Determinants of Innovation in the Malaysian Manufacturing Sector: An Econometric Analysis at the Firm Level*

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1.Introduction

The survey-based empirical literature on technological innovations in developed countries is relatively well established. Countries within the European Community have carried out three waves of national surveys of innovation in the form of the *Community Innovation Surveys* (CIS) since the early 1990s. Malaysia has attempted to replicate these surveys via its *National Survey of Innovation* in the manufacturing sector since the mid-1990s. The first survey was conducted in 1995 (covering the period 1990-1994), the second survey in 2000 (covering 1997-1999) and the latest in 2002/2003 (covering the period 2000-2001).

This paper undertakes an econometric analysis of the determinants of innovation in the Malaysian manufacturing sector using the firm-level data collected from the recent *National Survey of Innovation 2000-2001*. We explore the influence of firm and industry characteristics on the propensity to innovate in the manufacturing sector. Firm characteristics that are included in the study include age of firm, extent of local ownership, size of firm, export shares of revenues and type of ownership. The two industry characteristics that are examined are the type of industry in terms of technology level and market concentration.

The outline of the rest of the paper is as follows. Section 2 briefly discusses some of the recent survey-based empirical literature on innovation. This is followed by a description of the data used in the study in Section 3. Section 4 discusses the various model specifications used in the study. A summary statistics of the data is provided in Section 5. Section 6 examines the empirical results from the logistic regressions. Section 7 concludes.

2. Related Literature

The survey-based and firm-level empirical literature on the determinants of innovation is fairly recent. Kleinknecht and Mohnen (2002) provide a useful collection of empirical papers on the various aspects of innovation based on CIS-1 data. In the volume, Mohnen and Dagenais (2002) found that the propensity to innovate in Denmark is significantly determined by industry type, firm size (measured by number of employees) and group subsidiary. Baldwin *et al* (2002) examines the various determinants of product and process innovation such as firm size, ownership (foreign vs. local), number of competitors, R&D activity, patents, trade secret protection, and collaboration agreements. The French and Spanish experiences are discussed by Cabagnols and Le Bas (2002) and Martinez-Ros and Labeaga (2002), respectively. In Cabagnols and Le Bas (2002), market structure (measured by the Herfindahl Hirschman Index) is used as one of the determinants of innovation. Cainelli et al (2001) uses both the CIS-1 and CIS-2 data for Italy to examine the determinants of innovation in terms of explanatory variables such as firm size, geographical areas, and industry type.

The Ministry of Science, Technology and the Environment, Malaysia (MOSTE) has carried out three national surveys of innovation since the mid-1990s. Of these, two have been published – MOSTE (1997, 2001). Only summary statistics are reported in these publications. To date, no econometric analysis has been carried out on data collected from any of these surveys.

3. Source of Data

The data for the present study on innovation activities in Malaysian manufacturing sector comes from the *National Survey of Innovation* that was conducted between December 2002 and May 2003. The questionnaire and methodology for the Survey is similar to that adopted for the CIS-2 and CIS-3. The reference year for the Survey is 2000-2001. Employment and export share of sales data used in our analysis are for year 2001.

In the survey questionnaire, firms are asked whether they innovate or not based on definitions of innovation that are used in the *Oslo Manual* and the CIS surveys. Innovation can involve product or/and process innovation. The full definitions for innovation, product and process innovation is provided in the **Appendix**.

A total of 4,000 questionnaires were sent to various firms registered with the Department of Statistics, Malaysia. Of these, 749 firms responded giving a response rate of 18.7%. A total of 263 (or 35.1%) firms that responded indicated that they carried out innovation activities. These firms come from 23 industries (at the two-digit level) in the manufacturing sector.

Data on industry market concentration comes from a recent study commissioned by the Ministry of Domestic Trade and Consumer Affairs. The estimates of the Herfindahl-Hirschman Index (HHI) are for year 2000. Estimates of the HHI at the aggregated level (2-digit) are derived from disaggregated 5-digit HHI estimates (computed by the Department of Statistics) using a weighted approach. Turnover figures for the various industries are used to derive the weights.

4. Model Specification

We follow the conventional practice of using a discrete and limited dependent variable model to analyze the determinants of the propensity to innovate.

