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R&D and Export Intensities in Automotive Parts Firms in China, Malaysia, Philippines and Taiwan: Does Ownership Matter?

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This paper seeks to examine the importance of ownership in R&D intensities and export ownership in the automotive parts firms in China, Indonesia, Malaysia, Philippines and Taiwan. Consistent with the portfolio and ownership, location and internationalization theories of foreign direct investment about asset specific advantages, the pooled regressions show higher R&D intensities in local firms than in foreign firms. Export-orientation was only highly correlated with RD intensities in the local samples. The results also show foreign ownership to be highly correlated with export-orientation in the pooled regressions but not in the individual country regressions.

Keywords: R&D, Ownership, Exports, Automotive Parts, East Asia

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1. Introduction

Host governments look at several benefits to extract from attracting foreign direct investment – e.g. scarce capital inflow, job creation, exports to generate foreign exchange and technology transfer (see Lall and Streeten, 1977). This paper seeks to examine two of them, *viz*, one, attempts to complement their R&D efforts; and two, to use foreign firms to access export markets.

The debate on the relocation of R&D at host-sites is still intensely contested. Using the product cycle argument, Vernon (1966) had argued that multinational corporations (MNCs) would only relocate standardized mature product technologies outside their own home countries citing demand-supply conditions, protection of intellectual property rights and preference of national governments to support home firm operations. This debate has transformed considerably since the work of Helleiner (1973), Frobel, Heinrich and Kreye (1980), Dunning (1994) and Cantwell (1995).

Helleiner (1973) and Frobel, Heinrich and Kreye (1980) provided the initial evidence to show the international decomposition of production so that only low value added stages of manufacturing such as assembly and processing were relocated in developing economies – even of products still to mature. Whereas Helleiner considered such an internationalization of production as beneficial to developing economies, Frobel, Heinrich and Kreye interpreted it to expand exploitation with deleterious consequences for the developing economies. Evident in Helleiner's (1973) argument is that he relocation on labour-intensive stages of production in low cost

sites helps generate investment, employment and exports. The last point shows that foreign firms enjoy greater export-intensity potential compared to local firms.

Dunning (1994) and Cantwell (1995) produced evidence of R&D activities undertaken in developing economies making the case that it is the motives of MNCs that essentially explain if they would offshore R&D activities. This argument differs from the account of Amsden, Tschang and Goto (2000) who used evidence from Singapore to argue that it was only in peripheral aspects, which do not relate to the critical elements in which MNCs have offshored R&D activities. Ernst (2006) provided evidence of R&D offshoring in Taiwan and attempted to explain why MNCs have transformed their conduct.

Given the complexity involved in the R&D offshoring conduct of MNCs, Rasiah (2004; 2005; 2006) offered an alternative framework to examine technology diffusion, including R&D offshoring. Because the extent to which MNCs endowed with superior capabilities abroad would invest in R&D activities would depend on the embedding environment at host sites Rasiah argued that both taxonomies and trajectories will be important – which is consistent with the broader perspective of these concepts expounded by Dosi (1982) and Pavitt (1984). Lall (1978) and Rasiah (2003) showed evidence to argue that MNCs will begin participation in R&D activities with simple adaptations in processes and production machinery and equipment. It is only when the embedding environment becomes stronger with institutional deepening to support designing and new product development will MNCs have the motivation to spread into such deeper R&D activities (see Rasiah, 2006).

R&D offshoring in Taiwan is a classic example of such a pattern (see Ernst, 2006; Rasiah, 2007).

To study the patterns of R&D offshoring two major methodologies can be used. The first relies on case studies that enable a rich construction of technology sectorally with specific products and processes that firms develop at host-sites – both new to the firm and country, as well as new to the universe. The second can take on a more representative study but without sufficient mapping of relationships between firms and institutions using a survey of firms. The latter can provide a sense of R&D complexity when sequenced with the depth of activities undertaken by the firms. This paper uses the second methodology because of the nature of data available for analysis. Although R&D grants are typically provided only to local firms in a number of developing economies, it has not deterred foreign MNCs from offshoring R&D activities in Taiwan.

