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Innovation and Productivity: Evidence from Firms Level Data on Malaysian Manufacturing Sector

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ABSTRACT

This study aims to investigate the impact of innovative activities related to productivity among firms in Malaysian manufacturing sector, using cross section data in 2008 with the total number of observations is 7222 firms from 36 manufacturing sub-sectors. The link between R&D, innovation and productivity has been examined through a complex interaction via the structural model. The results reveal that, export-oriented firms, size of firm, type of industry and market size heavily influence the decision to engage in R&D and at the same time firm allocates some significant amount of expenditure for R&D. The result also support that exporting firms tend to innovate to enhance their product competitiveness globally and patent their products worldwide as a form of protection from imitation. In addition, the innovation activities with the support of quality labor and technology are able to trigger firm's productivity.

Key words: Firm level data, innovation, export, productivity

JEL: O31, O33, D21 L25

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Any remaining errors or omissions rest solely with the author(s) of this paper.

INTRODUCTION

The theory of economic growth generally deals with the economy's long-run trend or potential growth path which measures the wealth and the nation's standard of living. The primary focus of world economics is to accelerate the growth rate of national incomes. Hence, the development of the countries is highly dependent on their economic growth performance which is measured by GDP per capita. This 'growth man ship' is becoming a way of life and the performance rank has been used as the global scorecard in determining the status of the countries or governments (Tadaro & Smith, 2003). For nearly half a century, the economic growth performance gap between rich and poor countries has been widely discussed. Instead of converging, the gaps between rich and poor countries are diverging. However the rise of the East Asian countries, especially Japan, Singapore, Hong Kong, South Korea and Taiwan miraculously narrows these gaps and surpass the high income economies boundary which has been set to tackle these issues. Malaysia, on the other hand has been lagging far behind those countries since 1990s (Figure 1).

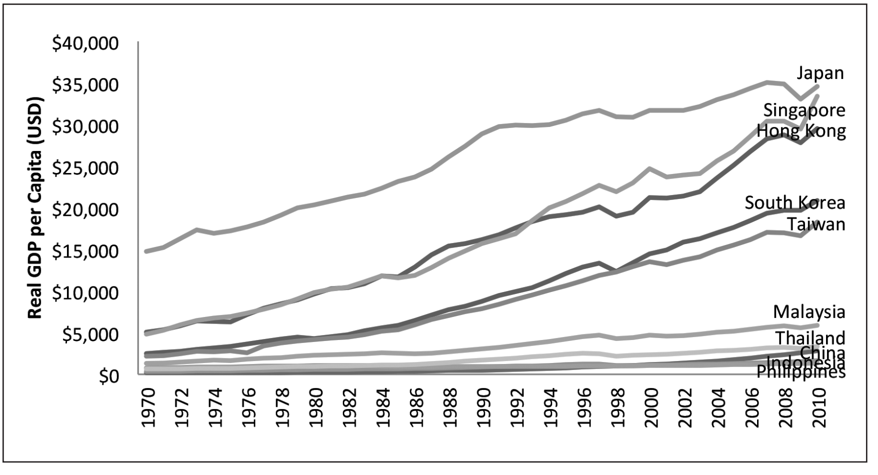

Figure 1 Real GDP per capita for selected Asian countries

Malaysia's economic growth slows down since the Asian Financial Crisis of the late 1990s, where the economic downturn contracted productivity growth to 2.9% as compared to Asian New Industrializing Economies (NIEs) which settled at 4.4% (Table 1) and contributing to the nation's GDP per capita gap performance (NEM, 2010). Therefore, superior productivity performance will improve Malaysia's cost competitiveness, improve living standard and close the real income gap (Roa *et al*., 2001). In congruent with these aspirations, the Malaysian Government through its

New Economic Model (NEM) has formulated strategic policy to stimulate economic development by focusing on productivity growth based on the development of human capital and innovation across all sectors.