The propensity to innovate is modelled as:

$$y_i = \mathbf{X}_i\boldsymbol{\beta} + \mu_i \qquad \text{..... (1)}$$

where

$$y_i = \begin{cases} 1 & \text{if firm } i \text{ innovates} \\ 0 & \text{otherwise} \end{cases} \qquad \text{..... (2)}$$

$\mathbf{X}_i$ is the set of exogenous (dependent) explanatory variables.

The probability of innovation is modelled as a logit model:

$$prob(y_i = 1) = \frac{\exp \mathbf{X}_i\boldsymbol{\beta}}{1 + \exp \mathbf{X}_i\boldsymbol{\beta}} \qquad \text{..... (3)}$$

Model 1: Firm Characteristics

In our simplest model, we postulate that the probability of innovating is influenced by the following factors: age of firm (AGE), extent of local ownership (OWN), firm size measured by total employees (SIZE1), and the percentage of sales derived from exports (EXPORT).

The full model is expressed as follows:

$$y = b_0 + b_1 AGE + b_2 OWN + b_3 SIZE1 + b_4 EXPORT + m \quad \ldots\ldots (4)$$

Model 2: Firm Characteristics With Ownership Type

In a slightly different model, we include ownership structure dummies to take into account the different ownership structures (TYPE). The four types of ownership in our data set are sole-proprietorship, partnership, private limited (Sdn.Bhd.) and public limited (Bhd).

The regression model with the four types of ownership structures is as follows:

$$y = b_0 + b_1 AGE + b_2 OWN + b_3 SIZE1 + b_4 EXPORT + b_5 TYPE_1 + \ldots\ldots + b_8 TYPE_4 + m \quad \ldots\ldots (5)$$

Model 3: Firm and Industry Characteristic

Innovation may be more probable in some industries compared with others. We add two types of variables to capture industry characteristics. An interesting hypothesis would be that firms in high-technology industries are more likely to innovate compared to those in low technology industry. We investigate the possibility of differences in the propensity to innovate in the different types of industries classified by technological levels.

Hatzichronoglou (1997) provides a classification scheme for manufacturing industries that we can use for this purpose. Using this classification scheme, we label an industry as one of the following:

(a) high technology (IND_1);

(b) medium-high technology (IND_2);

(c) medium-low technology (IND_3); and

(d) low technology (IND_4).

Table 1 summarizes the classification of the various industries by their technological characteristics.

The effect of market concentration on innovation can be tested by including an industry concentration measure. We use the Herfindahl-Hirschman Index (HHI) as a measure of concentration.

The regression equation that incorporates both technological characteristics and market concentration is as follows:

$$y = \beta_0 + \beta_1 AGE + \beta_2 OWN + \beta_3 SIZE1 + \beta_4 EXPORT + \beta_5 TYPE_1 + \ldots\ldots + \beta_8 TYPE_4 + \beta_9 IND_1 + \ldots\ldots + \beta_{12} IND_4 + \beta_{13} HHI + \mu \quad \ldots\ldots (8)$$

5. Summary Statistics

The distribution of the innovating and non-innovating firms across the different manufacturing industries in the survey data set is summarized in **Table 2**. A significant number of firms sampled come from three industries, namely: food products and beverages (115 firms), wearing apparel, dressing and dyeing of fur (102 firms) and fabricated metal products (93 firms). These industries account for 41.4% of the total firms in the data set.

Table 3 summarizes the distribution of innovating and non-innovating firms by employment size. The firms in the survey data set are predominantly small firms. Close to 60% of the firms in our data set have less than 50 employees. Compared to non-innovating

firms, a greater proportion of innovating firms tend to be large firms. About 45.2% of innovating firms have less than 50 employees while 67.7% of non-innovating firms have less than 50 employees. The average number of employees for innovating and non-innovating firms is 304 and 74 employees, respectively.

About 78.6% of the firms in the data set are 100% owned by Malaysians (see **Table 4**). There appears to be little difference between innovating and non-innovating firms in terms of the extent of local ownership (75.3% vs. 80.5% in the case of wholly locally-owned firms).

As for the type of ownership, more of the innovating firms tend to be of the private limited type (70.7%) while non-innovating firms tend to show a greater presence of sole-proprietorship and partnership (51.3%) (see **Table 5**).

