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Technological Effort in Developing Countries: Multinational Corporations in Malaysia

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ABSTRAK

Kertas ini bertujuan untuk melihat faktor-faktor yang berkemungkinan mempengaruhi usaha MNC bagi melaksanakan kegiatan berkaitan dengan perkembangan teknologi di negara-negara membangun. Faktor seperti pengubah suaian terhadap proses pengeluaran dan bantuan yang diberikan kepada firma-firma tempatan menunjukkan wujudnya kemungkinan aktiviti berkenaan. Terdapat bukti menunjukkan bahawa MNC berorientasi eksport yang beroperasi di negara-negara membangun melaksanakan kegiatan berkaitan dengan perkembangan teknologi di negara-negara tuan rumah demi keberkesanan penyertaan mereka dalam pasaran dunia.

ABSTRACT

This paper examines the factors that influence the likelihood of MNCs undertaking technological effort in developing countries, using a data set obtained from a survey. Factors such as modification to the main production line by MNCs and assistance they rendered to local firms were found significant in indicating the likelihood of technological activities. The paper also provides evidence that export-oriented MNCs in developing host countries do undertake technological effort for effective participation in the world market.

INTRODUCTION

Technology is essential for the development and growth of firms. In many cases, the creation of multinational corporations (MNCs) centres on technological capability. Their continued existence is also linked to their ability to maximise their technological advantage. Technology is increasingly becoming the key element in international trade competitiveness. To parti-

cipate effectively in the global market, firms have to maintain their competitiveness through undertaking technological effort.

Despite the importance of R&D, it would be erroneous to identify technological effort as R&D alone. For example, the stages that firm undergo in mastering their equipment also require technological effort. Similarly, any technical changes introduced to the equipment are indicative of firm's technological effort. Technological effort is not merely confined to equipment and machinery but also involves human resources. As such, training undertaken by firms is crucial for their technological development. It seems that in order for firms to develop and grow, they must undertake some form of technological effort. However, despite its essential nature, not all firms undertake technological effort and those that do, undertake it at varying degrees. Various factors contribute to a firm's decision to undertake such activities. Thus, the objective of this paper is to examine the factors that influence the likelihood of foreign firms undertaking technological activities in developing countries.

Section 2, introduces a brief background to the study. Section 3 discusses the technological effort of MNCs' affiliates in developing countries. Section 4 provides a description of the survey and the hypothesis. Sections 5 and 6 discuss the empirical models and the findings respectively. Finally, Section 7 provides a conclusion.

BACKGROUND: FDI IN MALAYSIA

Foreign direct investment has always been a major factor in developing Malaysia's industrial sector. Manufactured goods, mainly products from the electronics and electrical (E&E) industries make up the nation's largest body of exports. However, most manufactured exports were produced by foreign firms. For example, the electronics industry which contributes more than half the exports of manufactured goods comprised mostly foreign-owned multinationals.

One argument for promoting the presence of MNCs in Malaysia is to provide domestic firms with access to advanced technologies through subcontracting, the creation of spin-off firms, OEM and training activities. There are also examples of MNCs undertaking technologically related activities. US-based MNCs, for example, have adopted a globalise strategy in their R&D activities – preferring to capitalise on the advantages and strengths of its world affiliates and their locations. For example, Intel has chosen Malaysia as the location for its design centre for microprocessor

for hand held equipment (UNCTAD 1995). It has globalise its R&D activities to such an extent that engineers from its Malaysian affiliate have been required to assist in the establishment of one of Intel's highly-automated plants in the US. Motorola has also established an R&D centre in Malaysia and has designated it as a corporate design centre for cordless telephone for Motorola worldwide (Hobday 1996). Komag USA (M), the world's largest producer of thin-film disks, has its own R&D centre which is involved in the introduction of new products and process development activities. Advanced process development activities are undertaken at its Malaysian affiliates enabling Komag to respond faster to the needs of its customers (drive disk assembly plants), which are located in the region. Matsushita also has an R&D centre for air-conditioners in Malaysia. Malaysia is, in fact, one of the world's largest producers of air-conditioners (Sim & Othman 1995). It has been argued that with such rapid advances in manufacturing technology, MNCs operating in Malaysia can no longer be described as merely "screwdriver plants". However, the examples mentioned are the exceptions rather than norms in the industry.

TECHNOLOGICAL EFFORT OF MNCS' AFFILIATES

This section focuses on the factors that influence MNCs to undertake technological effort or technological activities in developing countries. The following subsections discuss the factors and characteristics that explain the likelihood of MNC affiliates undertaking technological effort namely, adaptation, technology acquisition, firm characteristics, technological characteristics, and linkages.

