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variables: Product Innovations (Yes/No)	Change Design	Improvement of Existing Product	Development of New Product based on Existing Technologies	Development of New Product based on New Technologies	New Product to Existing Market	New Product to New Market
R&D dummy (Yes/No)	-0.027	0.001	**0.131****	0.006	0.070	**0.155***
	[0.047]	[0.024]	**[0.049]**	[0.056]	[0.046]	**[0.068]**
Main customer is MNCs	-0.099	0.024	-0.062	-0.005	0.032	-0.101
	[0.078]	[0.027]	[0.075]	[0.079]	[0.056]	[0.104]
Main customer is JVs	-0.020	-0.011	-0.099	0.072	-0.020	0.060
	[0.066]	[0.034]	[0.087]	[0.081]	[0.065]	[0.090]
Main supplier is MNCs	**0.102***	-0.009	0.015	0.101	0.012	0.091
	[0.051]	[0.031]	[0.062]	[0.070]	[0.052]	[0.079]
Main supplier is JVs	0.081	0.014	**0.216****	**0.128+**	**0.125****	0.034
	[0.049]	[0.027]	**[0.052]**	**[0.072]**	**[0.039]**	[0.090]
In-house design	0.053	0.006	-0.032	0.017	**-0.069+**	-0.071
	[0.058]	[0.027]	[0.056]	[0.066]	**[0.041]**	[0.073]
CAD, CAM, CAE	0.053	0.021	-0.056	0.088	0.005	0.041
	[0.053]	[0.028]	[0.057]	[0.065]	[0.045]	[0.070]
OEM	0.024	0.033	**0.143***	0.008	-0.013	0.059
	[0.046]	[0.025]	**[0.060]**	[0.065]	[0.046]	[0.066]
ODM	-0.054	0.040	0.050	-0.030	0.063	-0.077
	[0.053]	[0.026]	[0.057]	[0.064]	[0.046]	[0.086]
OBM	0.100*	0.041	0.068	0.098	0.034	0.078
	[0.051]	[0.027]	[0.058]	[0.063]	[0.048]	[0.073]
ISO9000, 14000, or other international standard	-0.032	-0.004	0.051	-0.068	0.009	0.016
	[0.049]	[0.024]	[0.056]	[0.062]	[0.048]	[0.071]
QM or QC circle	-0.010	-0.013	0.044	0.106	0.090	-0.018
	[0.056]	[0.024]	[0.073]	[0.083]	[0.066]	[0.082]
Adopted JIT	-0.068	0.020	-0.014	**0.135***	-0.024	0.081
	[0.050]	[0.026]	[0.056]	**[0.062]**	[0.045]	[0.074]
OJT	-0.003	0.004	-0.002	**-0.109+**	-0.030	-0.030
	[0.050]	[0.027]	[0.056]	**[0.062]**	[0.044]	[0.076]
OFFJT	-0.007	-0.003	0.086	0.069	0.077	0.061
	[0.049]	[0.026]	[0.052]	[0.059]	[0.048]	[0.073]
Size of domestic sales	0.002+	0.000	-0.001	0.001	0.000	0.001
	[0.001]	[0.000]	[0.001]	[0.001]	[0.001]	[0.001]
Years of product life cycle	-0.018+	-0.009+	-0.001	-0.009	-0.009	0.016
	[0.010]	[0.005]	[0.012]	[0.013]	[0.009]	[0.014]
Number of product types	0.002	0.001	0.006	0.007	0.017**	0.017*
	[0.005]	[0.003]	[0.006]	[0.007]	[0.005]	[0.007]
Top management have a master degree	-0.053	-0.004	0.004	0.077	0.017	-0.137+
	[0.050]	[0.024]	[0.057]	[0.059]	[0.045]	[0.074]
Top management was engineer	0.086	0.038	-0.012	0.080	-0.002	0.019
	[0.054]	[0.030]	[0.057]	[0.065]	[0.047]	[0.072]
Top management have an experience for	0.065	-0.033	-0.017	0.110+	0.080	0.046
	[0.049]	[0.024]	[0.054]	[0.058]	[0.049]	[0.072]
Ratio of high school graduates among	0.001	0.001+	0.000	0.000	0.001	0.000
	[0.001]	[0.000]	[0.001]	[0.001]	[0.001]	[0.001]
Ratio of technical college graduates among	0.000	0.000	0.000	-0.002*	0.000	-0.001
	[0.001]	[0.000]	[0.001]	[0.001]	[0.001]	[0.001]
Indonesia	0.099+	-0.002	0.064	-0.090	0.144**	-0.055
	[0.055]	[0.038]	[0.087]	[0.106]	[0.030]	[0.106]
Philippines	0.056	-0.034	0.070	-0.052	0.055	-0.203*
	[0.064]	[0.042]	[0.083]	[0.098]	[0.062]	[0.097]
Hanoi	0.041	0.035	0.038	-0.078	0.175**	0.189+
	[0.076]	[0.031]	[0.101]	[0.121]	[0.036]	[0.097]
Ho Chi Minh	0.470**	0.105**	0.080	0.061		
	[0.046]	[0.033]	[0.104]	[0.121]		
Observations	483	483	483	483	338	338

Notes: Other control variables are: age, size, local firms, joint venture, industry, and function dummies.
Robust standard errors in brackets.+ significant at 10%; * significant at 5%; ** significant at 1%
Reference country is Thailand.