Table 1 Productivity growth of Selected Asian Countries, Annual average Change (1987 -2007) in Percent

Country	Pre-Crisis (1987 – 1997)	Post Crisis (1998 – 2007)
China	4.5	9.2
Asian NIEs	3.5	4.4
Malaysia	5.5	2.9
Thailand	5.2	3.1
Indonesia	3.1	3.0
Singapore	4.5	2.4
Philippines	-0.7	2.3

Source: EPU, World Bank

Modern growth theory identifies three key determinants of longer term productivity growth which are accumulation of physical capital, accumulation of human capital and the rate of innovation and technological change. These factors according to Rao *et al*. (2001) are connected and complemented each other through complex interaction. Advanced technologies are generally incorporated in production process to improve productivity but new investments in machinery and equipment and skills development in the labor force are required in order to use state-of-the-art technologies effectively. Thus, the determination of productivity performance depends on how effective the three key factors mentioned are managed within a firm. Besides from these three factors, a country's business environment such as openness to trade and investment, the degree of competition in economy, the financial system, quality of management and intellectual property protection play important roles in stimulating investment in innovation and improving productivity.

As Malaysia embarks on the journey to become a high growth and high income economy, innovation as a key driver of growth in enhancing productivity has been emphasized and formulated as one of the strategic policy under NEM. Innovation has huge potential to significantly contribute to productivity growth as well as economic performance of many developed countries including Asian NIEs. The success of the policy depends on the readiness of a country to adopt and implement such policy and it must be supported by favorable business environment and resilient economic structure. Thus, the aim of this study is to examine the impact of innovative activities related to productivity among firms in Malaysian manufacturing sector.

This study aim to examine the relationships between innovation and productivity as well as the effect of innovation activities on firm productivity using the CDM model and consequently improvised Lee's finding (Lee 2004 and 2011) by using different manufacturing data published by Department of Statistics. Hence, this study uses cross-sectional data for the year 2008 and large number of observations in contrast to Lee (2011) who conducted a study at firm level data using National Survey of Innovation (NSI) for the period of 2002 – 2004 to examine the effect of innovation, productivity and trade in Malaysia. Surprisingly, Lee's result reveals that there is no evidence of relationship between innovation and productivity.

The paper is organized as follows. Section 2.0 briefly introduces the review of the literature; while Section 3 outlines the model and the methodology and Section 4 presents the data, econometric estimations and its results. Finally, conclusion and recommendation are addressed in Section 5.

LITERATURE REVIEW

The availability of numerous empirical studies and literature still does not provide a unique answer on the effect of innovation in both product and process productivity at the firm's level (Griliches 1995). Recent firm level studies, including Griffith *et al*. (2006) observation on four European countries (France, Germany, Spain and UK), Chudnovsky *et al*. (2006) on Argentina, and Hall *et al*. (2009) on Italy, Lee and Kang (2007) on South Korea report on the positive effect of innovation on productivity.

Innovation can be defined as "the implementation of a new or significantly improved product that is good or service, or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations" (OECD, 2007). Several definitions of innovation can be drawn from previous studies. Lionnet (2003) defines innovation as a process by which a novel idea is brought to the stage where it eventually produces money. It is a dynamic technical, economic and social process involving the interaction of people coming from different horizons, with different perspectives and different motivations. Innovations represent a process, namely an activity of creating a new product or service, new technology process, new organization, or enhancement of existing product or service, existing technology process and organization. In addition Vinnova (2002) defines innovation as "innovations that are new products, services and processes, form the basis for sustainable growth and prosperity in a knowledge-based society".

The literature on the linkages of Innovation and productivity has been discussed for several decades. In Solow's model (1956), technological innovation is emphasized to be exogenously augmented with labor productivity in ensuring long term economic growth. As innovation issues become more important to productivity and economic growth, Romer (1986) incorporates technological innovation endogenously in the model, together with physical and human capital. Enormous studies on growth theories found varied results across the countries on the impact of either innovation on productivity or the impact of productivity on innovation. The mixed results are strongly related to the methodology, data as well as variables used in the study. Furthermore, the variability and uncertainty of innovation definition and its conduct overtime led to the unique answer on the magnitude of the impact.

