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Traditional versus decentralized innovation strategies of multinational enterprises

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Abstract

In this paper we investigate innovation strategies of foreign multinational enterprises (MNEs) by distinguishing between traditional centralized and newer decentralized competence models. In centralized competence models, MNEs maintain core research and development (R&D) functions at home, and conduct design and market screening in host locations. In decentralized competence models, MNEs also undertake R&D in host country locations. We test empirically the interrelations and heterogeneities among these three types of host country affiliate innovation activities: design, market-screening, and R&D. Our results indicate that traditional and new roles of MNEs are complements, although the determinants of each strategy are somewhat different. The presence of local knowledge spillovers is positively associated with the probability that an affiliate does R&D, design, and market-screening activities. R&D activities are more likely to appear when an affiliate has more developed internal capabilities and has been operating for a longer time in the host country. Our findings provide some support for the predictions of decentralized competence models.

JEL codes: F23, O31, O32, H32, C35.
Keywords: Overseas R&D; Multinational Enterprises (MNEs); innovation policy.

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1. Introduction

The increased interest in developing countries as locations for research and innovation reflects broader trends in the internationalization of technological capabilities and corresponding shifts in the geographical allocation of foreign research and development (R&D) expenditures by multinational enterprises (MNEs). For example, in 2003, US MNEs performed 13.7% of their R&D abroad – up from 11.7% in 1994 and 6.6% in 1966. Developed regions (Canada, Western Europe, Japan, Australia, and New Zealand) accounted for about 84% of US MNE overseas R&D expenditures in 2003, down from over 90% in 1994. Conversely, the rest of the world received 16% of overseas R&D expenditures by US MNEs in 2003, up from under 10% in 1994. In 2003, nine countries – China, Israel, Singapore, Brazil, Mexico, Malaysia, Korea, India, Taiwan – received the greater part (88%) of R&D expenditures by US MNEs outside of developed regions.[1] Similar trends are seen among non-US MNEs. For example, between 1989 and 1999, the expansion of R&D by Japanese MNEs to developing countries increased ten times more rapidly than their worldwide R&D expenditures (UNCTAD, 2005, p.5).

A concurrent debate has emerged among scholars about the ways in which MNEs undertake innovation in developing countries. Traditionally, innovation was seen as an activity that took place through technology transfer processes from parent companies to affiliates while high-value-added activities remained centralized in parents' home countries (Hymer, 1960; Vernon, 1966). In such

[1] Analysis of Bureau of Economic Analysis (BEA) data on operations of US Multinational Companies in Mataloni (2005), Mataloni and Fahim-Nader (1996), and Serapio (1999) and Kumar (2001).

"concentrated competence" models, overseas research and technological development by MNEs played a limited role, being mainly related to the adaptation of group products and processes to subsidiaries' market conditions. However, since the 1990s, a new wave of scholars, including, Cantwell (1995), Dunning and Narula (1995), Florida (1997), and Kuemmerle (1999), among others, have suggested that MNE research and innovation strategies appear to be evolving along what can be termed a "decentralized competence" path. Under this new paradigm, location decisions in developing countries by foreign multinationals are no longer seen exclusively as a way to take advantage of large markets and cheap labor; rather, they are also viewed as a means to undertake research and generate new technological competencies from emerging locations that have rising scientific and technological capabilities.

As yet, empirical findings are only patchily available about where, why and how MNEs are evolving their research and innovation strategies in developing countries. Recent work has suggested that decentralized research and innovation strategies are being pursued by MNEs in countries like China and India (Pearce, 1999; Dalton and Serapio, 1999; Kumar, 2001; Thursby and Thursby, 2006). However, there is less discussion about the extent to which MNE research and innovation activities are being embedded in other developing countries and, in these countries, how domestic capabilities for research and innovation are related to MNE strategies. In this paper, we seek to contribute to this area of study by exploring the research and innovation characteristics of a group of multinationals in Malaysia, linkages between different sorts of innovation strategies, and relationships of MNE strategies with domestic innovation capabilities and localized knowledge spillovers.

Using firm-level data for the Malaysian manufacturing sector, our approach probes if affiliates of MNEs primarily pursue localized design and marketing activities (which would be consistent with traditional concentrated competence models) or whether they also have added a R&D orientation (reflecting the adoption of newer decentralized competence strategies). We identify R&D to include the introduction of technologically new or improved products, processes, services or software. The paper also studies the extent to which domestic firms' absorptive capacity as well as internal-firm specific capabilities needed to benefit from this knowledge affect MNEs' innovation decisions. We test whether the average industry level of domestic research and affiliates' human capital affect these decisions, also controlling for the effects of other elements suggested by previous empirical works such as establishment's size, age, sector affiliation and workforce diversity.

Results of our analysis confirm that a series of different factors influence MNE affiliate choices about whether to engage in R&D in addition to more traditional activities such as market intelligence and design. Affiliates that perform R&D tend to have been located in Malaysia for longer time, are bigger, have superior science and engineering capabilities, and operate mainly in science-based sectors. MNE affiliates that engage in design activities show similar patterns, except that age and science capabilities are not significant. By contrast, the likelihood of an affiliate undertaking market screening is influenced by another set of factors, and it occurs mainly in supplier-dominated sectors.

Notably, the level of same-sector domestic firms' absorptive capacity (and the possibility to interact with and use knowledge spillovers from domestic firms) is positively associated with the probability that an MNE affiliate will engage simultaneously in R&D, design, and market screening. Overall, our research suggests that the nature of innovation in MNEs is complex and, in addition to consideration of corporate strategy, also requires attention to local capacity building, management diversification, and sectoral factors.