Table 10 Robustness Checks; Process Innovations Impacts of Partner's Types and Own Capabilities

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variables: Process Innovations (Yes/No)	Improved Existing Machines	Bought New Machines	Introduced New-Know How on Production Methods	Change Quality Control	Change Production Control	Change Cost Control
R&D dummy (Yes/No)	0.021	**0.122****	**0.183****	0.010	**0.058+**	0.012
	[0.026]	**[0.047]**	**[0.048]**	[0.028]	**[0.035]**	[0.042]
Main customer is MNCs	-0.013	-0.022	-0.001	0.027	-0.025	-0.094
	[0.040]	[0.067]	[0.062]	[0.039]	[0.052]	[0.068]
Main customer is JVs	0.023	**0.131****	-0.073	-0.012	0.004	0.039
	[0.030]	**[0.050]**	[0.081]	[0.045]	[0.051]	[0.053]
Main supplier is MNCs	-0.006	0.019	0.037	-0.041	-0.075	0.017
	[0.033]	[0.057]	[0.050]	[0.046]	[0.053]	[0.055]
Main supplier is JVs	-0.021	0.003	0.109*	-0.038	0.026	0.002
	[0.047]	[0.066]	[0.047]	[0.050]	[0.047]	[0.055]
In-house design	0.037	0.036	-0.053	**-0.088****	-0.025	-0.061
	[0.033]	[0.054]	[0.043]	**[0.024]**	[0.036]	[0.042]
CAD, CAM, CAE	-0.002	0.013	0.052	0.044	-0.013	0.047
	[0.027]	[0.054]	[0.052]	[0.035]	[0.036]	[0.050]
OEM	**0.066+**	**0.095+**	0.080	0.052	0.059	0.002
	[0.034]	**[0.056]**	[0.051]	[0.033]	[0.038]	[0.043]
ODM	**-0.077***	0.016	-0.019	-0.045	-0.038	0.054
	[0.034]	[0.054]	[0.051]	[0.036]	[0.041]	[0.045]
OBM	**-0.051+**	-0.068	-0.059	-0.001	-0.043	-0.046
	[0.026]	[0.052]	[0.048]	[0.032]	[0.038]	[0.043]
ISO9000, 14000, or other international standard	0.038	0.015	0.074	-0.001	0.028	-0.060
	[0.031]	[0.050]	[0.049]	[0.032]	[0.039]	[0.041]
QM or QC circle	0.047	0.097	0.073	**0.115***	0.081	**0.113+**
	[0.039]	[0.071]	[0.066]	**[0.054]**	[0.058]	**[0.065]**
Adopted JIT	**0.055***	**-0.082+**	**0.093***	0.055	-0.007	-0.025
	[0.026]	**[0.049]**	**[0.047]**	[0.034]	[0.038]	[0.044]
OJT	0.001	**-0.143****	0.011	0.036	0.038	0.072
	[0.027]	**[0.049]**	[0.048]	[0.033]	[0.040]	[0.046]
OFFJT	-0.015	0.076	0.032	0.052	0.040	0.026
	[0.026]	[0.050]	[0.048]	[0.032]	[0.039]	[0.044]
Size of domestic sales	0.000	0.001	0.001	0.001	0.001	0.001
	[0.000]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Years of product life cycle	-0.007	-0.006	-0.007	-0.008	-0.009	-0.010
	[0.005]	[0.011]	[0.010]	[0.007]	[0.007]	[0.009]
Number of product types	0.000	0.009	0.006	-0.002	0.000	0.006
	[0.003]	[0.006]	[0.005]	[0.004]	[0.004]	[0.005]
Top management have a master degree	0.014	0.046	0.045	-0.001	0.043	0.031
	[0.021]	[0.048]	[0.043]	[0.032]	[0.033]	[0.042]
Top management was engineer	0.059+	-0.013	0.002	0.021	0.04	0.025
	[0.032]	[0.052]	[0.050]	[0.032]	[0.040]	[0.045]
Top management have an experience for MNC/JV	0.000	0.002	0.097*	-0.007	-0.002	-0.027
	[0.027]	[0.050]	[0.047]	[0.033]	[0.037]	[0.047]
Ratio of high school graduates among blue-collar workers	0.000	0.000	0.000	0.000	0.000	0.000
	[0.000]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Ratio of technical college graduates among engineers	0	0	-0.001	0	0	0.001
	[0.000]	[0.001]	[0.001]	[0.000]	[0.001]	[0.001]
Indonesia	0.027	-0.003	-0.074	0.071*	0.068+	0.110*
	[0.029]	[0.088]	[0.096]	[0.028]	[0.041]	[0.046]
Philippines	0.015	0.077	0.089	-0.064	0.023	0.04
	[0.034]	[0.072]	[0.064]	[0.056]	[0.050]	[0.060]
Hanoi	0.076**	0.037	0.085	-0.048	0.003	-0.025
	[0.020]	[0.089]	[0.066]	[0.076]	[0.065]	[0.084]
Ho Chi Minh	0.126**	0.065	0.255**	0.121**	0.206**	0.231**
	[0.030]	[0.090]	[0.056]	[0.041]	[0.045]	[0.054]
Observations	467	483	483	473	473	483