THE NEED FOR ADAPTATION

Technology is often designed for the place of origin, and once transferred to another location, adaptation may be necessary to suit the local environment and maximise the benefits from locally sourced inputs (Dunning 1995). The extent of adaptation undertaken by MNCs, therefore will depend on the nature of affiliates' operations. It is argued that MNCs are likely to undertake technological activities if they operate in a large host country market (Odagiri & Yusada 1996). The activities usually take the form of R&D, supporting manufacturing activities of local affiliates. Other activities will include the necessary adaptation of the product if the MNCs are to maintain or increase their local market share. Thus, MNCs with promi-

nent presence in the local market could indicate a greater likelihood of undertaking technological effort.

In the early development of the production of semiconductors, MNCs operations were designed to exploit the abundance of low cost labour in host countries. However, with the rapid advancement of technologies and increasingly globalise operations, export oriented subsidiaries as observed by Papanastassiou and Pearce (1994), underwent a widening of their functions.

Adaptation also occurs to allow firms to meet local content requirements. Here it is envisaged that MNCs' subsidiaries may undertake some form of technological measure to cater for necessary modifications to the production operation. Assuming the technological level of many host countries is low, such technological activities by MNCs are then likely to make an important contribution. Adaptation by MNCs, could also be identified through changes in plant design and production method of subsidiaries.

FIRM LEVEL DETERMINATS OF TECHNOLOGICAL EFFORT

This sub-section discusses selected firm characteristics that influence their likelihood of MNCs undertaking technological effort. The characteristics that will be analysed in the following sub-sections are size of firms, export-orientedness and ownership structure.

SIZE OF FIRMS

The argument as to whether size of firm influences technological activity has attracted a lot of attention. It is argued that large firms are better able to conduct technological activities compared to small firm. Various studies have either confirmed or questioned this hypothesis. The relationship between firm size and R&D, however, is still ambiguous. Cohen and Klepper (1996) in their study reported that larger firms undertake higher levels of technological activity. Katrak (1991) in his study of technological effort among Indian firms found size of firm was significant in explaining technological effort. Similarly, Kumar and Saqib (1996) and Braga and Willmore (1991) found a positive relationship between firm size and technological activities in their studies on Indian and Brazilian firms respectively. A study on R&D conducted by Spanish firms also found that larger sized firms were more able to undertake technological effort (Sanchez 1994). Technological activities among smaller firms, however, increased as technology became more easily available and cheaper.

EXPORT ORIENTATION

With increasing globalisation, export-oriented subsidiaries no longer act simply as assembly plants for MNCs. As noted earlier, depending on their roles vis-à-vis parent firm strategies, there is evidence that export-oriented subsidiaries do undertake technological activities (Papanastassiou & Pearce 1994).

Several studies have reported a positive relationship between export-orientation (measured by the percentage of exports to total production) and the likelihood of undertaking technological activities. For example, Braga and Willmore (1991) in their study on the Brazilian manufacturing activities, reported that the relationship between the ratio of export to sales and technological effort (R&D) was positive and significant. Similar findings were also reported by Kumar and Siddharthan (1994) for the Indian industry.

The importance of export-orientation was also captured by Aw and Hwang (1995) in their study of the productivity of electronic firms in Taiwan. They reported significant productivity differences between groups of exporter firms and non-exporter firms. Papanastasiou and Pearce (1992) and Zejan (1990) in their studies of R&D undertaken by US and Swedish MNCs respectively, found that firms that had a higher export ratio were more likely to undertake R&D. However, Athukorala (1995) commented that in the case of the electronics industry in Sri Lanka, foreign firms undertook little technological activity since most activity was limited to manual work. It is interesting to note that, to a certain extent, the Malaysian electrical and electronics industry is similar to the electronics industry in Sri Lanka (in particular, both are geared for export). Nevertheless, the Malaysian electrical and electronics industry is more developed than its Sri Lankan counterpart with many affiliates having been upgraded from assemblers to manufacturers (Hobday 1996). Whether export-orientedness has an influence in determining the likelihood of affiliates in undertaking technological activities will be tested in this study.

FOREIGN OWNERSHIP

The structure of firm ownership is influenced by many factors. Among the factors discussed in the literature are; trade-offs related to the level of resource commitment, risk and returns (Stopford & Wells 1972), the degree of control (Caves 1982), and bargaining power of the host government (Lecraw 1984).

MNCs preferred full control over their technological activities rather than sharing with others (Stopford & Wells 1972). This claim was further confirmed by Braga and Wilmore (1991) and Haddad and Harrison (1993) in their studies relating to Brazil and Morocco respectively. These studies found evidence linking higher foreign equity and firms' willingness to undertake technologically related activities.