2. Concentration and decentralization of R&D by MNEs

There is a large and diverse literature on the determinants of overseas innovative activities by multinationals. Within this literature, there is a long-established view – based on Vernon's (1966) product life cycle model or Hymer's (1960) control thesis – that MNEs locate abroad low-valued activities of the value-chain while keeping high-added-value activities in home countries. In sequence, such companies develop product and process capabilities in their home countries, export, and then set up routine production facilities in foreign countries. In developing countries, the availability of cheaper labor and other low-cost input factors attracts MNE facility locations. However, the subsequent expansion of innovative activities in foreign countries is mainly associated with demand-side motives. MNE affiliates may engage in activities such as servicing foreign markets and/or providing technical support to offshore manufacturing plants or subcontractors. They may also seek to increase sales in foreign markets by using local affiliates to adapt products and process to foreign markets' conditions, for example, to account for differences in local suppliers and consumers needs. MNE affiliates may also seek to improve production and distribution processes to reduce cost and improve subsidiaries' productivity. Yet, despite the development of such limited innovation capabilities in foreign developing countries, in this model MNEs maintain what can be termed a "centralized competence" strategy. Essentially, the MNE is relying upon and exploiting research, product development and process capabilities created within its home country.

The spatial stickiness of innovation is one reason that has been posed in the literature to explain why MNEs may decide to concentrate their innovation activities in their home countries (Ernst, 2005). In contrast to other stages of the value-chain, innovation is judged to be highly immobile and embedded in specific industrial clusters and knowledge milieus. So it can be difficult to move to new locations that do not have a strong innovation tradition. The person-embodied nature of knowledge and the high level of uncertainty associated with R&D mean that innovative activities often demand intense and frequent personal communication and rapid decision making, leading to geographic concentration in home countries (Patel and Vega, 1999). Geographic concentration may also help to take advantage of economies of scale and scope in knowledge production. In addition, it can help to protect firm-specific technology from imitators, while saving on the costs of coordination of R&D units located in different countries.

By contrast, contemporary visions of the role of MNEs and internationalization of technology emphasize supply-side factors such as taking advantage of host research infrastructure, inexpensive but high quality researchers and skilled employees, and local knowledge and innovation networks (Niosi, 1999; Florida, 1997; Pearce, 1999). Innovation facilities in foreign countries are seen not only as a means to monitor new R&Ds but also to generate new technologies/ products and processes from foreign locations. Under this “decentralized competence” approach, MNEs are seen to increasingly use and exploit the technological advantages and capabilities of host countries. Feinberg and Gupta (2004) suggest that the assignment of R&D competencies to foreign affiliates has much to do with opportunities to capture and use local knowledge spillovers. Friedman (2005) argues that developments in communications technologies and software capabilities have facilitated, if not accelerated, the ability of MNEs to exploit and coordinate developing country knowledge capabilities. However, taking advantage of such opportunities does require an appropriate strategic orientation: as Blanc and Sierra (1999) suggest MNEs need to build an organization with local proximity and effective external and internal linkages to exploit the benefits of internationalizing R&D.

[Table 1 about here]

In parallel with the theoretical debate on the research and innovation strategies of MNEs, a growing number of empirical studies have explored whether MNEs’ are actually expanding their research activities to developing countries, and which factors influence MNEs’ decisions to invest in overseas R&D. According to several sources MNEs have started decentralizing their R&D. For example, in a recent survey conducted by UNCTAD (2005) on more that 1,000 foreign direct investment projects in R&D it is found that more than two thirds of these projects are located in developing countries or economies in transition, and that the Asia Pacific region accounts for more than half of the total number of projects worldwide. A survey done by the Economist Intelligence Unit (2004), reveals that 22% of respondent companies conduct some applied research in overseas developing markets, while more than half report they are planning to increase their overseas R&D activities in the future, with China and India being the main recipients for future investments. Kumar (2001), based on data from the US Department of Commerce for the period 1966-1994, finds that developing countries host over 9% of overseas research expenditure of US MNEs, and that it is highly concentrated in few countries in Latin America and Asia. In case of Japanese corporations, he finds that about 9% of their overseas R&D is concentrated in newly industrialized Asian countries. There is also some evidence indicating that MNEs' have increased their presence in some industrialized countries as well as in some developing countries. Dalton and Serapio (2000) find for the case of US multinationals, that R&D spending abroad increased from 5.2 billion US dollars in 1987 to 14.1 billion dollars in 1997. Though, more than half of this investment went to highly industrialized economies, they also find evidence suggesting that research investment increased in newly industrializing or developing countries, including Singapore, Brazil, China, and Mexico.

Empirical evidence on the determinants of MNEs decisions suggest that there are important variations in foreign R&D strategy across countries origin, destinations and sectors. For example, Thursby and Thursby (2006), based on a survey of 250 multinationals (mostly based in the United States and Western Europe), find that the factors that affect the decision to produce in a developing country differ from the factors that explain R&D investments in developing economies. Traditional factors such as lower cost are not the main factors driving companies to locate their R&D in countries like China and India. The quality of R&D personnel, opportunities for university collaboration and the growth of potential in the market are found to be more important attractors. Narula and Dunning (2000) argue that MNEs use combinations of resource-seeking, market-seeking, and strategic asset-seeking rationales for foreign direct investment, with variations according to recipient country factors and corporate-specific characteristics.

Other research has highlighted the role played by potential knowledge spillovers in the host country. Almeida and Phene (2004), for example, using a sample of U.S. MNEs engaged in the semiconductor industry, find that opportunities for university collaboration and technological diversity of host country affect the number of successful semiconductor patents applied for by a subsidiary. Kumar (2001), based on data from US and Japanese affiliates finds that corporations operating in developing countries with higher number of scientist are more likely to have their operations supported by local R&D. Hicks and Hegde (2005) in an industry-level analysis, find that the number of scientific articles of host countries positively influences US affiliates' patents and level of R&D investments. Todo and Miyamoto's (2002), for the case of Indonesia find that knowledge diffusion from MNEs requires foreign or domestic efforts in R&D and human resource development.