Notes: Other control variables are: age, size, local firms, joint venture, industry, and function dummies.
Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.
Reference country is Thailand.

Table 11 Robustness Checks; Sales, Procurement, and Management Practices Innovation Impacts of Partner's Types and Own Capabilities

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent variables: Upgrading in Sales, Procurement, and Management Practices (Yes/No)	Change Marketing	Change Inventory Control	Change Domestic Procurement	Change International Procurement	Change Domestic Delivery	Change International Delivery	Change Accounting System	Change HRMP	Change Environment Management	Adopt New ISO
R&D dummy (Yes/No)	-0.046	0.004	0.048	0.064	0.037	**0.151****	**0.152****	**0.129****	0.036	0.002
	[0.039]	[0.039]	[0.050]	[0.060]	[0.050]	**[0.052]**	**[0.056]**	**[0.044]**	[0.052]	[0.062]
Main customer is MNCs	**-0.150***	-0.11	-0.019	-0.074	**-0.179***	-0.033	**-0.204***	-0.002	0.055	0.016
	[0.073]	[0.070]	[0.071]	[0.087]	**[0.080]**	[0.072]	**[0.083]**	[0.059]	[0.067]	[0.082]
Main customer is JVs	-0.051	-0.017	-0.046	0.011	**-0.140+**	-0.022	-0.023	0.055	**0.139***	-0.048
	[0.065]	[0.062]	[0.075]	[0.084]	**[0.078]**	[0.081]	[0.081]	[0.055]	**[0.068]**	[0.092]
Main supplier is MNCs	**0.076+**	-0.005	-0.092	0.096	0.075	**0.217****	0.072	-0.075	0.067	**0.275****
	[0.044]	[0.052]	[0.070]	[0.081]	[0.056]	**[0.070]**	[0.070]	[0.063]	[0.064]	**[0.064]**
Main supplier is JVs	0.069	0.06	0.039	0.087	**0.105***	0.131	0.104	-0.011	-0.002	0.077
	[0.044]	[0.047]	[0.066]	[0.076]	**[0.052]**	[0.082]	[0.075]	[0.063]	[0.075]	[0.080]
In-house design	-0.035	-0.003	-0.031	0.012	-0.015	-0.089	**0.123+**	-0.014	-0.046	**-0.255****
	[0.040]	[0.044]	[0.056]	[0.071]	[0.054]	[0.062]	**[0.064]**	[0.049]	[0.057]	**[0.060]**
CAD, CAM, CAE	0.031	-0.002	0.041	-0.034	-0.066	0.046	-0.045	0.015	-0.044	0.04
	[0.042]	[0.044]	[0.055]	[0.065]	[0.049]	[0.061]	[0.068]	[0.051]	[0.062]	[0.073]
OEM	0.019	0.039	0.028	0.062	0.06	**0.143***	0.015	0.069	-0.059	0.084
	[0.040]	[0.044]	[0.054]	[0.065]	[0.052]	**[0.061]**	[0.068]	[0.049]	[0.064]	[0.072]
ODM	0.013	-0.038	0.042	-0.05	0.021	0.073	0.072	-0.009	0.062	0.015
	[0.045]	[0.046]	[0.059]	[0.069]	[0.055]	[0.062]	[0.064]	[0.050]	[0.057]	[0.070]
OBM	0.006	0.043	-0.065	0.049	-0.018	**-0.105+**	**-0.111+**	-0.032	0.023	-0.015
	[0.044]	[0.043]	[0.053]	[0.067]	[0.052]	**[0.063]**	**[0.066]**	[0.046]	[0.061]	[0.068]
ISO9000, 14000, or other international standard	0.029	0.047	0.023	0.014	0.055	0.001	0.007	0.054	0.073	**0.493****
	[0.044]	[0.044]	[0.055]	[0.060]	[0.052]	[0.060]	[0.063]	[0.050]	[0.060]	**[0.058]**
QM or QC circle	-0.03	0.052	0.017	**0.139+**	0.114	0.11	0.101	0.057	0.076	-0.027