6. Regression Results

In this section we discuss the maximum likelihood regression results. The regression results for the three models discussed above are summarized in **Table 6**.

The likelihood ratio test indicates that the null hypothesis that the appropriate model contains only a constant (intercept) is decisively rejected. The goodness-of-fit (as measured by the pseudo R^2) of the more comprehensive Model 3 is higher than that of Model 1 and Model 2 indicating that the more comprehensive Model 3 has higher explanatory power than Model 1 and Model 2.

Firm Characteristics

(a) Age of Firms

The negative sign for the coefficient of the variable representing firm's age indicates that younger firms are more likely to innovate compared to older firms. Age of firm is a significant explanatory variable at the 5-percent level in Model 2 and Model 3. The odds ratio indicates that an increase in the age of a firm by one year reduces the probability of innovating by 0.98.

(b) Extent of Local Ownership

The coefficient for the variable representing the extent of local ownership has an inconsistent sign across the different models. The variable is also statistically insignificant in all three models.

(c) Firm Size

The positive sign for the coefficient of the variable representing firm size indicates that larger firm are more likely to innovate compared to smaller firms. This variable is statistically significant at the 5-percent level in all the models. An increase in the size of the firm by one employee increases the probability of innovation by 1.0013 (Model 3).

(d) Share of Export in Sales

The negative sign of the coefficient for the variable representing percentage share of export in sales indicates that firms that produce for domestic market tend to be more innovative than those producing for export markets. This variable is significant at the 5-percent level in all the three models. The odds ratio indicates that a one percentage increase in share of exports in sales is associated with an increase of decline of 0.0120 in the probability of innovation.

(e) Type of Ownership
The different sizes of the coefficients for the dummy variables representing the various types of ownership structure indicate that the propensity to innovate differs across the different types of ownership. Private limited firms (Sdn.Bhd.) and public limited firms (Bhd.) have higher probability of innovation compared to sole-proprietorship and partnership firms. In general, all these explanatory variables are statistically significant.

Industry Characteristics

(f) Type of Industry by Technological Characteristics

The sizes of the coefficients for the dummy variables representing the types of industries (classified by technological characteristics)

suggest that firms in low technology industry are more likely to innovate that those in low-medium technology and high-medium technology industries. However, with the exception of the high-medium technology variable, none of these dummy variables are statistically significant as explanatory variables for the propensity to innovate.

(g) Market Concentration

The positive sign for the coefficient for the variable representing market concentration indicates that higher market concentration is associated with higher propensity to innovate. The market concentration variable is statistically significant at the 5-percent level.

7. Conclusions

The econometric analysis on the innovation survey data indicates that the propensity to innovate is positively related to firm size and negatively correlated to the age of the firm. A surprising finding is that propensity to innovate is negatively correlated to the share of exports in sales. Our findings also indicate that the extent of local vs. foreign ownership is not an important determinant of innovation. However, ownership structure appears to be an important determinant of innovation. Private limited and public limited firms are more likely to innovate compared to sole-proprietorship and partnership firms. The findings on the influence of industry-level characteristics are mixed. While the influence of industry's technology level is inconclusive, the propensity to innovate is positively correlated with market concentration.

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Table 1: Classification of Industry by Technology Level

sion	Industry	Incidence of Innovation	OECD Product Classification
5	Food Products and Beverages	30	Low-Technology
6	Tobacco Products	50	Low-Technology
7	Textiles	73	Low-Technology
8	Wearing Apparel; Dressing and Dyeing of Fur	28	Low-Technology
9	Tanning and Dressing of Leather; Luggage, Handbags, Saddelery, Harness and Footwear	25	Low-Technology
0	Wood; Products of Wood and Cork Except Furniture; Articles of Straw and Plaiting Materials	16	Low-Technology
1	Paper and Paper Products	38	Low-Technology
2	Publishing, Printing and Reproduction of Recorded Media	52	Low-Technology
3	Coke, Refined Petroleum Products and Nuclear Fuel	100	NA
4	Chemicals and Chemical Products	42	Low-Medium-Technology
5	Rubber and Plastic Products	41	Low-Medium-Technology
6	Other Non-Metallic Mineral Products	39	Medium-High-Technology
7	Basic Metals	27	Low-Medium-Technology
8	Fabricated Metal Products, Except Machinery and Equipment	29	Low-Medium-Technology
9	Machinery and Equipment N.E.C.	10	Medium-High-Technology
0	Office, Accounting and Computing Machinery	50	High-Technology
1	Elecrical Machinery and Apparatus N.E.C	67	High-Technology
2	Radio, Television and Communication Equipment and Apparatus	82	High-Technology
3	Medical, Precision and Optical Instruments, Watches & Clocks	75	High-Technology
4	Motor Vehicles, Trailers and Semi Trailers	80	Medium-High-Technology
4	Motor Vehicles, Trailers and Semi Trailers	80	Medium-High-Technology
5	Other Transport Equipment	30	Medium-High-Technology