The decision to invest in research and innovation in developing countries is also sensitive to the institutional framework of the host country. For example, it has been shown that the R&D strategies of firms engaged in research activities across international borders is influenced by the intellectual property regime (IPR) of the receiving country (Hagedoorn, Cloodt and van Kranenburg, 2005). In a recent study about the research activity of U.S.multinationals, Branstetter et.al. (2005) find that stronger IPR regimes (the majority of host countries included in their analysis are emerging economies) have a positive impact on the volume of affiliate's royalty payments to US parent firms. They also find that stronger IPR is associated with an increase in affiliate R&D spending and the level of non-resident patenting. Lee and Mansfield (1996) also find similar results.

However, not all recent studies confirm that MNEs are decentralizing research and innovation capabilities. Patel and Vega (1999), using US patent data for a sample of 220 firms with the highest volume of patenting outside their home country in the 1990s, find that firms rarely exploit host country advantages. Firms invest abroad in fields where domestic R&D expenditures are large and where there are mergers and acquisitions, suggesting that these firms keep most of their technology close to the home base, internationalizing only technology that helps subsidiaries to suit foreign markets and to resolve technical problems. Von Zedtwitz and Gassmann (2002) add to this argument the need to consider separately R&D activities when analyzing investment decisions of foreign MNEs. Their results indicate that multinationals are reluctant to research outside of their home country, because the process is costly and not very efficient. At the same time, they report that MNEs do undertake development activities abroad, because managerial problems are less severe. Another study (Innovarometer 2004) found that only one percent of a sample of European firms had relocate R&D to Asian countries. Of these, about one half of firms that relocated R&D activities reported that main reason to do so was related to cost reduction, while only about one-fifth said that they did it in order to have better access to qualified scientists and engineers.

Finally, recent evidence suggests the existence of interdependence between MNEs' domestic and foreign R&D (Fors, 1997; Belderbos et al, 2006). On the one hand, this could represent the spillover of foreign expertise into domestic firms. But in keeping with the decentralized competency models, it could suggest that MNEs are locating foreign research and innovation capabilities in regions with strong complementary skills in local firms.

This overview suggests that research and innovation strategies of MNEs in developing countries are evolving, but the pace and character of this evolution remains to be fully explored. For example, it can be argued that Vernon's model assumed a linear innovation model, while contemporary perspectives perceive more networked and integrated connections between research, design, and marketing. This research proposes to examine these interrelationships, taking into account complementarities in decisions about innovation investments.

3. Empirical Model and Estimation Procedure

Our review of the current theoretical and empirical discussion about the research and innovation strategies of MNEs shows an as yet unresolved debate about the roles of MNE affiliates in developing countries. Our analysis further examines these perspectives through empirical modeling that probes whether or not an affiliate performs knowledge-based innovation activities in the host country. We explore three types of affiliate innovation activities: R&D; adaptive design and engineering; and market scanning and intelligence. Human capital, local capacity, and other measures such as firm's size, age, managerial diversity, and technological opportunity of the industry sector in which a subsidiary operates are used as independent variables (see Table 2 for variable description). The basic structure of our model may be specified as follows,

$$Y_j=X_{1j}b_{1j}+ X_{2j}b_{2j}+ X_{3j}b_{3j} + X_{4j}b_{4j}+ u_j$$

where Y_j represents a set of innovation activities of an affiliate (j=1…J), X_{1j} is a vector of proxies for internal knowledge sources, X_{2j} is a proxy for external knowledge sources, X_{3j} is a vector of affiliate's internal resources, X_{4j} is a vector for affiliate's manufacturing activity, while u_j is a vector of unobserved factors.

To develop our model, we consider the types of innovation strategies that MNEs may pursue. We assume that affiliates activities are used by parent companies for multiple purposes, to develop technologically new products and process, to screen local market and/or to adapt their products and processes to local suppliers and local tastes. We do not assume that all MNE affiliates continue to pursue centralized competence strategies, without local investment in research and innovation; nor do we assume that all MNE affiliates have now embraced decentralized strategies, incorporating R&D with other knowledge activities. Affiliates have several choices regarding innovation and use them in different combinations in order to be competitive in the market.

To incorporate these assumptions, we define Y_1=1 if an affiliate develops technologically new or improved products, processes, services, or software, Y_2=1 if an affiliate engages in design and engineering activities, and $Y_3 = 1$ if an affiliate does market research, business or technology scanning to inform business planning. As these dependent variables are discrete and non-ordered and because, in principle, affiliates can engage simultaneously in different innovation strategies at the same time, the appropriate model to estimate our model is a multivariate probit (MVP). Our approach is then to estimate the probability that a subsidiary performs an innovation strategy (P_j), where j represents types of innovation activities, assuming that the errors terms are jointly normally distributed with mean zero and variance-covariance matrix Σ,

$$E(Y_1 = 1) = P_1 = X_{11}b_{11} + X_{12}b_{12} + X_{13}b_{13} + X_{14}b_{14} + u_1$$

$$E(Y_2 = 1) = P_2 = X_{21}b_{21} + X_{22}b_{22} + X_{23}b_{23} + X_{24}b_{24} + u_2$$

$$E(Y_3 = 1) = P_3 = X_{31}b_{31} + X_{32}b_{32} + X_{33}b_{33} + X_{34}b_{34} + u_3$$

$$(u_1, u_2, u_3) \sim N(0, \Sigma)$$

This specification allows for systematic correlations between choices of innovation activities. Such correlations may be positive or negative. Positive correlations may indicate the existence of complementarities among decisions. Negative correlations may be due to substitutability across each activity. Positive correlations may also indicate that there are common unobserved factors that affect each knowledge activity of the value chain. The multivariate probit takes into account these correlations but cannot distinguish between each source of correlation. It so indicates the correlation between strategies, conditional on observables. But it serves to test the efficiency of univariate probits. If correlation coefficients turn to be significant, then the estimation of independent probit models will still be inefficient.