Due to the availability of micro level data, some researchers have used this type of data to observe the effect of innovation on productivity and identify the determinants of innovation. Grilinches (1979) in his seminal work models the relationship between innovation and its determinants in a knowledge production function and he further observed the contribution of innovation to productivity through augmented output production function. Further, Crépon, Duguet, and Mairesse (1998), henceforth CDM made used of Innovation Survey which include broader set of variables to examine the relationship between productivity, innovation and research at the firm level. CDM was the first to integrate empirically these relationships in a recursive model allowing for the estimation of innovation inputs (R&D investment) in an investment function (Crespi and Zuniga, 2010). CDM not only looks at innovation per se but was also able to separate out innovation activities into process and product innovation.

The CDM model approach is based on a simple three-step modelling of the logic of firms' innovation decisions and outcomes (Halls *et al*., 2009); involving the decision to engage in R&D, then the decision on how to link to innovation output and finally incorporate the innovation output into the production function to look into the impact of innovation on firm's productivity. The model incorporates others aspect of innovation rather than taking R&D expenditures directly as variables.

Building on the CDM model, a new wave of studies based on innovation surveys emerged and reported similar results for other industrialized countries (Crespi and Zuniga, 2010). Hall, Lotti and Mairesse (2009) in their study on innovation and productivity in Italian manufacturing sector, they discover that both process and product innovation give a positive impact on firm's productivity. Similar results are obtained from a study done by Griffith *et al*. (2006) and in their study they have included four European countries; France, Germany, Spain and the UK. Although the results for all countries supported the impact of innovation on productivity, there are differences particularly in the variation of productivity associated to the degree of innovative activities. On the other hand, the results for developing countries are rather mixed; whilst some findings support the evidence of firm ability to transform R&D into innovation thus enhancing productivity but others do not. Among those who find positive effect of innovation on productivity are Chudnovsky *et al*. (2006) on Argentina, and Lee and Kang (2007) on South Korea.

Although there are positive evidences on the impact of innovation on productivity, the result for both process and product innovation varies across countries. Study by Vakhitova and Pavlenko (2010) on Ukrainian found that only process innovation significantly contributed to firm's productivity but product innovation on productivity seemed to be insignificant. Whereas, Damijan et, al. (2006) in their study on Slovenia found the existence of strong correlation between innovation and productivity levels, but no support for the importance of innovation on productivity growth due to insignificant impact of product and process innovations on productivity growth.

In contrast, Lee (2011) make used of the three innovation surveys data covering period of 1997 to 2004 studied on the relationship between trade, innovation and productivity in Malaysian firm found there is positive but not statistically significant relationship between product innovation and productivity. Interestingly, he found that firms which are involved in the export activities tend to be innovative which is evident in the relationship between exporting and R&D expenditures. Similarly with finding from Berger (2009) on the impact of innovation on productivity in Thailand manufacturing firms, he discovers no evidence of a positive impact of process innovation on productivity.

Although all these studies used similar CDM model, the results report incongruent trend and pattern. The different findings may be due to the variables and type of data used in estimating the relationship. Consequently, the model has been improvised continuously by researchers depending on their interest. Parisi *et al*. (2006) and Chudnovsky *et al*. (2006) for example have applied the modified version of the model by incorporating time dimension. Most empirical studies has used cross sectional data such as the R&D expenditures data and following the same convention this study used the R&D expenditures data to capture the R&D equations model. Griffith *et al*. (2006) include variables such as international competition, protection, funding, size of firm and demand pull factor as explanatory variables for the R&D intensity and knowledge production function equations. He incorporated innovation intensity, process innovation, product innovation, capital intensity and size of firm based on no of employees in the output production function.

In addition, Lee (2009) besides integrating demand pull factors and supply push factor in R&D equation, he takes into account the size of firm, export activity and local ownership as explanatory variables in both R&D and knowledge production equations. Contrary to Griffith *et al*. (2006), he used augmented Cobb Douglas production function to measure productivity. Productivity according to Lee (2009) is the function of labor quality, investment intensity, predicted innovation input and firm size. Similar to studies by Crepon *et al*. (1998) and Chudnovsky *et al*. (2006), Lee (2009) incorporated quality of labor instead of the number of employees as one of the function of labor productivity due to direct contribution of skilled labor in improving labor productivity.