Export intensity differentials between foreign and local firms can be studied simply by examining the share of output going to export markets, and when connected with efficiency levels, to developed export markets. Because of superior technology and experience of participation in global markets, foreign firms are generally considered to enjoy greater access in export markets. These premises may not hold if the ownership advantages sought by foreign firms is limited to accessing protected domestic domestic markets – which for many years was notoriously the case in several economies – e.g. India, Brazil, Mexico and Korea (Rasiah, 2003). However, given the liberalization that has taken place in east Asia over the last few decades it can be expected that foreign firms in general will be more export-oriented.

Taiwan, China, Indonesia, Malaysia and Philippines were chosen to examine ownership effects on R&D and export-intensities intensities in a range of economies facing different levels of development of the embedding host-site environment. Korea and Thailand were in the original study but were dropped owing to acquisitions of local firms by foreign capital following the financial crisis of 1997-98.

The auto parts industry allows the assessment of systemic and institutional influences because of the significance of the industry in the economies chosen and the importance of R&D for firms to compete at the technology frontier. The rest of the paper is organized as follows. Section 2 reviews the literature on FDI and institutional and systemic support. Section 3 discusses the methodology and data. Section 4 examines differences in R&D and export-intensity, and important explanatory variables such as skills intensities between foreign and local firms, and the statistical relationships involving R&D. Section 5 presents conclusions.

2. Literature review

The theory of foreign direct investment (FDI) posits that multinationals enjoy asset specific (tangible and intangible) advantages over local firms (see Hymer, 1960; Dunning, 1958, 1974). Whereas the portfolio theory of FDI of Hymer emphasized ownership and host-site advantages that explain international operations Dunning emphasized ownership, localization and internationalization (OLI) elements in the relocation process. Access to superior resources in parent plants abroad is one factor considered to explain this advantage. The relocation of such an activity to developing

economies allows multinationals to internalize such resources. Owing to the superior demand (higher income populations) and supply (stronger institutions – human capital and R&D support, and property rights protection), Vernon (1966; 1971) had argued that MNCs would retain production of new products at parent sites. Vernon argued that relocation will only take place when the product matures. The decomposition of production especially in light manufacturing provided an initial critique to Vernon's product cycle argument (see Helleiner, 1973). The most sophisticated of product technologies – e.g. memory chips and microprocessors – experienced a global decentralization of production so that the low value added labour-intensive stages of production of the latest products such as assembly and test were relocated to developing sites such as Malaysia and China.

The superior experience and tacit relationships in global markets also supports the view that foreign firms will be more export-intensive than local firms. Helleiner's (1973) argued that the decentralization of production into different stages actually helped raise not only investment and employment but also exports from hosts-sites in developing economies. However, this premise may not hold if the relocation of multinational firms was targeted to supply protected domestic markets.

Nevertheless, the empirical evidence in the 1960s and 1970s tended to support the view that MNCs only relocated standardized product technologies, and whenever R&D was carried out at these sites they were confined to minor modifications to equipment and processes (see Hughes and You, 1969; Lall, 1979; Rasiah, 1992). It was not until the emergence of strong evidence of off-shoring by MNCs in developing economies that serious questions emerged about the product cycle argument (see Dunning, 1994;

Cantwell, 1995; Prasada, 2000; Hobday, 1996; Rasiah, 1996, 2004; UNCTAD, 2005; Ernst, 2006).

Motives for relocation to a large extent helped explain MNC initiatives to relocate R&D activities to host-sites economies (see Cantwell and Mudambi, 2001; Narula and Dunning, 2000). Dunning (1994) had already opened the way for a better understanding of spillovers at host-sites by addressing the motives for relocation. These developments nevertheless are still consistent with Hymer's (1960) efforts to relate relocation to host-site advantages and the expansion into multinational operations consequently raises concentration in specific product markets. It is indeed the host-site's benefits relative to other sites that explain R&D off-shoring today.

Evolutionary economics models added emphasis to the concept of technology by advancing the concept of NIS and its composition as a constellation of economic agents (firms and institutions) and the relationships between them (see Nelson and Winter, 1982; Freeman, 1987, 1989; Lundvall, 1988). The focus on science and technology infrastructure, sequencing in learning and innovation, and user-producer interactions are central to evolutionary arguments on technology. Using Japan's experience, Freeman (1987, 1989) had demonstrated convincingly that international flows of stocks of knowledge from developed to developing economies take a sequential shift involving import, adaptation, assimilation and innovation.[1] Lundvall (1988; 1992) introduced interesting empirical evidence to argue over the interactive nature of learning between producers and users. Edquist (2001) reiterated the industrial district argument on the need for interdependent relationships between economic

agents. Lall (1992) showed how firms move up the technology trajectory by learning initially simple and later complex technological capabilities before eventually participating in R&D activities.