3.1 Estimation procedure

The estimation procedure is as follows. We start by conducting a series of contingency tables and chi tests to check pairwise complementarities across strategies (0,1), (1,0), (1,1) (1,0) for each pair of decision. As the dimension of our decision variable is more than two, we then investigate occurrences of each strategy conditional on the occurrence of other strategies (0,0,0), (1,0,0), (1,1,0)….(0,0,1). We then estimate a multivariate probit with three equations – one for each innovation strategy: R&D, design and market screening – by the method of simulated maximum likelihood (SML) and test whether correlation coefficients among residuals are significantly different than zero, and so estimation of a joint recursive system is needed. This estimation also allows us to see whether coefficients of explanatory variables are statistically different across equations. In addition, we evaluate our model using the Geweke-Hajivassiliou-Keane (GHK) smooth recursive simulator to see whether results change or maintain consistency.[2]

4. Data and Hypothesis

To test our empirical model we use data from the Malaysian Knowledge Content Survey (Myke) in 2002/2003 and from the Malaysia's 2002 Annual Survey of Manufacturers (referred to as the "annual survey" in the balance of this paper).[3]

[2] On the use of the GHK simulator see Greene (2000) and Cappellari and Jenkins (2003).
[3] See Shapira, et. al., (2006) for details on the Knowledge Content Survey.

Myke contains questions about the knowledge content characteristics of 18 key private sectors (10 manufacturing and eight services sectors) while the annual survey refers only to manufacturing activities, including ownership, employment, facilities, investment, sales, and financial performance. Both data sources were merged and the sub sample of foreign MNEs selected. All in all, our sample consists of 177 manufacturers with ultimate headquarters located outside of Malaysia. These are identified as affiliates of MNEs.

4.1 Hypotheses affecting the decision that an affiliate engages in innovation activities

Following the absorptive capacity theory (Cohen and Levinthal, 1990) we hypothesize that affiliates with higher levels of human capital will have more incentives and capabilities to develop knowledge-based strategies in the host country. We compute affiliate's level of HUMAN CAPITAL as the total number of workers with scientific and technical (including computer science, software, and electrical/electronic engineering) university degrees divided by the total number of workers, and assume that with more qualified workers, an affiliate will be more effective recognizing, assimilating and transforming economically valuable knowledge. This leads to our first testable hypothesis, as follows:

H1: The probability that an MNE affiliate undertakes R&D, in the host country will be positively affected by the level of knowledge capital of the affiliate

Another internal knowledge source that may affect affiliate's absorptive capacity and the decision about which kinds of innovation activities to assign to a subsidiary is the ethnic diversity of the workforce (Milliken and Martins, 1996). Our measure of diversity refers to the ethnic origin of upper level managerial workers. We build a Blau Index (Blau, 1977) as $1 - \Sigma p_k^2$ (MANAGERS DIVERSITY), where p_k is the proportion of subsidiary's managers for each ethnic group, including both males and females.[4] Management diversity may be a source of creativity. It may increase the expose to greater variety of ideas and perspectives, and hence facilitate the performance of innovation activities. Conversely, diverse ethnic management may result in less group cohesion than a homogenous management group, and result in less trust and communication with the workplace, resulting in a lower propensity to engage in innovation activities (Keller, 2001). For this analysis, we opt for an optimistic view, girded by the assumption that MNEs will be more likely to employ international best practice employment policies than local firms, and that those affiliates with such practices will find it easier to undertake innovation activities. So, our hypothesis regarding the impacts of multi-ethnic managers is:

H2: The likelihood that an affiliate engages in R&D in the host country will be affected positively by the ethnic diversity of managers

[4] This is a particularly important aspect to probe in Malaysia, given the multi-ethnic nature of the population. There are three major groups (Malay, Chinese, and Indian), plus several other minorities. Ethnic groups considered in this study are: Malay, Ibans, Bidayuhs, Bajaus, Kadazans, other indigenous groups, Chinese, Indians, Malay, non- Malay Indonesians, non-Malay Filipinos and non-Malay Bangalsdeshis.

MNEs' affiliates may be more likely to perform R&D and to develop local knowledge networks in industries where external knowledge sources, measured by domestic firms' absorptive capacity, are high (Todo and Miyamoto, 2002). The higher the level of domestic R&D, the more likely that MNE affiliates will find a labor pool of qualified scientist and engineers that they can employ. Also, it is reasonable to expect that MNEs will need to compete through innovation in sectors where domestic firms are also innovative. To test this hypothesis, we construct an index (LOCAL CAPACITY) as the industry average of domestic research intensity for each manufacturing code included in the annual manufacturing survey, and use a log transformation. The measure used in the estimations is defined as log(domestic capacity$_k$=mean (industry)$_k$) where k is each of two-digit manufacturing activities. Our hypothesis is:

H3: The probability that an MNE affiliate undertakes R&D will be positively affected by the level of R&D of domestic firms in the same industry

The decision to engage in innovation activities may be also affected by the number of years an MNE affiliate has operated in the host country (see, for example, Kumar, 2001). As affiliates accumulate experience and skills over time, the more they know the local market, and the more they will be interested in (and efficient at) performing innovation activities to exploit their position. So, we expect that the longer an affiliate is in the host country, the more embedded it is and the greater is its chances of performing innovation in the host country. To test this hypothesis, we use from the Malaysian Department of Statistics (DOS)

Annual Survey the starting date of manufacturing activities in Malaysia and construct a discrete variable called AGE.