METHODOLOGY

In order to measure the relationship among productivity, innovation and research and development at firm level, we employ the CDM model approach introduced by Crepon, Duguet and Mairesse (1998) and then augmented by Griffith *et al*.(2006). The model is divided into two components; first, the model explains how research activity influence innovation output and second, how innovation output influences productivity.

There are three equations involved in this model, namely R&D activity, Innovation Function and Production Function. In R&D activity equation, among the variables used are exporting firm, firm size, market size and type of industries. For Innovation Function equation, innovation will be determined by the latent innovation effort proxy by patent and also other explanatory variables (firm size, market size and type of industries and export activity). For Production Function equation, Augmented Cobb-Douglas Production Function will be used to regress productivity variable (added value per employee) on explanatory variables namely predicted innovation input, quality of labour (proxy by percentage of employee with college/university degree), capital intensity (fixed asset per employee) and firm size.

R&D Model

The firm decisions to embark on R&D can be modelled in two different equations which are R&D intensity equation and selection equation. The R&D intensity equation can be specified as:

$$r_i^* = x_I \beta_1 + e_{1i} \tag{1}$$

where is R&D intensity, is a set of explanatory variables, the coefficient vector and the error term.

However, not all firms observed are ready to embark on R&D. In fact only small numbers of firms in Malaysia reported their involvement in formal R&D, even though many firms do have same form of innovation activities. The selection equation provides the condition under which a firm *i* is observed to embark on R&D intensity, when:

$$z_i\gamma + e_{2i} > 0 \tag{2}$$

where the set of explanatory variables, the coefficient vector and the error term.

In Crepon *et al*. (1998), it is assumed,, where the set of explanatory variables represent the tendency to invest is equal to the R&D intensity. Although the explanatory variables can represent the determination of firms in deciding whether to invest or not to invest, yet there exist some variations in the literature. To illustrate this variability, for example the study by Crepon *et al*. (1998), has used market share, size of employee, degree of diversification, dummy variable for demand pull factors, supply push factors and industry as set of their explanatory variables. This study tries to incorporate several explanatory variables such as firm size, market share and dummy for industry into regression equation by applying Heckman selection model.

Like Griffith (2006), Chudnovsky *et al*. (2006) and Berger (2009) the study expected that the R&D intensity increasing with size. However, according to Chudnovsky *et al*. (2006), there is reversely effect between the decision to invest and firm size at some point of time. Crepon *et al*. (1998) who suggested that market share influence R&D intensity in a positive manner, this study also anticipated positive relationship between them. Both exporting and foreign owned are also expected to show positive relationship on R&D expenditure due to their competitive nature (Baldwin & Gu, 2004 and Hall *et al*. 2009).

The dummy for industry is represented by k number of sub-sectors. In this case, there were 11 sub-sectors involved namely, electrical and electronics; chemical and chemical products; plastic and rubber products; food and beverages; machinery and equipment; basic metal; textile; apparel; transport equipment; scientific research and pharmaceutical and others. Each of sub-sectors will be coded as 1 if the sub-sector for example, electrical and electronics is observed and other sub-sectors will be coded as 0. Besides positive and significant coefficient, the study also expected high contribution from high-tech based industry such as electrical and electronics and scientific research and pharmaceutical to R&D intensity.

Innovation Function Model

After the latent innovation effort is obtained, and then the innovation function is modelled as follows:

$$g_i^* = r_i^* \beta_2 + x_{2i} \beta_3 e_{2i} \tag{3}$$

where is the innovation proxy by patent indicator, where explanatory variables represented by is the latent innovation effort and is a vector of other determinants namely firm size, export and dummy for industry. and are coefficient vectors and is the error term. Unlike other literatures which mainly incorporate product and process innovation as an indicator, this study attempts to look at only patent indicator as a proxy for innovation due to the unavailability of data and different data set. Like Crepon *et al*. (1998), this study examines the innovation equations from the innovation product perspective only.

We then estimate the innovation function equation through Probit model using predicted value of R&D intensity, and other related variables.