As for firms in higher or advanced levels of technology, such as R&D intensive firms, it would be assumed they would prefer full ownership and complete control over proprietary know-how. This was confirmed by Padmanabhan and Cho (1996) in their study on the ownership strategy of Japanese firms. Erramilli (1997) also reported that parent firms with greater R&D preferred full ownership in their subsidiaries. Whether the level of foreign ownership or equity influences firms to undertake technological effort will be further determined in this study.

HUMAN CAPITAL

A study on US-based MNCs in thirty-three host countries by Kokko and Blomstrom (1995) indicated a positive relationship between the availability of skilled labour and imports of technology by MNCs. Skilled labour reduced the cost of training needed to be undertaken by MNCs. Implicitly, host countries with an abundance of skilled labour were attractive to MNCs and, in turn, MNCs that were located in such countries were more likely to undertake technological activities due to the lessened need to train the workforce.

Niosi et al. (1995) showed that mastery of the imported technology was essential in ensuring firms to undertake technological activities efficiently. The study suggested that mastery of imported technology could be achieved through systematic learning which involves various forms of training and job-related experiences. The tacit and complex nature of technology warrants a systematic and rigorous approach in mastering technology. The importance of mastering technology rests on the nature of training provided by MNCs for their workforce. Sending staff to headquarters for technical training on MNCs' core technology, for example, reflects a greater likelihood to undertake technological activities compared to on-the-job training (Guyton 1995).

An important advantage of MNCs' affiliates is their ability to attract better employees than domestic firms. This is a significant factor in ensuring firms to undertake technological activities. MNCs in developing countries – (and in developed ones) on average offer higher wages than local firms (Haddad & Harrison 1993 and Kumar 1990).

As far as the age of technology goes, Mansfield and Romeo (1980) suggested that firms were more likely to transfer older technology rather than newer technology to their suppliers or counterparts. MNCs were more likely to transfer older technology in order to maximise their return. The study also reported that technologies transferred to developing countries were usually older than those technologies transferred to developed countries. This is because newer technologies are inappropriate or are difficult and expensive to transfer to developing countries. Although this phenomenon might still be true, present developments in the international electronics industry indicate that firms are at the technological frontier. Hobday (1995) and Baba and Hatashima (1995) found that US and Japanese MNCs' subsidiaries in NICs and ASEAN countries in many instances used the latest technology.

THE SURVEY

The Malaysian electrical and electronics industry has been selected for this study. It consists of two related industries, namely, the electronics and electrical industries. In ensuring that firms in the survey had been in operation for some time, the study utilised the 1995 Malaysian Industrial Development Authority's (MIDA) directory of the electrical and electronics industry as its population frame. A total of 45 firms participated in the survey, all of the firms in the sample were either operating from Free Zones (FZs) or were Licensed Manufacturing Warehouses (LMWs). They were typical of foreign firms in the electrical and electronics industry, and had been attracted by various incentives provided by the government. Efforts were taken to ensure that each sub-sector of the electrical and electronics was proportionately represented. Firms in the sample produced US$6.6 billions or 20.94% of the industry's output and employed 52,132 workers or 15.11% in 1995. These represent a significant amount of output produced and workforce employed by firms that participated in the survey.

THE MODELS AND VARIABLES

Since the dependent variable is categorical, the logit model is employed in this study although the probit model is also a feasible option. As noted by Aldrich and Nelson (1984), the preference for one model over another (i.e. logit versus probit models) is more due to practical reasons than theoreti-

cal grounds. In fact, in most applications, there don't seem to be any much difference (Greene 1997). The differences between these two models are only apparent in very large samples.

The task of the empirical analysis is to determine the characteristics that influence the likelihood of firms undertaking various forms of technological efforts. The binomial logit model was employed. The following subsections will present the specification of the models used.

MODEL SPECIFICATION

Responses were obtained from firms as to whether they have undertaken various technological activities or not. These firms were asked if they undertook a particular technological activity. The responses obtained formed the dependent variables for the analysis. The models employed explain the various technological efforts undertaken by firms in a cumulative function of the form:

$$E(Y_i) = P_i = F(\alpha + \beta X_{ij} + \varepsilon) = F(Z_i)$$

$$F(Z_i) = L(Z_i) \equiv \frac{e^{Z_i}}{1 + e^{Z_i}}$$

where

Y_i = a discrete random variable equal to one if the ith firm carries out a given activity and zero otherwise
P_i = probability that the ith firm engages in a particular activity
X_{ij} = value of the jth explanatory variable for the ith firm
ε = random disturbance term

This logit regression was applied to data for four technological activities. The next subsection discusses the technological activities.