H4: The probability that an MNE affiliate performs R&D in the host country will be positively affected by the number of years that it operates in the host country

Firm's size is another internal resource that may be affecting subsidiaries' innovation decisions. Large affiliates may be better able to take advantage of economies of scale and scope in research and appropriate returns from their innovative activity, being more likely to perform innovation activities in the host country. Yet, results from empirical studies are mixed. Some authors find that affiliate's size has a positive impact on subsidiary innovation (Odagiri and Yasuda 1996, Feinberg and Gupta, 2004) while others find a negative effect (Almeida and Phene, 2004). We measure firm size, SIZE, as the natural logarithm of firm's number of employees, and propose that,

H5: The probability that an affiliate undertakes R&D in the host country will be positively affected by the affiliate size

MNEs decisions may also vary across types of industries. We capture the effect of technological differences across industries, following Pavitt's (1984) taxonomy of industry trajectories and previous work by Hegde and Shapira (2005). Four dummy sector variables are used: SUPPLIER DOMINATED = 1 if an affiliate operates in a traditional manufacturing sector, including food, textiles, leather, wood products, rubber and plastics, and other manufacturing such as jewelry;

SCALE INTENSITY = 1 if an affiliate manufactures motor vehicles or other transport equipment; SPECIALIZED SUPPLIERS = 1 if an affiliate manufactures non-metallic products, basic metals, machinery or electronic products; and SCIENCE BASED = 1 if an affiliate operates in chemicals. We anticipate that opportunities and pressures (as well as returns) to innovate are relatively greater for affiliates in specialized supplier and science-based sectors, whether through export requirements, changing product demands, specialization, or the inherent complexity of process technologies in these sectors.

H6. The probability that an affiliate performs R&D is affected by the technological opportunity of the sector that the affiliate operates in, with R&D more likely in specialized supplier and science-based sectors

Our model can be illustrated by Figure 1. Four factors affect affiliate's decision to engage in knowledge-based activities. Internal knowledge sources, measured by human capital and ethnic diversity of managers, and external knowledge sources, captured by the level of local firms' absorptive capacity, improve affiliate's level of knowledge absorption, contributing positively to the development of these activities. Internal resources, as size and experience in the host country, also affect the capacity to engage in these activities. The type of manufacturing activity of the affiliate also matters to explain affiliate's behavior. Finally, there is a group of influencing factors that we would like to observe but we can not with current data.

[Figure 1 about here]

5. Results

Descriptive statistics for the sub-sample of 177 multinationals are reported in Table 2. According to these results, 36% of affiliates develop R&D activities. This percentage doubles the domestic single-establishment ratio (15%) and it is four percentage points higher than the domestic owned group rate (29%).[5] A higher proportion of affiliates is engaged in market intelligence (49%) and design activities (47%). R&D activities are often developed with other partners. But cooperation takes place mainly with other units in the enterprise group. Cooperation with universities or other institutions is very rare. In addition, we know that MNEs engage more often in process innovation than in product development and that incoming spillovers inside Malaysia are particularly important for MNEs. The first source of knowledge is internal and then from market sources. Institutional sources (such as universities, national laboratories, or other business organizations) do not appear to be very important for MNEs. Domestic group firms report similar results, but for them institutional sources are by far more relevant.

[Table 2 about here]

A statistical analysis of occurrences shows that MNE affiliates engage in varied bundles of innovation activities, but there are some prominent strategies

[5] Malaysia's R&D expenditure as a percent of GDP was about 0.7% in 2002. Compared with other emerging economies, Malaysia's R&D effort is lower than in China (1.2%) and India (0.8%), although higher than in emerging economies such as Indonesia, Thailand and Vietnam (National Science Board, 2006, Table 4.13; UNDP, 2005, Table 13.).

(Table 3). Nearly a third of MNE affiliates report no innovation activities at all. Of those affiliates who do engage in innovation activities, the most frequent responses are (1) to undertake R&D, design and market screening together (1,1,1) and (2) to pursue design and market screening activities without doing R&D (0,1,1). Also notice that the occurrence of (0,0,0) plus (0,1,1) is more common than (1,0,1) plus (1,1,0), and that (1,1,1) plus (1,0,0) occurs more frequently than (1,0,1) and (1,1,0), indicating possible complementarities between design and market screening activities.[6] Analysis of frequency tables and significant chi-square statistics suggest that our three dependent variables seem to be statistically pairwise related (Table 4).[7] Correlations are higher between design and market intelligence, than between R&D and market intelligence or design.

[Table 3 about here]

[Table 4 about here]

These results are corroborated by the multivariate probit model. As Table 5 shows the three correlation coefficients of the error terms in the multivariate probit are positive, ranging from 0.28 to 0.81, and significant, suggesting complementarities across innovation strategies rather than substitutability. However, they could also be indicating the existence of an omitted bias.

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[6] Mohnen and Röller (2005) propose to test complementarities with discrete choice variables thought a two stage model and super- and sub-modularity tests. Since we do not have enough information on MNEs that are not performing innovative activities of any kind, it is difficult for us to do such analysis.

[7] We further examined a correlation matrix of covariates used in the estimation. Results indicate that regression variables do not seem highly correlated, and there are not serious problems of multicollineality.

[Table 5 about here]

The first three columns of Table 5 show the estimation results of the multivariate probit using simulated maximum likelihood and the last three columns show the results using the GHK simulator. As can be seen in this table, the results using both methods are very similar, indicating the robustness of the model. In the performance of R&D, the traditional factor of size is positively associated. Local capacity (R&D performed by domestic companies in the same industry) is also significant and positively associated. MNE affiliates with greater internal capabilities (measured by scientific and technical human capital) are more likely to undertake R&D. Affiliates with less ethnically homogeneous managers have a higher probability to do R&D, suggesting that one of the potential benefits of diversity is creativity and increased innovation. However, the impact of diversity does not turn out to be significant for R&D when we use the GHK simulator. As expected affiliates that have been operating a longer time in Malaysia have a higher probability to perform R&D. The probability that an affiliate does R&D is higher if it is in a science-based sector.