Despite being associated with inward-oriented industrialization there is overwhelming evidence of export markets being critical to drive technical change in auto parts manufacturing (see Schumpeter, 1934; Hirschman, 1958). However, the hypothesis assumed here is consistent with Smith (1776) and Young (1928), that the division and labour and the size of the market drive each other simultaneously. Hence, a positive and strong relationship is expected between R&D intensity and export-intensity without any direction of causation assumed. Because of the greater reach of foreign firms in global markets (Hirschman, 1970; Dunning, 1974), foreign ownership is expected to be positively correlated with export-intensities.

This paper fuses the arguments advanced by the FDI theorists - Hymer (1960) and Dunning (1958; 1974) and the evolutionary theorists of Schumpeter (1934), Nelson and Winter (1982), Lundvall (1988) and Freeman (1989) to examine: 1) differences in R&D and export intensities between foreign and local firms facing different levels of development; 2) and whether export-intensity is positively correlated with R&D intensity even when controlled for ownership.

[1] Fukasaku (1992) used this framework to examine the evolution of technology in the Mitsubishi Nagasaki Shipyard.

[Table 1]

3. Methodology and data

This section introduces the methodology used to examine the statistical differences and relationships involving R&D intensities. The paper employs indexes to compare and examine R&D intensities in the six countries chosen.

No attempt is made to trace causation owing to the lack of panel data, and simultaneous causations expected between institutional, systemic, and firm-level variables. More importantly, following Smith (1776) and Young (1928) the paper assumes that causation runs both ways. In addition, there are also dynamic influences such as increasing returns, structural inter-dependence and complementarities (see Abramovitz, 1956; Kaldor, 1957).

The paper uses two-tail t-tests to examine statistical differences between foreign and local firms in all six countries. Tobit regressions were carried out to examine the relationships involving R&D and export intensities. Export intensity and ownership are used as the key explanatory variables.

3.1 Specification of variables

The variables used in the paper are specified in this sub-section, which along with the components, sources of data and where relevant, their relationships with R& intensity

are shown in Table 2. The firm-level dependent variables used are R&D intensity, and export intensity to examine if differences arise when the relationship is reversed. The specification of these variables is undertaken below.

R&D Intensity With the exception of contract R&D with public labs and universities, firms seldom participate in basic research. Hence, firm-level R&D is largely focused on process technology and product development – especially diversification of use and proliferation. Given that the strength of the R&D infrastructure among the economies in the sample vary fairly strongly with Taiwan enjoying the highest score followed by China, Malaysia, Philippines and Indonesia (see Table 1) R&D can be expected to produce a statistically significant and positive relationship with X/Y. Also, R&D intensity can be expected to be strongly and positively correlated with X/Y owing to greater competition in export than in domestic markets. However, because foreign firms still enjoy access to R&D facilities at their home sites their intensity of R&D utilization at host-sites is expected to be lower than in local firms especially in the more advanced economies such as Taiwan in the sample.

The data collected allowed the computation of two R&D proxies, *viz*., R&D expenditure as a percentage of sales and R&D personnel as a share of employment. It was not possible from the sample data to disentangle investment advanced between process and product R&D, and hence this proxy was measured to relate to both product and process R&D and was measured as:

$RD_i = 1/2[RDexp_i, RDemp_i]$

Where RD_{exp} and RD_{emp} refer to R&D expenditure as a share of sales and R&D personnel in workforce respectively of firm i. Because the proxies were evenly weighted, RD was divided by 2.

Export-intensity Given the positive effects of scale and scope, and competition provided by integration in export markets, export-intensity was examined separately as well as used as an explanatory variable in the RD regression. The proxy of export-intensity was used to represent firm-level export-orientation and was estimated as:

Export intensity = X_i/Y_i

Where X and Y refer to exports and gross output respectively of firm i in 2001.