DEPENDENT VARIABLES

The dependent variables in the regression represent the technological efforts of firms. The technological efforts seek to see whether R&D (*RNDLOCAL*) and technological modification (*MODTECH*) has been under-

taken and to observe the development of new technology as a result of mastering acquired technology (*DEVELOP*) and the usage of the new technology by other firms (*DIFFUSE*).

R&D is an input indicator of technological effort. Firms in the survey were asked whether they undertook R&D locally (*RNDLOCAL*). A value of ONE was assigned if the firm provided an affirmative response and ZERO otherwise. Fourteen (31.1%) of the sample firms provided affirmative responses to this enquiry. The survey indicates that most locally conducted R&D activities were for adaptive purposes to suit local requirements and to increase efficiency. Most of the R&D activities undertaken usually led to incremental innovation benefiting parent firms as a consequence of providing inputs for future production and process and design decisions. Obviously, the main limitation in analysing technological effort through quantitative techniques (as in this paper) is that it implicitly assumes firms' R&D activities are homogeneous.

MODTECH is the modification of the main production equipment and processes undertaken by firms. Thirty-eight (84.4%) of firms in the sample provided affirmative responses to this enquiry. Technological modification in the context of this paper refers to basic changes and adaptations carried out by firms on existing technologies. These incremental changes as identified by Bell *et al.* (1984) are undertaken to overcome difficulties such as bottlenecks and production problems. Most modifications do not require major investment by firms, and some involve only slight technological activity. However, no modification is effortless nor without cost since it demands a concerted effort from firms and requires explicit allocation of firm resources.

Information was also solicited to determine whether firms had developed (*DEVELOP*) a new technology as a result of the changes made to the existing technology. Seventeen (37.8%) firms provided affirmative responses. *DEVELOP* is usually carried out when firms fully understand the technology involved and are able to improve the existing technology. The improvements are usually the results of various small breakthroughs, which cumulatively lead to significant changes in the production or process. *DEVELOP* indicates mastery of the imported technology. Further improvising and upgrading of the technology will subsequently lead to technology transfer – diffusion i.e. the innovator moves on to a higher technology level.

The questionnaire also includes a question on whether other firms used the technology that they developed (*DIFFUSE*). Ten (22.2%) firms in the sample indicated that others were using the technologies that they

had developed in the industry. Some studies such as Enos and Park (1988) considers technology transfer is complete when the technology is used by others.

INDEPENDENT VARIABLES

The independent variables are classified into three main categories namely, firm profiles, technological profiles and linkages profile. The following sub-sections discuss the independent variables according to these categories.

FIRM PROFILES

YEAR is the number of years the firms have been operating in Malaysia. Firms with longer years in operations were expected be more likely to accumulate more technological experience and utilise it in their technological activities. A positive sign was expected in the models.

TSALES is the total sales of firms. The literature suggests a positive relationship between size and the likelihood of firms undertaking technological activities. However, studies carried out by previous researchers have resulted in mixed findings. Nevertheless, with the large resources usually needed to undertake technological activities, a positive sign is expected for *TSALES*.

TEXPORT indicates the percentage amount of products exported by foreign firms. Firms with a high export percentage were expected to be more inclined to conduct technological activities since they are exposed to international competition, which necessitates high quality products. Factors such as globalisation, emerging new markets and stiff competition mean that firms cannot afford to lag behind technologically if they are to succeed. Exporting to other markets now, more than ever, requires products to be technologically advanced. As such, whether MNCs export or sell locally, they still need to maintain their technological competitiveness. This view contrasts with that of several authors who have argued that firms with a high export intensity do just the opposite (i.e. will not undertake technological activities) since their products are not sold locally, thus there is no need to undertake technological activities for the purpose of adaptation or modification. Nevertheless, a positive sign was expected for *TEXPORT*.

FEQUITY is the percentage of equity held by foreigners. The literature relating to the impact of foreign equity is ambiguous. It is acknowledged in several studies that MNCs with technological advantages prefer wholly owned subsidiaries in order to prevent their technology from leaking away to competitors. However, MNCs may take on local equity if the local partner has contributed significant financial resources or provided access to local resources.

A dummy variable (*ELECTRICAL*) was used to test if there was any significant difference between electrical and electronics firms. A firm was given a value 1 if it is classified electrical and 0 otherwise.