The probability to engage in design activities is influenced by somewhat different factors. The coefficient of managers' diversity is positive and highly significant but affiliate size and age are not statistically significant. Similarly, internal capability (scientific and technical human capital) is not significant. However, local capacity is significant. When we use the GHK simulator, these results are confirmed. Market-intelligence is also influenced differentially. Performing market intelligence activities is not significantly associated with science-based sectors, although it is significant for supplier dominated sectors and is significantly associated with local capacity.

The results are mostly consistent with our hypotheses, but with important qualifications by type of innovation activity. The probability that an affiliate will undertake innovation activities if it has greater internal capabilities is confirmed.

6. Concluding Remarks

Traditional centralized theories propose that multinationals' R&D functions are based in their host countries because there are scale and scope economies to doing these high value activities centrally, protection of trade secrets is facilitated, coordination costs are reduced, and complex knowledge demonstrates spatial stickiness, to name a few of the rationales. Under this view, MNEs set up overseas innovation operations to take advantage of low costs while, except for adaptation requirements, keeping high value activities at home. The emergence of decentralized competency models has evolved in recent years to explain the observation that MNEs may locate the high value activities in the supply chain outside of host countries to take advantage of local capabilities, markets, and diverse knowledge sources. Malaysia provides a good setting for examining these two perspectives on multinationals' innovation strategies. Although Malaysia has attracted high tech production, particularly in specialized supplier industries such as electronics, it has not appeared to have a well known internal industrial R&D base or evidence in the past of substantial transfer with domestic firms.

Our analysis provides some support for the decentralized competency model. It shows that the likelihood that an affiliate conducts R&D in Malaysia is significantly associated with domestic firms' absorptive capacity as measured by domestic firms' levels of research expenditures. Moreover, domestic firms' absorptive capacity is significant in design and marketing as well as in R&D. The analysis also suggests that MNE's subsidiaries must have internal capabilities and a pool of human capital to leverage these local competences for the conduct of R&D. Affiliate size, as measured by number of employees, is associated with the performance of R&D in Malaysia as well. Furthermore, the technological quality and capabilities of the human capital pool--measured by number of employees with technical degrees--is significant to the performance of research by MNEs in Malaysia.

One driver of the decentralized competency model is the increasingly prominent linkage between R&D and other functions. The Vernon life cycle perspective tends to assume a linear model of innovation that can split business functions into separate innovation activities. This analysis found that R&D, design, and marketing are complementary and interdependent in an MNE. Even though R&D is somewhat weakly related to design and marketing, we may conclude that the decentralization of this activity is in part associated with the necessary interconnections between more sophisticated research-intensive activities and more routine marketing work. One limitation on this finding is the use of cross sectional analysis. While the cross sectional results indicate that all types of innovation activities are taking place together and seem to be complementary, a dynamic analysis based on panel data would be needed to confirm whether R&D, design, and marketing by multinationals actually occurred simultaneously or whether one was established before the others. Both the product life cycle/control model and the decentralized competency model are based on dynamic analysis. However, we do have a proxy for time-based relationships in the age variable, which measures the length of time an MNE has done business in the host country. The age of an MNE was shown to have a small but systematically significant positive impact on the probability of conducting R&D, and this impact was indicated in both independent and multivariate probit analysis. Future analyses based on dynamic panel data can confirm whether early multinational activities in a new emerging market are related to low value-added activities or high value R&D and design.

Multinationals appear to exhibit different strategies depending on the sector they operate in and the technological content of this sector, as measured by the Pavitt sectoral taxonomy. In specialized supplier industries such as electronics, the probability of conducting design activities is higher than the probability of conducting R&D. In science-based industries, the probability of a multinational conducting R&D is higher when a firm belongs to a science-based sector; however, the probability of a science-based multinational conducting marketing activities is not significant. Moreover, these innovation activities occur in science-based sectors where local firms have educational and other internal and external capabilities. MNEs appear to demonstrate behaviors associated with differentiated innovation strategies that distinguish between industrial, local human resource, and organizational capabilities in domestic firms and industries. Size also appears to be a differentiating factor in that larger MNEs have a higher probability of conducting research in the host country, but size is not a relevant variable in the decision to perform design and marketing activities.

Mutlinational behavior reflects different strategies for dealing with risk and uncertainty with respect to establishing manufacturing functions in emerging economies such as the one we have analyzed. This study suggests that the development of human capital and domestic firms' R&D capabilities is important for addressing risk in the operation of innovative remote operations. MNEs in general are more likely to be innovative, particularly in sectors where domestic firms are also innovative. This suggests that policy should seek to promote complementarities between MNEs and domestic firms (rather than viewing MNEs solely as competitors for domestic enterprises). However, R&D by MNEs appears to increase the longer the affiliate has been in-country, suggesting need for patient encouragement of MNE research activities in emerging economies. The nature of innovation in MNEs is complex, requiring attention to local capacity building, management diversification, and sectoral considerations.

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Table 1 Vernon product-cycle model vs new decentralized competence models in developing countries

	Vernon product-cycle model	**New decentralized competence models**
Approach	- Lineal vision of innovation	- Evolutionist and systemic
Decentralized activities	- Production facilities - Innovation with low added-value content follows production - Innovation mostly refers to minors technological transfers to affiliate in order to adapt to host country market conditions - May include market – screening an d design activites - In areas where they are strong at home	- Innovation and production occur at the same time, one inseparable from the other - Market-screening, design and other arts of the value chain with high-added-value content (e.g. R&D) are part of a complex process that occurs at the same time
Reasons to decentralize	- Being close to customers - Support production and reduce production costs of affiliates - Take advantage of large markets - Use cheap labor	- Use host country' technological infrastructure - Monitor new technological advances - Use cheap highly qualified personnel - Use country specific scientific or engineering expertise - New funding sources
Location of R&D	*In home countries* - Stickiness of knowledge - Reduce transaction costs - Take advantage of economies of scale and scope in knowledge production	*In host countries* - Improve affiliate's absorptive capacity - Diversify external knowledge sources - Low cost of R&D - Quality of R&D personnel - Localized knowledge spillovers - Establish knowledge links with local universities and R&D firms.