Production Function Model

Finally, we use augmented Cobb-Douglas production function to measure productivity:

$$q_i^* = \alpha_1 k_i + \alpha_2 l_i + \alpha_3 g_i^* + \alpha_4 w_i + e_i \tag{4}$$

Where is the labor productivity for firm *i*, which is measured by added value per employee and is the capital intensity (fixed asset per employee) for firm *i*. These two variables are in the form of natural log. l_i is labor quality proxy by percentage of employees with college/university degree, g_i^* is the predicted innovation input, is the firm size and is the error term.

The augmented Cobb-Douglas production function that used to measure labour productivity and is normally measure by value added per employee. Like Crepon (1998), Damijan *et al*. (2008) and Lee (2011) that used value added per employee as a labour productivity proxy due to the efficiency of this variable that has omitted the cost of material and services in the measurement which represents net wealth created by the employees.

Lee (2011), Crepon *et al*. (1998) and Chudnovsky *et al*. (2006), incorporated labour quality; capital intensity; predicted innovation input; and firm size. Like others, the study also utilised capital intensity in the model and expect the positive relationship of the variable to productivity. Unlike others, Chudnovsky *et al*. (2006) revealed that innovators attained higher productivity level and large firm tend to be more innovative than others as they have higher probability to become innovator. In this case, the study expects different coefficient magnitude between firm size and productivity as suggested by Chudnovsky *et al*. (2006).

Innovation has also been incorporated in many firm's productivity model which is represented by patent variable or R&D expenditure. However the relationship between R&D expenditure and productivity is uncertain. Griffith *et al*. (2006), Berger (2009) Chudnovsky *et al*. (2006) and Kim *et al*. (2009) found significant and positive relationship between innovation and productivity. There are also evidence showing the insignificant relationship between them (Lee, 2011; Vakhitova and Pavlenko, 2010). In this study, using R&D expenditure as a proxy to innovation, the relationship is expected to be positive as suggested in the theory as well as some empirical findings.

The Method

In the R&D model, the existence of binary dependent variable in both equations is represented by; 1 if the R&D is observed and zero if no R&D is observed, Heckman Selection maximum likelihood approach was applied for both R&D intensity and selection equations. For R&D intensity equation, actual censoring value has been selected. Not like actual censoring value which predicts zero as a missing value, the Heckman selection method considers zero as a variable and included it in the estimation. We anticipated that the result from both estimations would be different and would provide some explanation later. Thus the R&D function for estimation is as follows:

$$r_i^* = dx_i\beta_1 + dsize_i\beta_2 + dind_i\beta_3 + \log sale_i\beta_4 + e_{1i} \tag{5}$$

Where,

r_i^* = R&D binary for firm *i, (1 if R&D observed and 0 if no R&D observed);*

dx_i = dummy for export for firm *i*;

$dsize_i$ = dummy for firm size for firm *i*;

$dind_i$ = dummy for industry group form firm *i*;

$\log sale_i$ = sale in log for firm *i*;

$\beta_4\beta_1$, β_2, β_3 & β_4 = represent coefficient vectors; and

e_{2i} = the error term

We then, estimate single innovation equation which only involved product innovation using patent as a proxy. As a binary form of dependent variable, we used Probit model to estimate the following equation.

$$Inno_1^* = r_1^*\beta_1 + dx_i\beta_2 + dsize_i\beta_3 + dind_i\beta_4 + e_{1i} \quad (6)$$

Where,

$Inno_1^*$ = Patent binary for firm *i* (1 if have patent and 0 if not);

$r_1^*\beta_1$ = latent R&D for firm *i* and other variables are same as above description.

In order to estimate production function equations, we then applied Augmented Cobb-Douglas Production function using least square method. We divided the estimation into two equations which are with innovation and without innovation in order to observe the innovation impact.