	[0.046]	[0.060]	[0.067]	**[0.084]**	[0.070]	[0.073]	[0.082]	[0.065]	[0.080]	[0.086]
Adopted JIT	0.026	0.02	0.065	-0.012	**0.102+**	0.011	0.043	-0.028	0.08	**0.120+**
	[0.043]	[0.043]	[0.054]	[0.064]	**[0.054]**	[0.059]	[0.060]	[0.047]	[0.056]	**[0.064]**
OJT	0.016	-0.047	-0.025	0.044	0.018	-0.026	0.075	-0.011	0.008	0.1
	[0.043]	[0.044]	[0.054]	[0.067]	[0.053]	[0.063]	[0.063]	[0.048]	[0.059]	[0.074]
OFFJT	0.065	0.05	0.071	-0.011	0.055	**0.104+**	**0.127***	**0.116***	0.063	**0.110+**
	[0.042]	[0.044]	[0.051]	[0.062]	[0.050]	**[0.058]**	**[0.062]**	**[0.046]**	[0.055]	**[0.063]**
Size of domestic sales	0	0	0.001	0	0.003**	0	0	0.001	0.002+	-0.001
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Years of product life cycle	-0.016*	0.002	-0.016	-0.024+	-0.012	-0.011	-0.023+	-0.018+	-0.033**	-0.039*
	[0.008]	[0.009]	[0.011]	[0.013]	[0.010]	[0.013]	[0.013]	[0.010]	[0.013]	[0.015]
Number of product types	0.007	0.001	0	0.003	-0.002	-0.009	0.003	0.004	0.003	0.002
	[0.004]	[0.005]	[0.006]	[0.007]	[0.005]	[0.007]	[0.007]	[0.005]	[0.007]	[0.007]
Top management have a master degree	0.069*	0.001	-0.003	0.153*	-0.003	0.032	0.043	0.031	-0.022	0.099
	[0.034]	[0.042]	[0.054]	[0.061]	[0.050]	[0.057]	[0.060]	[0.045]	[0.057]	[0.062]
Top management was engineer	-0.009	0.043	-0.025	-0.025	0.03	0.091	-0.053	-0.011	0.088	0.089
	[0.040]	[0.045]	[0.052]	[0.066]	[0.052]	[0.058]	[0.064]	[0.046]	[0.060]	[0.069]
Top management have an experience for MNC/JV	0.065	0.056	0.008	0.035	-0.013	-0.07	-0.048	-0.001	0.081	0.08
	[0.040]	[0.042]	[0.055]	[0.062]	[0.053]	[0.057]	[0.060]	[0.047]	[0.055]	[0.061]
Ratio of high school graduates among blue-collar workers	-0.001	-0.001	-0.002*	-0.001	-0.001	-0.001	0	0	0.001	-0.001
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Ratio of technical college graduates among engineers	0.001	0	0	0.001	-0.001	-0.001	0	0	0	0.002+
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Indonesia	0.055	-0.094	0.005	-0.021	-0.01	-0.069	0.193*	0.110*	0.017	0.172+
	[0.055]	[0.090]	[0.087]	[0.105]	[0.084]	[0.098]	[0.096]	[0.050]	[0.100]	[0.091]
Philippines	-0.003	-0.042	-0.057	0.052	-0.188*	-0.011	0.027	0.088	0.007	0.004
	[0.057]	[0.068]	[0.085]	[0.096]	[0.088]	[0.094]	[0.098]	[0.058]	[0.090]	[0.096]
Hanoi	0.141**	-0.187+	0.035	0.208*	0.065	0.142	0.242*	0.08	0.063	0.217*
	[0.036]	[0.111]	[0.096]	[0.094]	[0.083]	[0.119]	[0.096]	[0.070]	[0.109]	[0.100]
Ho Chi Minh	0.274**	0.215**	0.331**	0.511**	0.291**	-0.017	-0.134	0.267**	-0.012	0.021
	[0.045]	[0.055]	[0.067]	[0.072]	[0.061]	[0.113]	[0.122]	[0.057]	[0.118]	[0.131]
Observations	483	483	483	483	483	483	483	483	483	483

Notes: Other control variables are: age, size, local firms, joint venture, industry, and function dummies.
Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.
Reference country is Thailand.