Figure 1 Affiliates' knowledge-based activities in decentralized competence models

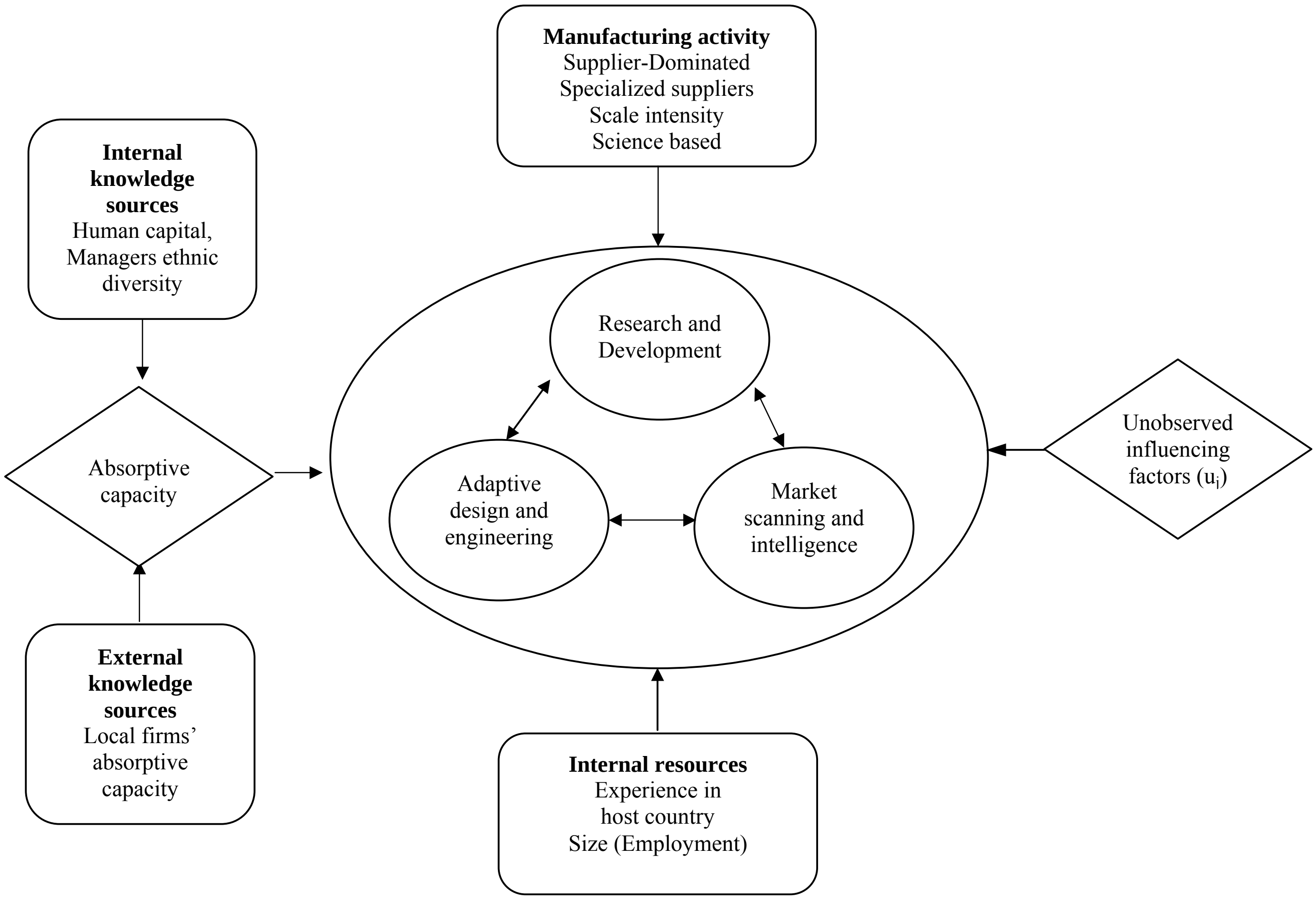

Table 2. Description of variables

Variable	Description	Mean (*std. dev.)*
RESEARCH AND DEVELOPMENT	Binary; = 1 if affiliate undertakes research and development to develop technologically new or improved products, processes, services or software, = 0 otherwise.[a]	0.36 (0.48)
DESIGN & ENGINEERING	Binary; = 1 if affiliate does design and engineering, including industrial, layout, product, process & service design specifications for production and delivery, = 0 otherwise.[a]	0.47 (0.50)
MARKET INTELLIGENCE	Binary; = 1 if affiliate does market intelligence activities, including market research, business or technology scanning to inform business planning, = 0 otherwise.[a]	0.48 (0.50)
HUMAN CAPITAL	Continuous; log (workers with a science degree /total number of employees). Numerator includes workers with degrees in computer science, software development, electrical and electronic engineering.[a]	0.01 (0.015)
MANAGERS DIVERSITY	Index; = $(1 - \Sigma p_k^2)$ where p_k is the proportion of workers for seven ethnic groups (k=Malay, Ibans, Bidayuhs, Bajaus, Kadazans, Chinese and Indians, Indonesians, Filipinos, Bangladeshis). [b]	0.45 (0.23)
LOCAL CAPACITY	Index; average of domestic R&D in each of the 16 manufacturing sectors that are considered for the analysis. Excluding R&D performed by MNEs. [a]	12.78 (1.19)
AGE	Discrete; average number of years doing manufacturing activities in Malaysia. [b]	17.47 (9.11)
SIZE	Continuous; log of number of full time equivalent employees (full time and part-time employees adjusted to full-time). [a]	5.24 (1.1)
SUPPLIER DOMINATED	Binary; = 1 if affiliate operates in food and beverages, textiles and apparel, leather and leather products, wood and wood-based products, rubber and plastics, petrochemical and other manufacturers, = 0 otherwise (N=39). [b]	0.22 (0.41)
SCALE INTENSIVE	Binary; = 1 if affiliate operates in motor vehicles and other transport equipment, = 0 otherwise (N=12).[b]	0.17 (0.37)
SPECIALIZED SUPPLIERS	Binary; = 1 if affiliate operates in metal and metal products, machinery and equipment, electrical, electronics and instruments = 0 otherwise (N=96). [b]	0.54 (0.49)
SCIENCE BASED	Binary=1; if affiliate operates in chemical, = 0 otherwise (N=30). [b]	0.07 (0.25)