Ownership The evidence on the influence of foreign ownership on R&D intensities is mixed. The Organization for Economic Cooperation and Development (OECD) (1998; cited in Amsden, Tschang and Goto, 2001: 5) reported that not more than 12 percent of total R&D expenditure was spent by firms outside home sites in developed economies. Lall (1992) argued that foreign firms transfer the innovation rather than the process itself abroad. Rasiah (1992; 1994) contributed empirical evidence to show that foreign firms generally participate only in process R&D in developing economies. However, Prasada (2000), Hobday (1996), UNCTAD (2005), Ernst (2006) and Rasiah (1996, 2004) provided evidence of the off-shoring of innovation activities in the electronics industry.

This paper takes hypothesizes that foreign firms R&D-related conduct at host-sites would change from simple improvements to process technology and product adaptation to product development when the embedding environment is equipped with frontier R&D activities or participation design-related R&D activities. This is consistent with Ernst (2006) findings of R&D offshoring in Taiwan. Local firms may show lower R&D intensities - if they simply participate in low value added assembly and processing activities at host-sites facing a weak R&D infrastructure - than foreign firms' if the latter is engaged in process and product adaptation activities as in Indonesia. However, because of the access foreign firms enjoy with home-site plants local firms are likely to invest much more than foreign firms in R&D activities at host-sites. In addition, because of superior access foreign firms have in global markets, foreign ownership is expected to enjoy a positive relationship with X/Y. Two different ownership proxies were used in the paper. The first (FO) simply used the foreign equity share, while the second (FO1) used a 50 percent foreign equity share to differentiate samples into foreign and local. FO and FO1 were measured as:

FO_i = Foreign equity/total equity.

$FO1_i$ =1 if foreign equity ownership of firm i was 50 percent or more; FO= 0 otherwise.

FO was used in the overall samples while FO1 was used to split the overall sample into foreign and local samples.

The breakdown of the firms on the basis of ownership is shown in Table 3. Because foreign firms enjoy access to assets at parent-sites while local firms are forced to develop their technology at host-sites, FO is expected to show a negative relationship

with RD. Because of superior access in export markets FO is expected to enjoy a strong and positive relationship with X/Y.

Insert table 2 here

Control variables

Four other important firm-level variables were included in the analysis. The control variables introduced in the equations are union incidence, size, age and country dummies. Size (S) was dropped from the pooled regressions owing to serious multi-collinearity problems with union (U) incidence (see Appendix 1), which is understandable as larger firms tend to allow unionization more than smaller firms.

Labour market variable Wages (W) was used in the individual country regressions as the labour market variable but was dropped in the pooled regression owing to high multi-collinearity problems with the country dummies (see Appendix 1).[2] Union (U) incidence was used instead in the pooled regressions to represent the labour market variable. The relationships between X/Y, and W and U, and RD and W and U are expected to be positive

W was measured as:

W_i = Total monthly wages and salaries/Workforce of firm i.

[2] Using W as an independent variable clearly biases the estimates.

U was measured as:

$U_i = 1$ if firm reports the presence of unionized workers; $U_i = 0$ otherwise.

Size There is a long-standing debate on the importance of size on firms' export and R&D intensities. Typical industrial organization arguments posit that firms achieve competitiveness with a certain minimum efficiency scale (MES), which varies with industries (see Scherer, 1980; 1992; Pratten, 1971). The auto parts industry is a diverse one in which some sub-sectors are scale-intensive (e.g. absorbers, stereo sets, and tires) while some specialize on the basis of scope (e.g. command navigation systems, gearbox, lights). Audretsh (2002) offered pervasive analysis of U.S. data to dispel arguments related to the significance of large size in efficiency and innovative activities. The increasing decomposition and dispersal of production involving electronics firms has made small size efficient. Given the controversy over the role of size in economic performance and the claims of industrial organization exponents over MES differences, a neutral hypothesis was framed – simply that size may have a bearing on technological capabilities.

Two categories, small and medium and large, were chosen and measured as a dummy variable:

$S_i = 1$ when employment size was 500 or less; $S_i = 0$ if otherwise.

Where S refers to size of firm i.

Age Age is considered to provide a positive relationship with export intensity and technological capabilities given that firms with longer experience are considered to enjoy greater experiential and tacit knowledge. However, the statistical relationship may not be positive if foreign firms, using superior technology from abroad and enjoying strong access to global markets, only started relocating their operations recently. Hence, a neutral relationship is assumed. The absolute age of the firm is used as an independent variable and was measured as:

A_i = years in operation of firm i.

Where A refers to the age of operation of firm i in 2001.