Table 12 Robustness Checks; Total Quality of Management and Production Process Innovation Impacts of Partner's Types and Own Capabilities

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent variables: Upgrading Total Quality of Management and Production Process (Yes/No)	Decrease in Defection	Decrease in Inventories	Decrease in Materials	Reduce Labor Inputs	Improve Quality	Reduce Lead-time	Increase in Domestic Market	Increase in Abroad Market	Reduce Pollution	Meet Regulation
R&D dummy (Yes/No)	-0.011	0.015	0.059	0.057	0.038	**0.111+**	**0.132***	**0.164****	0.083	**0.084****
	[0.046]	[0.054]	[0.056]	[0.050]	[0.031]	**[0.058]**	**[0.055]**	**[0.051]**	[0.055]	**[0.031]**
Main customer is MNCs	-0.035	**0.140***	0.084	-0.107	0.025	**-0.151+**	**-0.268****	-0.013	-0.1	-0.047
	[0.067]	**[0.071]**	[0.079]	[0.066]	[0.037]	**[0.079]**	**[0.084]**	[0.072]	[0.078]	[0.057]
Main customer is JVs	-0.002	0.036	-0.052	**-0.150***	-0.037	-0.051	**-0.186***	0.055	**-0.176+**	-0.037
	[0.071]	[0.078]	[0.084]	**[0.060]**	[0.053]	[0.086]	**[0.091]**	[0.082]	**[0.091]**	[0.048]
Main supplier is MNCs	-0.055	-0.096	0.054	-0.024	-0.089+	-0.056	**0.121+**	0.053	0.04	-0.037
	[0.062]	[0.075]	[0.072]	[0.065]	[0.049]	[0.073]	**[0.065]**	[0.071]	[0.068]	[0.045]
Main supplier is JVs	-0.025	**0.127+**	0.124	0.055	-0.077	-0.05	0.094	-0.024	0.065	**-0.107+**
	[0.071]	**[0.072]**	[0.077]	[0.080]	[0.056]	[0.083]	[0.068]	[0.077]	[0.079]	**[0.058]**
In-house design	0.002	-0.026	**-0.160****	0.01	-0.017	**-0.179****	0.056	0.014	**-0.184****	-0.018
	[0.051]	[0.060]	**[0.060]**	[0.055]	[0.034]	**[0.063]**	[0.065]	[0.062]	**[0.055]**	[0.031]
CAD, CAM, CAE	0.005	-0.062	-0.015	0.007	0.108*	0.064	0.022	-0.002	-0.016	0.024
	[0.055]	[0.062]	[0.067]	[0.058]	[0.044]	[0.068]	[0.062]	[0.062]	[0.064]	[0.036]
OEM	-0.064	-0.089	-0.024	0.063	-0.029	0.041	0.078	0.053	0.047	-0.021
	[0.053]	[0.062]	[0.066]	[0.056]	[0.036]	[0.070]	[0.061]	[0.065]	[0.066]	[0.031]
ODM	0.035	0.03	0.015	-0.026	0.053	0.048	0.003	-0.04	**0.136***	0.031
	[0.051]	[0.063]	[0.063]	[0.061]	[0.034]	[0.066]	[0.065]	[0.062]	**[0.060]**	[0.030]
OBM	-0.065	-0.092	-0.012	-0.031	0.014	-0.007	-0.01	0.047	-0.07	**-0.049+**
	[0.053]	[0.060]	[0.064]	[0.058]	[0.036]	[0.067]	[0.062]	[0.061]	[0.065]	**[0.029]**
ISO9000, 14000, or other international standard	**0.105+**	0.039	0.005	-0.098+	-0.019	0.002	-0.011	0.027	0.068	0.028
	[0.055]	[0.059]	[0.062]	[0.059]	[0.034]	[0.063]	[0.060]	[0.060]	[0.061]	[0.033]
QM or QC circle	0.05	-0.05	0.024	0.109+	0.06	0.019	-0.057	-0.01	0.160+	0.088
	[0.074]	[0.073]	[0.083]	[0.060]	[0.056]	[0.081]	[0.071]	[0.081]	[0.086]	[0.061]
Adopted JIT	0.06	**0.171****	**0.135***	0.038	0.052	0.067	0.02	0.007	**0.097+**	0.104**
	[0.052]	**[0.060]**	**[0.060]**	[0.053]	[0.034]	[0.061]	[0.061]	[0.060]	**[0.057]**	[0.033]
OJT	0.017	0.055	**0.137***	0.025	-0.029	0.038	**0.125***	0.021	**0.155****	0.038
	[0.051]	[0.061]	**[0.063]**	[0.056]	[0.034]	[0.065]	**[0.060]**	[0.062]	**[0.060]**	[0.034]
OFFJT	-0.011	-0.046	0.034	-0.035	**0.060+**	0.041	0.037	0.023	0.053	-0.032
	[0.051]	[0.061]	[0.061]	[0.056]	**[0.034]**	[0.062]	[0.059]	[0.058]	[0.060]	[0.032]
Size of domestic sales	-0.001	-0.001	-0.001	-0.001	-0.001	-0.002*	0.001	-0.002*	0	-0.001*
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Years of product life cycle	-0.018	-0.007	-0.001	0.01	0.004	0.004	-0.023+	-0.040**	-0.007	-0.007
	[0.011]	[0.013]	[0.014]	[0.011]	[0.007]	[0.013]	[0.013]	[0.013]	[0.013]	[0.007]
Number of product types	0.001	0.005	-0.004	-0.005	-0.005	0.018*	0.006	0.007	-0.001	0
	[0.005]	[0.006]	[0.007]	[0.006]	[0.004]	[0.007]	[0.007]	[0.007]	[0.007]	[0.003]
Top management have a master degree	0.078+	0.058	0.003	0.087	0.076*	0.072	-0.034	-0.02	0.055	0.027
	[0.045]	[0.059]	[0.059]	[0.057]	[0.029]	[0.060]	[0.060]	[0.058]	[0.057]	[0.031]
Top management was engineer	0.027	0.082	0.176**	0.062	0.045	0.149*	-0.035	0.088	0.072	0.032
	[0.053]	[0.062]	[0.062]	[0.055]	[0.038]	[0.063]	[0.060]	[0.059]	[0.061]	[0.034]
Top management have an experience for MNC/JV	-0.052	0.028	-0.075	0.057	-0.031	0.027	0.125*	0.043	0.058	0.049
	[0.050]	[0.059]	[0.060]	[0.054]	[0.034]	[0.061]	[0.058]	[0.057]	[0.059]	[0.031]
Ratio of high school graduates among blue-collar workers	0.001	-0.002*	-0.002	0	0.002**	0	0.001	-0.001	0	0
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.000]
Ratio of technical college graduates among engineers	0	0.002+	0.002*	0	0	0.001	-0.001	0.001	0	0.001
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.000]
Indonesia	0.192**	-0.063	-0.062	0.063	0.081**	0.485**	0.286**	0.121	0.185*	0.066*
	[0.045]	[0.103]	[0.109]	[0.098]	[0.030]	[0.049]	[0.052]	[0.112]	[0.083]	[0.026]
Philippines	0.215**	0.073	0.074	0.238**	0.073+	0.483**	0.204*	0.172+	0.373**	0.064+
	[0.059]	[0.089]	[0.096]	[0.089]	[0.044]	[0.075]	[0.081]	[0.103]	[0.070]	[0.037]
Hanoi	0.234**	0.116	0.13	-0.048	0.047	0.301**	0.235**	0.068	0.210*	-0.014
	[0.044]	[0.098]	[0.112]	[0.098]	[0.045]	[0.100]	[0.073]	[0.125]	[0.089]	[0.060]
Ho Chi Minh	0.242**	0.506**	-0.024	-0.264**	0.028	0.338**	0.525**	0.247*	0.138	0.152**
	[0.067]	[0.062]	[0.121]	[0.081]	[0.059]	[0.111]	[0.058]	[0.123]	[0.109]	[0.039]
Observations	483	473	483	483	483	483	483	483	483	483