Note on data sources: [a]M = Malaysian Knowledge Content Survey, 2002; [b]AS = Malaysian Department of Statistics, Annual Survey of Manufacturers, 2002. Standard Deviation in parenthesis

Table 3. Analysis of Occurrences of MNE Innovation Activities

State	(0,0,0)	(1,0,0)	(1,1,0)	(1,1,1)	(0,1,1)	(0,1,0)	(1,0,1)	(0,0,1)
MNE Affiliates	56	14	8	34	29	13	8	15
Percent of total	31.6	7.9	4.5	19.2	16.4	7.3	4.5	8.5

Note: (0, 0, 0) indicates that an affiliate undertook no innovation activities. (1, 1, 1) indicates that affiliate undertook Research and Development, Design and Engineering, and Market Screening. Other combinations as indicated, with 1 = Yes, 0 = No respectively for Research and Development, Design and Engineering, and Market Screening.

Source: Analysis of Malaysian Knowledge Content Survey, 2002. N = 171.

Table 4. Relationship (Chi-Squared) between Dependent Variables

Relationship between Research and Development and Market Intelligence			
	Market Intelligence		
Research and development	*No*	*Yes*	*Total*
No	69 (61.1%)	44 (38.9%)	113
Yes	22 (34.9%)	**42 (65.6%)**	64
Total	91 (51.4%)	86 (48.6%)	177
χ^2= 11.6490 ***			
Relationship between Research and Development and Design			
	Design and Engineering		
Research and development	*No*	*Yes*	*Total*
No	71 (62.8%)	42 (37.2%)	113
Yes	22 (34.9%)	**42 (65.6%)**	64
Total	93 (52.5%)	84 (47.5%)	177
χ^2 = 13.2692 ***			
Relationship between Design and Market Intelligence			
	Market Intelligence		
Design	*No*	*Yes*	*Total*
No	70 (75.3%)	23 (24.8%)	93
Yes	21 (25.0%)	**63 (75.0%)**	84
Total	91 (51.4%)	86 (48.6%)	177
χ^2 = 44.6471****			

Note: Row totals = 100%.
Source: Analysis of Malaysian Knowledge Content Survey, 2002.

Table 5. Coefficients Multivariate Probit

	Simulated maximum likelihood			GHK simulator		
	Research and Development	Design & Engineering	Market Intelligence	Research and Development	Design & Engineering	Market Intelligence
Human Capital	0.28*** (0.14)	0.33 (0.14)	0.20 (0.13)	0.28*** (0.14)	0.35 (0.14)	0.22 (0.13)
Managers Diversity	0.10* (0.68)	1.73*** (0.72)	0.64 (0.66)	0.09 (0.69)	1.83*** (0.72)	0.66 (0.67)
Local Capacity	0.52** (0.31)	0.46*** (0.33)	0.63*** (0.30)	0.47** (0.31)	0.43*** (0.32)	0.64*** (0.31)
Size	0.33*** (0.13)	0.07 (0.13)	-0.01 (0.12)	0.33*** (0.13)	0.06 (0.13)	-0.04 (0.12)
Age	0.01*** (0.01)	0.02 (0.01)	0.03* (0.01)	0.01*** (0.01)	0.03 (0.01)	0.03* (0.01)
Supplier Dominated	2.49** (1.43)	2.40*** (1.58)	2.48** (1.42)	2.31* (1.39)	2.18*** (1.56)	2.59** (1.41)
Science Based	2.90*** (1.18)	1.97*** (0.93)	1.28 (1.16)	2.78*** (1.15)	1.7*** (1.27)	1.25 (1.11)
Specialized Suppliers	1.45** (1.30)	2.57*** (1.29)	1.78** (1.30)	1.30* (1.27)	2.33*** (1.44)	1.88* (1.27)
Constant	-9.54*** (5.32)	-8.53*** (5.68)	-9.9*** (5.07)	-8.8*** (5.23)	-7.8*** (5.55)	-9.3*** (5.15)
Rho21	0.28** (0.15)			0.34*** (0.19)		
Rho31	0.22** (0.15)			0.38*** (0.17)		
Rho32	0.68*** (0.10)			0.81*** (0.19)		
Log likelihood	-168.72			-167.81		
Wald Chi2(24)	46.08			45.02		
LR test of Rho21=Rho31= Rho32=0 Chi2 (3)	25.25***			27.08***		

Notes: * significant at 10%; ** significant at 5%; *** significant at 1% Standard errors are reported in parentheses. Scale Intense, reference sector. Coefficients reflect changes in z-values. Estimation is based on multivariate probit module by Capellari and Jenkins (2003)

Source: Analysis of Malaysian Knowledge Content Survey, 2002. N=177.