TECHNOLOGICAL PROFILE

TECHAGE represents the age of a firm's main production line. Firms employing older technology were expected to undertake relatively more technological effort in ensuring the competitiveness of their operation. Some of the firms in the survey acknowledged that they still employed the same technology used since their inception; however, in most cases, their technologies had undergone continuous modification. It should be noted that technology age alone was not a definite indication of a firm's technological level. Some of the firms' equipment had undergone as much as 80% modifications but fundamentally still retain the same basic technology. A positive sign was expected for *TECHAGE*.

MODIFICA represents the extent of modification of the main production line undertaken by firms. In the survey, *MODIFICA* is referred to the approximate percentage of modification that has taken place in the firms' production processes. Such modification usually requires firms to undertake some form of technological activity. The percentage of modification in the survey varied from 0% to 80%. A positive sign was expected for this variable implying that technologically active firms would be more likely to undertake modification of their main production lines. However, *MODIFICA* was not included in the *MODTECH* model in order to avoid the possibility of endogeneity.

The last set of variables capturing technological profile was the equipment and processes employed by firms. Equipment and processes used by firms in the sample included *CNC*, *CAD*, *CAM*, and *MRPII*. Equipment and processes employed by firms were also good indicators of firms' technological level. Each piece of equipment and process plays a different role in a firm's operation, thus the signs were expected to be mixed.

ASSOCIATION WITH LOCAL FIRMS

There are various types of association between foreign and local firms. In the survey, this association is categorised into the variables discussed below in order to capture the association between foreign and local firms.

LSINPUT represents the percentage of local suppliers' input to MNC's final output. MNCs that utilised local resources usually have to undertake effort to modify their production processes to suit any differences that exist. Arguably, increase in local suppliers' input could lead to greater modification effort undertaken by MNCs. As such, usage of local suppliers' input will influence the likelihood of MNCs undertaking technological activities.

SUBCON indicates the degree of subcontracting that foreign firms have with local firms. Subcontracting activities provide opportunities for local firms' technological development.

ASIST1 represents the product design assistance extended by foreign firms to local firms. This type of assistance is crucial in the technological development of local firms. Meanwhile, *ASIST2* is the organisational assistance extended by foreign firms to local firms. Included in the assistance is managerial assistance. *ASIST3* reflects personnel training extended to local firms such as local firms' engineers or technicians sent for familiarisation courses at foreign firms or the presence of attachments of foreign firms' experts to assist in the training of local firms employees (see Table 1 for further details of variables used in the analysis).

RESULTS

Table 2 reports the maximum likelihood estimates of the parameters of the logit models for each of the four regressions.

In general, the regression coefficients have the expected signs and are significant. A likelihood ratio test rejected the hypothesis that all the regression coefficients are jointly equal to zero. All the models are significant at 1% level of significance.

McFadden (1979) suggested values for R^2 between 0.2 and 0.4 as representing a very good fit. The McFadden R^2 of the estimated models in the present research ranged from 0.228 to 0.442 indicating a good fit. Partial joint tests has also been conducted to determine the appropriateness of the model specification.

TABLE 1. List of the variables used in the analysis

Variables		Description	Mean
Dependent variables			
RNDLOCAL	=1	undertakes R&D locally	0.311
	=0	otherwise	
MODTECH	=1	modifies main production equipment & processes	0.844
	=0	otherwise	
DEVELOP	=1	introduces new technology as a result of changes undertaken in the acquired technology	0.378
	=0	otherwise	
DIFFUSE	=1	technology developed by firm used by others	0.222
	=0	otherwise	
Independent variables			
YEAR		Number of years in operation in Malaysia	12.159
TSALES		Total sales (RM '000)	43561.789
TEXPORT		Percentage of output exported	93.400
FEQUITY		Percentage of foreign equity	95.178
ELECTRICAL	=1	belongs to electrical industry	
	=0	otherwise	
TECHAGE		Average technological age of main production line (years)	8.956
MODIFICA		Percentage of modification undertaken on the main production line	23.044
CNC	=1	uses CNC machines	0.622
	=0	otherwise	
CAD	=1	uses CAD	0.600
	=0	otherwise	
CAM	=1	uses CAM	0.533
	=0	otherwise	
MRP11	=1	uses MRP11	0.378
	=0	otherwise	
LSINPUT		Percentage of local suppliers' input to MNC's final output	26.955
SUBCON	=1	subcontracts to local firms	0.711
	=0	otherwise	
ASIST1	=1	extends product design assistance to local firms	0.444
	=0	otherwise	
ASIST2	=1	extends organisational assistance to local firms	0.200
	=0	otherwise	