Notes: Other control variables are: age, size, local firms, joint venture, industry, and function dummies.
Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.
Reference country is Thailand.

5. THE DETERMINANTS OF THE FORM OF MUTUAL KNOWLEDGE EXCHANGES

5.1. The Impacts of Transferred Technologies from Partners

Table 13 suggests the concrete evidence of the technology transfer impacts of the determinants of mutual exchanges of engineers. As shown in column 1 to 5 of Table 13, the coefficient of R&D dummy variables play an important role of determinants of mutual knowledge flows with firm's main customer or main supplier. Findings revealed five main results to determine mutual knowledge exchanges in the margin of transferred technologies. First, result is related to the impact of quality controls especially when applied into own firm's characteristics rather than to the supplier's characteristics. Second, result is on the impact of cost controls. Third, result shows that delivery management system also determines the mutual exchanges of engineers. The coefficient for dummy variable that supplier provides delivery controls has significantly positive impacts on mutual exchanges in engineers with supplier. On the other hand, the coefficient for dummy variable that firm provides delivery controls to their main customer has significantly positive impact on mutual exchanges in engineers with customer. Fourth, licensing from supplier also determines the mutual exchanges of engineers. The coefficient for dummy variable that supplier grants licenses for mutual exchanges of engineers could be .250 with standard error of .079. Finally, ISO determines mutual exchanges of knowledge. The coefficient for dummy variable that customer requires ISO is .125 with standard error of .066.

In summary, if customer provides cost and delivery controls as well as providing licenses to customer, the propensity of mutual exchanges of engineers with customer increases. It is emphasized that if customer requires ISO, then the propensity of mutual exchanges of engineers with customer increases. If supplier provides quality, cost, delivery controls as well as licenses, then the propensity of mutual exchanges of engineers with supplier also increases.

5.2. The Impacts of Spacing

Table 13 also suggests that the JIT (Just-in-Time hereafter) does not have significant impact as one determinant of mutual exchanges of engineers. However, the coefficients of JIT with supplier are negative for the mutual exchanges of engineers in all specifications; standard errors are large. That is, JIT with supplier does not have significant impact on the two-way flow of engineers. Distances with customers also do not determine the mutual exchanges of engineers. Firms and their customers do not care about distance between them in terms of mutual exchanges of engineers. On the other hand, however the coefficient of distance with supplier is smaller than other explanatory variables like R&D and transferred technologies. It is significantly positive at the 1 percent level.