We then carried out, a single estimation for every single sub-sector to examine the impact of innovation as well as other factors on productivity. The equation specification for sub-sector is as follows:

$$AVE_{ij}^* = \alpha_1 k_{ij} + \alpha_2 l_{ij} + \alpha_3 g_{ij}^* + \alpha_4 w_{ij} + e_i \quad (7)$$

Where,

AVE_{ij}^* = labor productivity for firm *i*

k_i = capital intensity for firm *i*

l_i = skilled labor for firm *i*

g_i^* = innovation for firm *i*

w_i = firm size for firm *i*

α_1, α_2, α_3 and α_4 = coeficient vectors

e_i = the error term.

DATA AND EMPIRICAL RESULTS

The Data and Variables Selection

This study used the cross-section data from Annual Survey of Manufacturing 2008 produced by Department of Statistics, Malaysia. The total number of observations in the sample data is 7222 firms from 36 manufacturing sub-sectors which are coded under Malaysia Industrial Specification Code 2000 (MISC2000). However, in this study we only used nine targeted sub-sectors mentioned in IMP3 such as Electrical and Electronics, Chemical and Chemical Products, Plastic and Rubber Products, Food and Beverage, Machinery and Equipment Basic Metal, Textile, Apparel and Transport Equipment.

There are three models used in this study. The first model is to explain R&D expenditure, which includes dummy variables for R&D, export and firm size as well as sales ratio (in log) which represent market concentration/size. We created dummy for firm size comprising; Small size which employ 6 to 50 employees, Medium size firms which employ 51 to 150 employees, and large size firms which employ more than 150 employees. The second model included nine sub-sectors dummies beside one others sub-sector which comprising the remaining manufacturing sub-sectors the in the innovation equation, which incorporated the entire above variables as explanatory variables and adding patent dummy variable as a dependent variable. The third model is the basic variable which is normally used in the production function literature, namely, labor productivity, quality labor, capital intensity (all in logs). The summary of these variables is provided in Appendix1.

Empirical Results

Descriptive Statistics

This study observed 7,222 firms from 36 sub-sectors in the manufacturing sector but for the purpose of analysis only nine sub-sectors are highlighted in this study. The total number of employees involved in this data is 1.35million with the largest contribution from E&E sub-sector which recorded about 21.8%. Out of 7,222 firms selected as samples only 851 firms or 11.8% embark in some form of innovation while 88.2% do not innovate at all. The same trend is observable in other sub-sectors where only 10.0% to 13.8% of these firms participate in some form innovation. Out of nine sub-sectors, the Apparel sector contributes the lowest percentage of 4.4%, whereas Chemical, Transport Equipment and E&E sectors have the highest number of participants in innovation with 26.9%, 22.3% and 19.6% respectively (refer to Table 2). These sub-sectors especially E&E have attracted 31.3% of the total 69.7 billion Investment project in IMP2 (1996-2005), whilst Chemical and Transport Equipment attracted only 6.5% and 6.2% of the investment projects respectively.

Table 3 provides the additional summary statistics of the data used in this study. The standard variation is large as compared to the mean in all variables especially fixed asset per employee and added value per employee.

Econometrics and Analysis

Due to the cross-sectional data and most of the factors that have been considered are simultaneously determined, this study only produced correlation of variables and not necessarily causal relationship. All the independent variables except market share were dummy variables. They took the value 1 when the factor was important

Table 2 Statistics on sample representative

Industry	No. of firm	Total employees	% of employee to manufacturing	No of innovating firms	% of innovating firm
Food & beverages	1,238	148,335	11.0	131	10.6
Textiles	180	28,236	2.1	18	10.0
Apparel	520	48,870	3.6	24	4.6
Chemical	342	67,195	5.0	92	26.9
Rubber & plastics	696	175,786	13.0	96	13.8
Basic metal	299	49,239	3.6	36	12.0
Machinery & equipment	326	50,515	3.7	41	12.6
E & E	377	294,699	21.8	74	19.6
Transport equipment	193	70,301	5.2	43	22.3
Other sub-sectors	4,289	567,224	42.0	427	10.0
Total manufacturing	7,222	1,352,065	100.0	851	11.8