6	Furniture;Manufacturing N.E.C.	28	Low-Technology
7	Recycling	50	NA

Table 2: Distribution of Innovating and Non-Innovating Firms Across Manufacturing Industries, 2000-2001

sion	Industry	Number of Firms			Percentage Distribution (%)		
		Innovation	No Innovation	Total	Innovation	No Innovation	Total
5	Food Products and Beverages	35	80	115	30	70	100
6	Tobacco Products	2	2	4	50	50	100
7	Textiles	8	3	11	73	27	100
8	Wearing Apparel; Dressing and Dyeing of Fur	29	73	102	28	72	100
9	Tanning and Dressing of Leather; Luggage, Handbags, Saddelery, Harness and Footwear	2	6	8	25	75	100
0	Wood; Products of Wood and Cork Except Furniture; Articles of Straw and Plaiting Materials	7	37	44	16	84	100
1	Paper and Paper Products	6	10	16	38	63	100
2	Publishing, Printing and Reproduction of Recorded Media	30	28	58	52	48	100
3	Coke, Refined Petroleum Products and Nuclear Fuel	1	0	1	100	0	100
4	Chemicals and Chemical Products	14	19	33	42	58	100
5	Rubber and Plastic Products	20	27	47	43	57	100
6	Other Non-Metallic Mineral Products	14	22	36	39	61	100
7	Basic Metals	6	16	22	27	73	100
8	Fabricated Metal Products, Except Machinery and Equipment	28	65	93	30	70	100
9	Machinery and Equipment N.E.C.	4	38	42	10	90	100
0	Office, Accounting and Computing Machinery	7	7	14	50	50	100
1	Elecrical Machinery and Apparatus N.E.C	12	6	18	67	33	100
2	Radio, Television and Communication Equipment and Apparatus	9	2	11	82	18	100
3	Medical, Precision and Optical Instruments, Watches & Clocks	3	1	4	75	25	100

4	Motor Vehicles, Trailers and Semi Trailers	9	2	11	82	18	100
5	Other Transport Equipment	3	7	10	30	70	100
6	Furniture;Manufacturing N.E.C.	13	34	47	28	72	100
7	Recycling	1	1	2	50	50	100
	Missing Value	0	5	5			
	Total	**263**	**491**	**754**	**35**	**65**	**100**

Table 3: Employment Size of Innovating and Non-Innovating Firms, 2000-2001

	Number			Percentage (%)		
loyment Size	**Innovating**	**Non-Innovating**	**Total**	**Innovating**	**Non-Innovating**	**Total**
or Less	85	268	353	32.3	55.1	47.1
0 - 49	34	61	95	12.9	12.6	12.7
) - 249	72	68	140	27.4	14.0	18.7
or More	66	35	101	25.1	7.2	13.5
ng Value	6	54	60	2.3	11.1	8.0
Total	**263**	**486**	**749**	**100.0**	**100.0**	**100.0**

Table 4: Local Ownership vs. Foreign Ownership in Innovating and Non-Innovating Firms in the Manufacturing Sector, 2000/2001

	Number			Percentage (%)		
ntage Share of Local rship	**Innovating**	**Non-Innovating**	**Total**	**Innovating**	**Non-Innovating**	**Total**
Local Ownership	198	391	589	75.3	80.5	78.6

ty Local Ownership (& %)	23	22	45	8.7	4.5	6.0
Foreign Ownership	26	24	50	9.9	4.9	6.7
ty Foreign Ownership 00%)	10	12	22	3.8	2.5	2.9
g Value	6	37	43	2.3	7.6	5.7
	263	**486**	**749**	**100.0**	**100.0**	**100.0**