Table 13 The Determinants of Mutual Exchanges of Engineers

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variables: Customer (Supplier) dispatch engineers*Dispatch engineers to customer (supplier)	Partner is Customer			Partner is Supplier		
R&D dummy (Yes/No)	**0.147****	**0.131****	**0.130***	**0.112****	**0.102****	0.087
	[0.036]	**[0.038]**	**[0.063]**	**[0.036]**	**[0.039]**	[0.058]
Partner Provides Quality Controls	**0.161****	**0.160****	0.092	**0.206****	**0.233****	**0.306****
	[0.048]	**[0.050]**	[0.076]	**[0.052]**	**[0.055]**	**[0.080]**
Provide Quality Controls to Partner	**0.099***	**0.099***	0.071	0.025	0.007	-0.039
	[0.044]	**[0.047]**	[0.078]	[0.048]	[0.051]	[0.072]
Partner Provides Cost Controls	**0.164***	0.132	**0.189+**	**0.212****	**0.233****	**0.320****
	[0.080]	[0.083]	**[0.112]**	**[0.081]**	**[0.084]**	**[0.113]**
Provide Cost Controls to Partner	-0.056	-0.055	**-0.255***	-0.025	-0.077	-0.162
	[0.094]	[0.103]	**[0.110]**	[0.081]	[0.083]	[0.103]
Partner Provides Delivery Controls	-0.027	-0.023	-0.027	**0.128***	**0.150***	**0.247****
	[0.063]	[0.067]	[0.108]	**[0.063]**	**[0.067]**	**[0.091]**
Provide Delivery Controls to Partner	**0.161***	**0.177***	**0.189+**	0.040	0.030	0.121
	[0.065]	**[0.071]**	**[0.101]**	[0.066]	[0.070]	[0.104]
Partner Grants Licenses	**0.213****	**0.209****	0.051	**0.313****	**0.324****	**0.250****
	[0.053]	**[0.056]**	[0.085]	**[0.055]**	**[0.055]**	**[0.079]**
Provide Licenses to Partner	0.070	0.065	**0.162+**	-0.034	-0.041	0.038
	[0.050]	[0.052]	**[0.090]**	[0.054]	[0.056]	[0.086]
Partner Requires ISO	**0.116****	**0.104***	**0.125+**	**0.199****	**0.226****	0.099
	[0.043]	**[0.045]**	**[0.066]**	**[0.057]**	**[0.061]**	[0.083]
Require ISO to Partner	**0.093+**	0.054	-0.013	-0.028	-0.048	-0.084
	[0.049]	[0.052]	[0.080]	[0.049]	[0.052]	[0.071]
JIT with Partner	0.026	0.014	0.058	-0.027	-0.033	-0.049
	[0.043]	[0.047]	[0.071]	[0.038]	[0.041]	[0.060]
Distance to Partner		0.000	0.000		0.000	-0.000**
		[0.000]	[0.000]		[0.000]	[0.000]
Partner belongs to same industry		0.044	0.048		-0.012	0.047
		[0.043]	[0.066]		[0.039]	[0.058]
Partner is local		-0.083	-0.012		-0.057	-0.190*
		[0.057]	[0.095]		[0.052]	[0.077]
Partner is joint venture		0.052	0.060		0.001	-0.115
		[0.065]	[0.098]		[0.059]	[0.080]
Capital tie-up with partner		0.044	0.049		-0.081+	-0.138*
		[0.044]	[0.064]		[0.046]	[0.067]
Years of duration with partner		0.008	0.012		-0.003	0.005
		[0.006]	[0.010]		[0.006]	[0.009]
Indonesia	-0.086	-0.111+	-0.129	-0.131*	-0.179**	-0.108
	[0.055]	[0.062]	[0.126]	[0.052]	[0.056]	[0.112]
Philippines	0.082	0.028	-0.023	0.087	0.020	0.065
	[0.058]	[0.066]	[0.110]	[0.055]	[0.061]	[0.109]
Hanoi	0.185**	0.208**	0.201	0.205**	0.154*	0.004
	[0.067]	[0.078]	[0.138]	[0.067]	[0.076]	[0.132]
Ho Chi Minh	0.631**	0.587**	0.470**	0.422**	0.399**	0.198
	[0.047]	[0.059]	[0.106]	[0.070]	[0.079]	[0.132]
Partner's control		ü	ü		ü	ü
Firm's control			ü			ü
Observations	864	813	470	864	794	468

Notes: Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.
Reference country is Thailand.