Table 3 Descriptive statistics

Variable	N	Mean	Std. Dev.	Maximum	Minimum
Total employee	7222	187.21	509.83	11,704.00	6.00
Fixed asset per employee (RM)	7222	40,763.64	269,613.60	18,429,376.00	0.49
Added value per employee (RM)	7222	53,888.03	243,232.30	17,878,785.00	127.87
% export to turnover	7222	11.25	28.39	100.00	0.00
Ratio of graduate employees	7222	25.94	122.00	4,614.00	4.00

to the firm and value zero if it was unimportant. Thus, the marginal effect is for discrete change of dummy variable from 0 to 1. The marginal effects often used to measures the effect on the conditional mean of y of a change in one of the regressors in both linear and nonlinear regression (Cameron & Trivedi, 2005). The marginal effects also been used to replace coefficients in selection model and innovation model in most of the related literatures (Peter *et al*., 2003; Griffith *et al*., 2006; Berger, 2009; Hall *et al*., 2009; and Crespi and Zuniga, 2010).

Table 4 shows the results obtained by Heckman Selection method on both the decision to embark on R&D and on the amount of R&D expenditure. The firms' decision to embark on R&D is influenced by their firm size, market size, type of industry as well as export activities. The decision to embark on R&D is increasingly with the size of firms. This finding is congruent with the study by Crepon et.al. (1998) that the decision to embark on R&D increases significantly with the number of employee. Export activities are also statistically significant at 2.2% level in contributing to the R&D decision as a result of positive competition in the global market. Parallel to the findings by Griffith *et al*. (2006), this study also found significant evidence for larger firms; and firms operating in the international market are more likely to engage with R&D. Variable such as market size or market concentration shows significant level of 2.4% which demonstrates its influence on the decision to invest in R&D. Furthermore, the decision to invest is positive and statistically significant for Chemical, E&E, Food and Beverages, Plastic and Rubber, Transport equipment sub-sector and Machinery equipment sub-sector .

Table 5 reports the results from innovation equation. The overall model is significant at 1% which provides evidence to reject the null hypothesis. Thus, it can be concluded that all variables are significant influence on the firms' propensity to innovate. The predicted R&D expenditure is positive and significant, where a 1% increase in R&D expenditure is expected to increase innovation by 23.0%. The result implies that the greater the R&D expenditure, the higher the tendency for firms to innovate and this is not surprising as many literatures such as Crepon *et al*. (1998) Griffith *et al*. (2006) and Hall *et al*. (2009) and Lee (2011) support the argument that R&D expenditure will lead to higher innovation activities.

The ability of firms to operate in the global market is seen as an innovative move represented by positive and significant exports coefficient. Exporting firms tend to innovate to enhance their product competitiveness globally and patent their products worldwide as a form of protection from imitation. This is in line with the requirements of some importing countries especially US and Europe which necessitate both the process and product to be patented as one of the non-tariff barriers. Thus, for those firms involve in export, they have greater inclination to be innovative as compare to other non-exporting local based firms. Such finding

Table 4 R&D equation

Variables	R&D expenditure		Decision	
	Coefficient	Std. error	Coefficient	std. error
Exporting	-0.3753**	0. 1735	0. 1421*** [0.0223]	0. 0501
Medium firms (51 to 150)	-1.8628***	0. 3006	0. 3923*** [0.0617]	0. 0686
Large firms (>150)	-3.0810***	0. 3447	0. 6535*** [0.1028]	0.0152
Market Share	0. 1632***	0.0561	0. 1525*** [0.0240]	0.0233
Apparel			-0. 2682** [0.0422]	0. 1283
Basic Metal			-0. 0790 [-0.0124]	0. 1228
Chemical			0. 7161*** [0.1127]	0. 0782
E&E			0. 7659*** [0.1205]	0. 0753
Food & Beverage			0.5305*** [0.0835]	0. 0620
Machinery			0. 2760*** [0.0435]	0. 0934
Plastics & Rubber			0. 3705*** [0.0582]	0. 0637
Textiles			-0.0176 [-0.0028]	0. 1357
Transport			0. 7007*** (0.1102)	0. 0960
Constant	12.4869	0.6504	-0.7355***	0. 1457
/arthro	–1.0699 (0.1104)			
/lnsigma	1.0234 (0.0548)			
Rho	–0.7894 (0.0416)			
Sigma	2.7826 (0.1525)			
lambda	–2.1967 (0.2297)			
Observation	7222			
Censored Obs	6399			
Uncensored Obs	823			