Overall 345 auto parts firms responded to the survey (see Table 3). The national sampling frames of the five countries were not used owing to the difficulty of obtaining firm-level data. Case studies of auto parts firms in China, Indonesia, Taiwan and Philippines were carried out by national consultants, while the author undertook similar interviews in Indonesia, Philippines, Taiwan and Malaysia.

Insert Table 3 here

3.2 Statistical Equations

This section presents the equations used to estimate the statistical relationships involving RD and X/Y intensities. Tobit regressions were preferred in the X/Y and RD regressions since the dependent variables were censored between 0 and 1. Country dummies were used in both regressions.

Tobit: $RD = \alpha + \beta_1 X/Y + \beta_2 FO + \beta_3 A + \beta_4 U + \mu$ (1)

Tobit: $X/Y = \alpha + \beta_1 RD + \beta_2 FO + \beta_3 A + \beta_4 U + \mu$ (2)

Both regression equations above were repeated by individual countries, and pooled regressions as a whole and by foreign and local samples separately. Size was included in the country regressions.

4. Statistical results

This section discusses statistical differences in R&D and export intensities between foreign and local firms in the six economies, and the relationships involving R&D and export intensities.

4.1 Statistical differences

This section examines statistical differences in R&D and export intensities between foreign and local firms using two-tail t-tests of means.

The mean R&D intensity score of firms in Taiwan were significantly higher than those in China, Indonesia, Malaysia and Philippines irrespective of ownership (see Table 4). Local firms enjoyed a statistically significant higher RD mean than foreign firms in Taiwan and Philippines, though it was low in the latter (see Table 4). The case study interviews carried out in Taiwan showed that local firms managed to marry the world class industries of machinery and electronics to produce state-of-the-art auto parts products with significant numbers of patents taken in the United States. None of the firms in Philippines, Malaysia and Indonesia reported take up of patents in automotives in the United States.

With the exception of China, there were not obvious statistical differences between foreign and local firms in export intensities in the remaining four economies (see Table 4). Foreign firms enjoyed a higher X/Y mean than local firms in China. Local firms enjoyed higher means than foreign firms in Indonesia and Philippines, and foreign firms enjoyed higher means than local firms in Taiwan and Malaysia but these results were not statistically significant.

Insert table 4 here

Overall the results show a pattern among the statistically significant results in R&D. Local firms show higher R&D intensities than foreign firms in Taiwan and Philippines. The results also show that foreign firms' RD intensity rise the stronger the RDI index of the host-site demonstrating that foreign firms do undertake R&D activities off-shore. Foreign firms show higher export-intensity than local firms in China.

4.2 Statistical Relationships

This section examines the statistical relationships involving R&D and export intensities. All the rhe results passed the White and Cooke-Weisberg test for heteroskedasticity and hence it not likely that there are intervening variables influencing the correlations in the paper. Also the regressions also passed the chi-square (χ^2) model-fit tests.

Individual Country Results

Separate regressions were run to examine the relationships involving R&D and X/Y intensities and the results are shown in Tables 5 and 6.

R&D Regressions

FO enjoyed a inverse relationship in the R&D regressions among the statistically significant results. Once controlled for other explanatory and control variables FO was only statistically significant in the Malaysia, Philippines and Taiwan samples (see Table 5). FO was statistically highly significant (at 1% level) but the negative coefficient shows that local firms participate much more strongly in R&D activities than foreign firms in Taiwan and Philippines. The same relationship was observed in Malaysia but the coefficient of FO was only statistically significant at 10 percent level.

The explanatory variable of X/Y was statistically significant in the Malaysia, Philippines and Taiwan samples. The positive coefficients in the Malaysia and

Taiwan samples demonstrate that export markets are important in driving firms' participation in R&D activities. The negative coefficient in the Philippines sample suggests that the little R&D undertaken is targeted more towards the domestic market.

Wages was only statistically significant in China and Indonesia. The highly significant and positive coefficients show that automotive firms in these economies endowed with large labour forces are engaged in a wide range of activities but firms engaged in R&D activities pay a premium to hire human capital.

The S variable was statistically significant and its coefficient positive in the Indonesia (1%), Malaysia (1%) and Taiwan (5%) showing that scale is important in driving R&D activities in these economies. The control variable of A was only significant in Philippines and its negative coefficient means that newer firms participate more in R&D activities in the country.