TABLE 2. Results of logit estimations

Logit estimations				
	RNDLOCAL	*MODTECH*	*DEVELOP*	*DIFFUSE*
CONSTANT	8.911*	–11.290*	–8.923*	–2.790***
	(1.918)	(–1.800)	(–1.908)	(–2.774)
TSALES	0.311E-5*	–	–0.219E-5*	–0.441E-5**
	(1.746)	–	(–1.711)	(–2.282)
TEXPORT	–	–	0.788E-1*	–
			(1.660)	–
YEAR	–	–	–	–
FEQUITY	–0.127**	0.915E-1*	–	–
	(–2.146)	(1.665)		–
ELECTRICAL	5.322**	–	–	–
	(2.147)	–	–	–
TECHAGE	–	0.403*	–	–
		(1.873)		
MODIFICA	–		0.536E-1**	0.711E-1***
			(2.409)	(2.582)
CNC	–2.095	4.333	–	–
	(–1.167)	(1.474)		
CAD	5.604**	–	–	–
	(2.070)			
CAM	–2.237	–	–	–
	(–1.093)			
MRP11	1.882	1.745	–	–
	(1.227)	(1.079)		
LSINPUT	–0.854E-1*	–	–	–
	(–1.944)			
SUBCON	–	–	–	–
ASIST1	–	–	–	1.737*
				(1.762)
ASIST2	–	–	1.900*	–
			(1.813)	
McFadden R^2	0.382	0.442	0.228	0.306
LLHood	–17.236	–10.849	–23.041	–16.536
RLLHOOD	–27.899	–19.450	–29.833	–23.836
CHISQ	21.327***	17.202***	13.585**	14.602***
n	45	45		45 45

Note: Values in parentheses are t-ratios.

*** - denote the level of significance at 1%.

** - denote the level of significance at 5%.

* - denote the level of significance at 10%.

The first category of variables, as mentioned in the previous section, was firm's profile. *TSALES*, is a measure for the firm's size, considered significant in all the entered models. It was positively signed and achieved a level of significance of at least 10% in the regressions. This finding concurred with previous studies such as those of Braga & Willmore (1991) and Kumar & Siddharthan (1994) which confirmed that larger firms were more able to conduct technological activities than smaller firms. Moreover, it is important to note that given the R&D defined here was a locally conducted R&D, this finding was of even greater significance since it also implies that larger sized firms were not only able to conduct R&D but, in the case of foreign firms, conducted them in host countries. However, in other models, namely, *DEVELOP* and *DIFFUSE*, *TSALES* were negatively-signed implying smaller size MNCs were more likely to undertake the concerned technological effort. Thus the finding suggests that size had an opposite effect on the various technological activities.

The second firm's profile variable, TEXPORT, was positively signed and significant in DEVELOP. Although firms in the sample were highly export oriented (most of them exported more than 80% of their products), the difference in their export intensity could still be detected by the model. The results suggested that the differences in their export orientedness did influence the likelihood of undertaking technological activities.

YEAR, a proxy for experience and accumulated learning, the third variable in the firm's profile however, was not significant in the models and was consequently dropped. This was contrary to expectations. This probably indicate the limitation of YEAR as a proxy for accumulated learning in determining whether firms will be likely to conduct technological activities or not.

Foreign ownership of firms was captured by FEQUITY. It was significant in two models but displayed mixed signs. It was negatively signed in RNDLOCAL providing support for the literature that firms with lower foreign ownership (i.e. higher local equity) were more likely to conduct R&D than those firms with higher foreign equity. However, FEQUITY was positively signed in MODTECH, which at first might seem contradictory, but considering *MODTECH* is usually technologically less involved than R&D, firms with higher foreign ownership would settle on conducting the necessary modification rather than conduct R&D.

The final firm's profile variable was ELECTRICAL. It was positively signed and achieved a 5% level of significance in RNDLOCAL. Differences in industry groupings influences the likelihood of firms undertaking technological activities. The results provided evidence that firms in the electri-

cal sector were more likely to undertake R&D activities locally than electronics firms.

The second set of variables in the models present the technology profile of firms in the sample. To a certain extent, sophistication of a technology reflected how recently it had been introduced or used by firms in the industry. In a rapidly evolving environment such as the electrical and electronics industry, this appears to be very much the case. Firms that utilise relatively older technology are more likely to undertake technological activities in order to 'upgrade' its technological level. This hypothesis was supported by TECHAGE in MODTECH. It was positively signed and achieved a 10% level of significance. Firms with older technology were more inclined to undertake the concerned technological effort.