6. CONCLUSION

This paper presents evidence that mutual knowledge exchanges through engineers is an important connection with the diffusion of knowledge regarding product and process innovation in manufacturing sector in developing economies. This paper takes advantage of data that combines information of product creation and quality upgrading with relationships between connected firms (i.e., upstream and downstream firms) on the impacts of tacit knowledge exchanges in an economy of dense production network. Findings showed that manufacturing firms are more likely to achieve product innovations upon the exchange of engineers mutually with their main specific customer, especially in terms of development of new product based on new technologies and new product to new market. Using new technologies and creating new market need close collaboration with main existing customer. Findings showed that such connected firms are less likely to achieve improvement of existing machines and development of new product to existing technologies upon the exchanging engineers mutually with their main supplier. Mutual knowledge exchanges with supplier do not seem to fit existing machines and technologies. One concern is that the type of partner simply affects the product and process innovations of own manufacturing firms.

The results of product innovations are also supported by robustness check. Main customer or supplier types do not affect product innovations. Technology transfer needs face-to-face and two-way flow of knowledge, especially in quality controls, cost controls, delivery controls, licensing, and adoption of ISO. Further evidence of product and process innovations is that manager’s experience with foreign firms (including Joint venture firms) is an important technology of innovations. Experience of foreign firms plays a key role on new knowledge to local firms. This evidence provides policy implication on diversity training.

REFERENCES

Berliant, M., and M. Fujita (2008) "Knowledge Creation as a Square Dance on the Hilbert Cube," *International Economic Review*, 49 (4): 1251-1268.

Berliant, M., and M. Fujita (2009) "Dynamics of Knowledge Creation and Transfer: The Two Person Case," *International Journal of Economic Theory*, 5: 155-179.

Blalock, G. and P.J. Gertler (2008) "Welfare Gains from Foreign Direct Investment through Technology Transfer to Local Suppliers," *Journal of International Economics*, 74: 402-421.

Bloom, N., B. Eifert, A. Mahajan, D. McKenzie and J. Roberts (2010) "Management Matters: Evidence from India," mimeo.

Bloom, N. and J. van Reenen (2007) "Measuring and Explaining Management Practices across Firms and Countries," *Quarterly Journal of Economics*, 122(4): 1351-1408.

Bloom, N. and J. van Reenen (Forthcoming) "Why do Management Practices Differ across Firms and Countries?," *Journal of Economic Perspectives*.

___________ (Forthcoming) "New Approaches to Measuring Management and Firm Organization," *American Economic Review Papers and Proceedings*.

Conley, T. and C. Udry (2010) "Learning About a New Technology: Pineapple in Ghana," *American Economic Review*, 100(1): 35-69.

Easley, D. and J. Kleinberg (Forthcoming) *Networks, Crowds, and Markets: Reasoning about a Highly Connected World*, Cambridge University Press.

Fujita, M. (2007) "Towards the New Economic Geography in the Brain Power Society," *Regional Science and Urban Economics*, 37: 482-490.

Goyal, S. (2007) *Connections: An Introduction to the Economics of Networks*, Princeton University Press.

Hsieh, C., and P. Klenow (2009) "Misallocation and Manufacturing TFP in China and

India," *Quarterly Journal of Economics*, 124(4): 1403–48.

Hortacsu, A. and C. Syverson (2009) "Why do Firms Own Production Chains?," mimeo.

Jackson, M. (2008) *Social and Economic Networks*, Princeton University Press.

Javorcik, B. (2004) "Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages," *American Economic Review,* 94: 605-627.

Jones, B.F., S. Wuchty and B. Uzzi (2007) "Multi-University Research Teams: Shifting Impact, Geography, and Stratification in Science," *Science*, 322(21): 1259-62.

Keller, W. (2004) "International Technology Diffusion," *Journal of Economic Literature* 42(3): 752-782.

Kerr, W.R. (2008) "Ethnic Scientific Communities and International Technology Diffusion," *The Review of Economics and Statistics* 90(3): 518-537.

Kerr, W.R. (2010) "Breakthrough Inventions and Migrating Clusters of Innovation," *Journal of Urban Economics* 67(1): 46-60.

Kerr, W.R. and W.F. Lincoln (Forthcoming) "The Supply Side of Innovation: H-1B Visa Reforms and U.S. Ethnic Invention," *Journal of Labor Economics*.

Machikita, T. and Y. Ueki (2010) "The Impact of Face-to-face and Frequent Communications on Innovation: Evidence from Upstream-downstream Relations," mimeo.

Polanyi, M. (1966) "The Logic of Tacit Inference," *Philosophy*, 41(155): 1-18.

Polanyi, M. (1967) *The Tacit Dimension*, University of Chicago Press.

Rosenblat, T. and M. Mobius (2004) "Getting Closer or Drifting Apart," *Quarterly Journal of Economics*, 119(3): 971-1009.

Syverson, C. (2009) “What Determines Productivity at the Micro Level?,” mimeo, University of Chicago.

Wuchty, S., B.F. Jones and B. Uzzi (2007) “The Increasing Dominance of Teams in Production of Knowledge,” *Science*, 316: 1036-1039.