Insert table 5 here

Export Intensity Regressions

Foreign ownership was statistically significant in the X/Y regressions in the Indonesia, Malaysia and Philippines samples (see Table 6). The coefficients were positive in the Indonesia and Malaysia samples denoting that foreign firms are more export-oriented than local firms in these economies. The inverse relationship in Philippines shows that foreign firms are engaged more in supplying the domestic market.

Reversing the regression produced the same positive relationship between X/Y and RD in the Malaysia and Taiwan samples and negative relationship in the Philippines sample. The positive and significant (5%) coefficient in the Malaysia and Taiwan samples shows that participation in R&D activities has helped raise export intensities in these economies. The inverse relationship in Philippines confirms the domestic orientation of R&D activities in the country.

W is statistically significant in Indonesia, Malaysia and Taiwan while size is statistically significant in Indonesia and Malaysia (see Table 6). Lower wages seem to raise export competitiveness in Malaysia and Taiwan, which could be a consequence of specialization in low margin high volume exports. The higher premiums enjoyed in domestic markets could also explain this. The positive coefficient of W in the Indonesia sample suggests that skilled workers are engaged more in export manufacturing. The positive sign of S in Indonesia and Malaysia shows that scale appears to be important in these economies to compete in export markets.

Insert Table 6 here

Pooled Regression Results

The pooled RD and X/Y regressions produced positive and statistically significant results (see Table 7).

The coefficient of FO was positive and statistically highly significant (1%) in the X/Y regressions but negative and significant (5%) in the RD regressions. While foreign

firms are much more export-oriented than local firms, the latter were much more R&D intensive than the former. Whereas superior advantages abroad have produced strong export penetration, it has reduced R&D intensities. Lacking in asset specific advantages abroad local firms have been forced to deepen their R&D activities at home to upgrade and compete.

As expected RD was also statistically highly significant (1%) in the overall samples in the X/Y regression, and when the relationship is inverted in the RD regression (see Table 7). Although this exercise does not attempt to establish causation owing to the lack of panel data, consistent with the Smith-Young argument that causation run both ways the positive and strong relationship means that raising R&D intensities help expand export-intensities and *vice versa*. The ownership regressions show RD is not significant in the X/Y regression and X/Y in the RD regression though the signs are positive as expected in both of them. The statistically higher significance of RD in the X/Y regression and X/Y in the RD regression in the local sample confirms the importance local firms attach to host-site investment in R&D activities to compete in export markets, which is consistent with the Hymer-Dunning asset specific advantage thesis.

As expected U had a positive sign in all the regressions and was statistically highly significant (1%) in the overall (see Table 7). Whereas U was only statistically significant in the X/Y regression in the foreign sample it was only significant in the RD regression in the local sample.

Insert Table 7 here

Taken together, the statistical regressions produced interesting results. Local firms generally show higher R&D but lower export-intensities than foreign firms and these results are confirmed in the pooled regressions where the relationship between X/Y and RD both ways is statistically highly significant. The relationship – including when inverted - between X/Y and RD is positive in all three samples. Clearly, competition seems to have helped raise R&D intensities of local exporting firms. The results reinforce the foreign firms superior access to export markets, and the significance of export markets in driving R&D intensities up in local firms.

5. Conclusions

This paper examined differences in R&D and export intensities between foreign and local automotive parts firms in five East and Southeast Asian economies. The results allowed an assessment of statistical differences between foreign and local firms, as well as, the statistical relationships involving R&D and export intensities.

Two-tail t-tests produced some evidence of the ownership variable influencing the R&D and export intensity variables. Local firms enjoyed a statistically significant and higher RD than foreign firms in Taiwan and Philippines and foreign firms enjoyed higher X/Y intensity than local firms in China. Controlling for other influences using country-level regressions confirmed the influence of local ownership on R&D intensities in Philippines and Taiwan. In addition, FO also showed an inverse relationship with RD in the Malaysia sample. However, FO enjoyed a positive relationship with X/Y in the Indonesia and Malaysia samples and a negative

relationship in the Philippines sample. RD enjoyed a positive relationship with X/Y in the Malaysia and Taiwan samples but a negative one in the Philippines sample. Whereas R&D appears to be driving exports in Taiwan and Malaysia, it seems to be targeted towards the domestic market in Philippines.