Table 5: Ownership Type for Innovating and Non-Innovating Firms, 2000/2001

Ownership Type	Number			Percentage (%)		
	Innovating Firms	Non-Innovating Firms	Total	Innovating Firms	Non-Innovating Firms	Total
Sole Proprietorship	34	188	222	12.9	38.7	29.6
Partnership	8	61	69	3.0	12.6	9.2
Limited Company (Sdn Bhd)	186	216	402	70.7	44.4	53.7
Public Listed (Berhad)	14	14	28	5.3	2.9	3.7
Missing Value	21	7	28	8.0	1.4	3.7
Total	**263**	**486**	**749**	**100.0**	**100.0**	**100.0**

Table 6: Maximum Likelihood Estimates of Propensity to Innovate

	Model 1		Model 2		Model 3	
	Parameter	Odds Ratio	Parameter	Odds Ratio	Parameter	Odds Ratio
e	-0.0119	0.9881	-0.0169*	0.9832	-0.0182*	0.9820
	(0.0076)		(0.0082)		(0.0084)	
al Ownership	-0.0030	0.9970	-0.0037	0.9996	0.0002	1.0000
	(0.0037)		(0.0038)		(0.0040)	
e	0.0019*	1.0019	0.0014*	1.0014	0.0013*	1.0013
	(0.0005)		(0.0004)		(0.0004)	
ure of Export in es	-0.0088*	0.9913	-0.0129*	0.9872	-0.0107*	0.9893
	(0.0036)		(0.0037)		(0.0038)	
e of Ownership						
ole			-3.0909*	0.0455	-3.0227*	0.0487
prietorship			(0.6809)		(0.6882)	
artnership			-3.2212*	0.0399	-3.2634*	0.0383
			(0.7738)		(0.7897)	
rivate Limited			-1.5584*	0.2105	-1.5338*	0.2157
			(0.6524)		(0.6608)	

ublic Limited		-1.4721** (0.8065)	0.2294	-1.5154** (0.8131)	0.2197
e of Industry					
igh-Medium echnology				-1.4691* (0.5344)	0.2301
edium-Low h				-0.2992 (0.4771)	0.7414
ow Tech				-0.1148 (0.4650)	0.8915
rket ncentration				0.0006* (0.0002)	1.0006
ercept	0.3369 (0.3893)	2.3043* (0.7702)		1.9684* (0.8813)	
nber of servations	501	501		501	
elihood Ratio	33.97	95.39		115.53	
udo R^2	0.0489	0.1374		0.1664	
Likelihood	-330.1619	-299.4489		-289.3827	

Note: Standard errors are in parentheses
The High-Medium Technology variable was dropped due to collinearity
* Statistically significant at the 5-percent level
** Statistically significant at the 10-percent level

APPENDIX: DEFINITIONS

Innovation

An innovation is a new or significantly improved product (good or service) introduced to the market or the introduction within your company of a new or significantly improved process. The innovation is based on the results of new technological developments, new combinations of existing technology or utilisation of other knowledge acquired by the company.

A new product is a product whose technological characteristics or intended uses differ significantly from those of previously produced

products. An improved product is an existing product whose performance has been significantly enhanced or upgraded.

The innovation should be new to the company; it has not necessarily to be new to the market. It does not matter whether the innovation was developed by your enterprise or by another enterprise. Changes of a solely aesthetic nature, and purely selling of innovations wholly produced and developed by other companies shall not be included.

Product Innovation

Product innovation is a good or service which is either new or significantly improved with respect to its fundamental charcteristics, technical specifications, incorporated software or other immaterial components, intended uses, or user friendliness.

Process Innovation

Process innovation includes new and significantly improved production technology, new and significantly improved methods of delivering products. The outcome should be significant with respect to the level of output, quality of products or costs of production and distribution. The innovation should be new to the company; the company has not necessarily to be the first to introduce the process. It does not matter whether the innovation was developed by the company or by another company. Purely organizational or managerial changes shall not be included.

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