MODIFICA, the average percentage of modification reported by firms, was one of the significant independent variables in the selected models. It achieved at least a 5% level of significance in the entered models. MODIFICA was positively signed and was statistically significant in DEVELOP and DIFFUSE. This is an important finding since it provided evidence that firms that had undertaken a higher percentage of technological modification are more likely to undertake these technological activities.

This study hypothesised that the technological effort of firms could also be gauged through the equipment and processes it employed. In the estimated models, however, only *CAD* achieved the required level of significance. It is also positively signed thus suggesting that firms that employed it are more likely to conduct technological effort. *CNC*, *CAM* and *MRP11* exhibited mixed signs in the models; their coefficients however, are not significantly different from zero. As a whole, the performance of the equipment and process variables was not as statistically significant as expected.

The final set of categories of variables deals with the association between MNCs and local firms. This part of the analysis sought to determine the relationship between links with local firms and MNCs' likelihood of undertaking technological effort. LSINPUT, indicating the percentage of local suppliers' contribution to MNCs' final output, is employed to determine the relationship between local firms' input and the likelihood of MNCs' undertaking technological effort. LSINPUT is significant and is negatively signed in RNDLOCAL. This suggests that firms with less local linkages are more likely to conduct R&D locally. This finding, however, seemed to contradict the finding relating to FEQUITY in the same model. Closer scrutiny of the data revealed that the average foreign equity of firms in the sample is nearly 90% therefore the influence of the owner of the remaining

local equity on firm's objectives and operational decisions is at most, minimal. However, local equity (implied by a negatively signed FEQUITY) is shown to influence firms effort in R&D. At the same time the model showed that local linkages has very little influence on firms undertaking R&D. LSINPUT is not significant in the remaining models. This finding raises serious implications for policy makers who want MNCs' affiliates to undertake technological activities with the involvement of more local firms. The insignificance of local linkages in influencing the likelihood of firms undertaking technological effort can be explained by the nature of MNCs operating in the electrical and electronics industry. Most MNCs operate in Free Trade Zones (FTZs) or have a Licensed Manufacturing Warehouse (LMW) status, which give them almost a free hand in their operations as long as they export a certain amount of their output. However, most of the firms satisfied this requirement merely by trading among themselves, since technically, whenever a firm sells its product to firms in the FTZs or to a LMW it is considered an export. This, in fact, encourages MNCs to source among themselves and, in the process, places local firms at a disadvantage. It reduces foreign firms' sourcing activities with local firms. Relations with local firms are basically restricted to providing services such as installation contracting, building contracts, supplying workers, local freight and landscaping. The aforementioned scenario results in weak linkages, especially in developing local firms in the electrical and electronics industry. However, the government has acknowledged this loophole in several of its official documents and attempts are being made to rectify it. A study undertaken in Mexico has suggested that government would fare better in creating linkages between foreign and local firms if it concentrated more on creating a conducive business environment rather than imposing criteria such as local content requirement and the likes (Blomstorm et al. 1995).

Assistance extended to local firms, another proxy of association with local firms, significantly explained the likelihood of technological effort undertaken by firms. The study found that MNCs that extended assistance in the form of product design (*ASIST1*) and managerial (*ASIST2*) to local firms are more likely to undertake technological activities.

Subcontracting fails to achieve the required level of significant in all the models. This is quite a contrary to what is expected. It has been thought that MNCs that has taken much of their own production work, without subcontracting it out to others, especially the labour-intensive components sections, would have less resources available for technologically related activities. However, it could again be argued that firms that undertake most of their own production will have to undertake more technologi-

cal activities, such as introducing technical changes, in order to increase efficiency and productivity in production.

CONCLUSION

This study has analysed the technological activities of MNCs' affiliates. Models are constructed to quantitatively determine whether selected variables significantly influenced technological activities of MNCs. Size of firms, export intensity and foreign equity were found to be significant in influencing the likelihood of firms undertaking technological activities. Technical assistance extended by MNCs is also statistically significant in explaining the likelihood of MNCs undertaking technological activities. However, the negative signs for local input and the statistically insignificance of subcontracting activities were of concern. These seem to contradict the widely held belief that benefits usually arise from subcontracting activities and usage of local input. An obvious explanation for the results would be that local input and subcontracting activities involved are mainly labour intensive in nature and of low value-added activities reflecting the technological capability of local suppliers.

REFERENCES

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

Athukorala, P. 1995. Foreign direct investment and manufacturing for export in a new exporting country: The case of Sri Lanka. *World Economy* 18 (4): 543-564.

Aw, B.Y. & A.R. Hwang. 1995. Productivity and the export market: A firm level analysis. *Journal of Development Economics* 47: 313-332.