FO was statistically significant in both the pooled X/Y and RD regressions, the coefficient being positive in the former and negative in the latter. Obviously foreign firms are using the five economies to export more than to participate in R&D activities. The pooled regressions also showed strong relationship between RD and X/Y (both ways) only in the overall and local samples demonstrating the significance of in-house R&D in driving exports and *vice versa* in local firms. Consistent with the Hymer-Dunning thesis foreign firms still utilize home-site advantages to access know how as well as export higher value added products.

The results indicate that foreign ownership is important in driving exports but local firms remain the spearheads of R&D intensities at host-sites. Despite these conclusions it is also obvious that both local and foreign firms participate in R&D activities with the intensity varying from one economy another depending on the the level of development of their high tech institutions. Policies should thus target foreign direct investment to stimulate greater export-orientation but focus R&D instruments on local firms or joint-ventures. The strategies for individual economies would obviously differ with their specific endowments and their technology trajectories. These results should also provide the motivation necessary to carry out a more representative innovation survey to test the endogenous argument on the relationship

between institutional and systemic instruments, embodied technology in firms and economic performance.

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Insert Appendix 1 here

Table 1: Research and Development Infrastructure, 2001

	RDI
China	0.102
Indonesia	0.020
Taiwan	0.500
Malaysia	0.042
Philippines	0.034

Note: R&D Infrastructure (RDI) calculated using the usual normalization formula and the proxies of R&D scientists and engineers in population, and R&D investment in Gross Domestic investment (GDI) using 61 countries where the data was available from World Bank (2003) and national ministries. RDI were adjusted by dividing the scores with the highest observation so that the figures fall within $0 \leq X \leq 1$.

Source: Computed from World Bank (2003); Taiwan (2004); Malaysia (2004)

Table 2: List of variables and expected relationship with the dependent variables, 2001

Independent variables (in bold)	**Acronym**	**Dependent variables**	
		X/Y	**RD**
Export intensity	X/Y		+ve
R&D expense in sales	RDexp		
R&D personnel in workforce	RDemp		
RD index	RD	+ve	
Wage	W	+ve	+ve
Foreign ownership share	FO	+ve	-ve
Size	S	Unclear	Unclear
Age	A	Unclear	Unclear

Table 3: Breakdown of Surveyed Automotive Parts firms, 2001

	Foreign	Local	Total
China	12	45	57
Indonesia	6	82	88
Malaysia	22	66	88
Philippines	10	26	36
Taiwan	20	56	76
Total	70	275	345

Source: Calculated from ADB (2002), UNU-MERIT (2002) surveys

Table 4: Two-tailed t-tests Comparing Means of Foreign and Local Automotive Parts Firms, 2001

X/Y	**Foreign**	**Local**	**t**
China	0.360	0.190	2.684*
Malaysia	0.362	0.317	0.560
Taiwan	0.470	0.447	0.372
Indonesia	0.083	0.141	-0.947
Philippines	0.109	0.194	-1.579
RD	**Foreign**	**Local**	**t**
China	0.230	0.190	1.096
Malaysia	0.200	0.240	-1.057
Taiwan	0.470	0.690	-3.610*
Indonesia	0.110	0.100	0.176
Philippines	0.020	0.110	-3.406*

Note: * refers to 1% level of significance.

Source: Computed from ADB (2002), UNU-MERIT (2002) surveys using SPSS package.

Table 5: R&D Intensity Regressions by Individual Economies, 2001

	China	Indonesia	Malaysia	Philippines	Taiwan
XY	0.074 (0.301)	0.069 (1.071)	0.108 (1.826)***	-0.187 (-1.765)***	0.229 (2.042)**
FO	-0.023 (-0.146)	-0.027 (-0.276)	-0.123 (-1.818)***	-0.320 (-3.187)*	-0.279 (-3.234)*
W	0.867 (3.687)*	0.023 (2.382)**	-0.000 (-1.139)	0.031 (1.377)	0.003 (0.802)
S	0.103 (1.020)	0.141 (3.263)*	0.191 (3.954)*	-1.157 (-0.000)	0.195 (2.277)**
A	-0.002 (-0.617)	0.002 (1.116)	-0.007 (-2.740)*	-0.006 (-2.515)*	0.003 (0.886)
μ	0.243 (2.295)**	-0.043 (-1.280)	0.319 (5.485)*	0.191 (2.234)**	0.433 (3.149)*
N	57	88	88	36	76
***LR*χ2**	-1.692*	11.344*	25.009*	6.133*	-0.761*

Note: *, ** and *** refer to z statistics at 1, 5 and 10% level of significance.

Source: Computed from ADB (2002) and UNU-MERIT (2002) surveys using Eviews-5 Statistical Package.

Table 6: Export Intensity Regressions by Individual Economies, 2001

	China	Indonesia	Malaysia	Philippines	Taiwan
RD	0.030 (0.399)	0.820 (1.581)	0.506 (2.126)**	-1.394 (-2.597)*	0.252 (2.107)**
FO	0.011 (0.125)	0.659 (1.930)**	0.498 (3.560)*	-0.359 (-2.270)*	0.028 (0.296)
W	0.231 (1.618)	0.066 (1.978)**	-0.000 (-3.902)*	0.019 (0.593)	-0.009 (-2.885)*
S	-0.033 (-0.597)	0.306 (2.038)**	-0.297 (-2.644)*	-0.067 (-0.549)	0.045 (0.502)
A	0.002 (1.319)	0.007 (1.441)	0.018 (3.065)*	-0.010 (-2.723)*	-0.012 (-3.993)*
μ	0.063 (1.029)	-0.593 (-3.936)*	0.154 (1.098)	0.478 (3.616)*	0.727 (5.879)*
N	57	88	88	36	76
***LR* χ2**	31.417*	-44.006*	-31.148*	-5.820*	-0.761*

Note: *, ** and *** refer to z statistics at 1, 5 and 10% level of significance.

Source: Computed from ADB (2002) and UNU-MERIT (2002) surveys using Eviews-5 Statistical Package.

Table 7: Export and R&D Intensities, Pooled Regressions, 2001

	X/Y			RD		
	All	**FOREIGN**	**LOCAL**	**All**	**FOREIGN**	**LOCAL**
X/Y				0.231 (3.752)*	0.175 (1.118)	0.229 (3.477)*
RD	0.280 (4.287)*	0.157 (1.397)	0.309 (3.865)*			
FO	0.201 (2.957)*			-0.144 (-2.210)**		
U	0.128 (3.300)*	0.080 (1.184)	0.163 (3.411)*	0.108 (2.996)*	0.213 (2.753)*	0.059 (1.453)
A	0.002 (1.179)	0.000 (0.100)	0.001 (0.400)	0.004 (2.481)*	-0.003 (-0.781)	0.006 (3.767)*
COUN	-0.080 (-5.397)*	-0.095 (-4.078)*	-0.084 (-4.630)*	-0.087 (-6.284)*	-0.056 (-1.787)***	-0.088 (-5.871)*
μ	0.275 (3.746)*	0.505 (4.425)*	0.305 (3.643)*	0.449 (6.665)*	0.360 (2.320)**	0.418 (5.945)*
N	345	70	275	345	70	275
LR χ2	-135.46*	-10.01*	-124.46*	-119.87*	-24.040*	-93.07*

Note: *, ** and *** refer to z statistics for X/Y and RD respectively at 1, 5 and 10% levels of significance.

Source: Computed from ADB (2002) and UNU-MERIT (2002) surveys using Eviews-5 Statistical Package.

Appendix 1: Correlation coefficients involving independent variables used in regressions, 2001

	XY	*RD*	*U*	*A*	*FO*	*S*	*W*	*COUN*
XY	1.000	0.285	0.107	0.058	0.144	0.026	0.025	-0.220
RD	0.285	1.000	0.140	0.190	-0.055	0.288	-0.174	-0.216
U	0.107	0.140	1.000	0.239	0.041	0.419*	-0.186	0.154
A	0.058	0.190	0.239	1.000	-0.193	0.306	-0.136	0.024
FO	0.144	-0.055	0.041	-0.193	1.000	0.029	0.152	-0.164
S	0.026	0.288	0.419*	0.306*	0.029	1.000	-0.005	-0.037
W	0.025	-0.174	-0.186	-0.136	0.152	-0.005	1.000	-0.644*
COUN	-0.220	-0.216	0.154	0.024	-0.164	-0.037	-0.644*	1.000

Note: * - too high correlation found to bias estimates when used together as independent variables.

Source: Computed from ADB (2002) and UNU-MERIT (2002) survey using SPSS package.