Baba, Y. & H. Hatashima. 1995. Capability transfer in the Pacific Rim nations: The case of Japanese electrical and electronics firms. *International Journal of Technology Management* 10 (7/8): 732-746.

Bell, M., B. Ross-Larson & L.E.Westphal. 1984. Assesing the performance of infant industries. *Journal of Development Economics* 16: 101-128.

Braga, H & L. Willmore 1991. Technological imports and technological efforts: an analysis of their determinants in Brazilian firms. *The Journal of Industrial Economics* 39 (4): hlm.

Caves, R. 1982. *Multinational Enterprise and Economic Analysis.* New York: Cambridge University Press.

Cohen,W.M. & S. Klepper. 1996. A reprise of size and R&D. *The Economic Journal* 106: 925-951.

Dunning, J.H. 1995. *Multinational Enterprises and the Global Economy.* Reading: Addison-Wesley.

Greene, W.H. 1995. *LIMDEP Version 7.0 User's Manual.* New York: Econometric Software Inc.

_____. 1997. *Econometric Analysis.* 3rd Ed.. New Jersey: Prentice-Hall International.

Guyton, L.E. 1995. Japanese FDI and the transfer of Japanese consumer electronics production to Malaysia. *Journal of Far Eastern Business* 1 (4):.

Haddad, H. & A. Harrison. 1993. Are there spillovers from direct foreign investment? Evidence from panel data for Morocco. *Journal of Development Economics* 42: 51-74.

Hobday, M. 1995. *Innovation in East Asia*, Hants.: Edward Elgar.

Katrak, H. 1991. In-house technological effort, imports of technology and enterprise characteristics in a newly industrialising country: The Indian experience. *Journal of International Development* (3): 263-276.

Kokko, A. & M. Blomstrom. 1995. Policies to encourage inflows of technology through foreign multinationals. *World Development* 23 (3): 459-468.

Kumar, N. & M. Saqib. 1996. Firm size, opportunities for adaptation and in-house R&D activity in developing countries: the case for Indian manufacturing. *Research Policy* 25: 713-722.

Kumar, N. & N.S. Siddharthan. 1994. Technology, firm size, and export behaviour in developing countries: The case of Indian enterprises. *The Journal of Development Studies* 31 (2): 289-309.

Lecraw, D.J. 1984. Bargaining power, ownership, and profitability of transnational corporations in developing countries. *Journal of International Business Studies* 15 (1) (Spring-Summer): 27-43.

Odagiri, O & H.Yasuda. 1996. The determinants of overseas R&D by Japanese firms: an empirical study at the industry and company levels. *Research Policy* 25: 1059-1079.

Mansfield, E. & A. Romeo. 1980. Technology transfer to overseas subsidiaries by U.S. based firms. *Quarterly Journal of Economics*: 737-750.

McFadden, D. 1979. Quantitative methods for analysing travel behaviour of individuals: some recent development. Cited in Wrigley, N. 1985. *Categorical data analysis for geographers and environmental scientists*, Essex: Longman.

Niosi, J. et al. 1995. Technology transfer to developing countries through engineering firms: the Canadian experience. *World Development* 23 (10): 1815-1818.

Padmanabhan, P. & K.R. Cho. 1996. Ownership strategy for a foreign affiliate: An empirical investigation of Japanese firms. *Management International Review* 36: 45-65.

Papanastassiou, M. & H.D. Pearce. 1992. Firm-strategies and the research-intensities of US MNE's overseas operation: an analysis of host country determinants. Discussion Papers in International Investment and Business Studies. Series B, No. 145 (University of Reading). Dlm. Odagiri, O & Yasuda,

H. 1996. The determinants of overseas R&D by Japanese firms: an empirical study at the industry and company levels. *Research Policy* 25:1059-1079.

_____. 1994. Host-country determinants of the market strategies of US companies' overseas subsidiaries. *Journal of the Economics of Business* 1 (2): 200.

Sanchez, A.M. 1994. R&D and firm size: some evidence from Spain. *Technovation* 14 (2): 63-69.

Sim, O.F. & M.N. Othman 1995. *Managing Innovation in Japanese Companies: Lessons for Malaysia* Kuala Lumpur: ISIS.

Stopford, J.M. & L.T. Wells. 1972. *Managing the Multinational Enterprise: Organization of the Firm and Ownership of the Subsidiaries*. London: Longman.

UNCTAD. 1995. *World Investment Report 1995*. New York: United Nations.

Zejan, M.C. 1990. R&D activities in affiliates of Swedish multinational enterprises. *Scandinavian Journal of Economics* 92 (3): 487-500.

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