Note: Numbers in parentheses are standard errors and number in square bracket is marginal effects; LR test of indep. eqns. (rho = 0): chi2(1) = 59.63 Prob > chi2 = 0.0000; *** p<0.01, ** P<0.05, * P<0.1

Table 5 Innovation equation

Variables	Innovation	
	Coefficient	Std. error
Predicted R&D	1.3830*** [0.2301]	0.0898
Exporting	0. 7726*** [0.1286]	0.0551
Medium (51 to 150)	2.5464*** [0.4237]	0.1520
Large Firms (>150)	4.3808 *** [0.7290]	0.2371
Apparel	-0.0905 [-0.0151]	0.1093
Basic Metal	0.2711** [0.0451]	0. 1163
Chemical	0.6909*** [0.1150]	0.0854
E&E	0.1506*** [0.0750]	0. 0918
Food & Beverage	0.4200*** [0.0699]	0.0655
Machinery	0.1698* [0.0283]	0.1014
Plastics & Rubber	0.1801** [0.0300]	0. 0735
Textiles	-0.0846 [-0.0141]	0.1425
Transport	0.4242*** [0.0706]	0. 1140
Constant	-17.0379	0. 9947
Observation	7222	7222
Pseudo R-squared	0.1585	
LR Chi-squared	870.07 ***	

Note: Numbers in parentheses are standard errors and number in square bracket is marginal effects; *** p<0.01, ** P<0.05, * P<0.1

can be strongly supported by Lee (2011) who has also discovered that export has a positive impact on innovation.

Out of nine sub-sectors, seven sub-sectors namely the Chemical, E&E, Transport Equipment, Food and Beverages, Basic metal, Rubber and Plastics as well as Machinery and Equipment show positive and significant evidence on innovation. This indicates that the sub-sectors have influence on the propensity to innovate. The firm will innovate to ensure the sustainability of their market.

Table 6 present the results of the productivity equations. The positive and significant coefficients of capital intensity, labor quality and innovation indicate that firms are involved in higher investment in technology and together with the support of high quality labor they can improve production process as well as create higher added value on their existing product or new product in the market which ultimately boost firms' productivity.

Table 6 Productivity production function: Manufacturing firms

Variables	Model 1	Model 2
	Coefficient	**Coefficient**
Capital intensity	0.1814*** (0.0080)	0. 2740*** (0.0084)
Labour quality	0.2272*** (0.0130)	0. 2099*** (0.0147)
Predicted innovation	0.6836*** (0.0200)	
R&D intensity		0.1487*** (0.0343)
Medium firms (51 to 150)	-0.1917*** (-0.0332)	0. 2515*** (0.0341)
Large firms (>150)	-0.6530*** (-0.0401)	0. 2147*** 0345
Export	-0.3866*** (-0.0295)	0.0090 0294
Constant	11.1613*** 0.1194	8.1267*** (0.0891)
Observation	4615	4615
R^2	0.4200	0.2765

Note: Standard errors in parentheses; *** p<0.01, ** P<0.05, * P<0.1

This finding is analogous to the modern growth theory which identifies three key determinants of long term productivity growth encompassing accumulation of physical capital, accumulation of human capital and the rate of innovation and technological change.

The elasticity of capital intensity, labor quality and predicted innovation is about 0.18, 0.23 and 0.68 respectively. Comparatively, the impact of innovation on productivity is the highest, followed by labor quality and hence, it can be concluded that innovation is the key determinant of productivity growth. As comparison, R&D intensity in that normally used as a proxy to innovation (Model 2) also shows a positive and significant contribution to the innovation but the elasticity of 0. 15 is much more lower than the predicted innovation output as suggested by the CDM model.

Table 7 represents production function for selected six sub-sectors that have been chosen based on their significant impact on innovation as discussed previously. The innovation impact coefficients appear differently in seven sub-sectors. The estimated coefficient of predicted innovation is positive and significant in all sub-sectors with Chemical posted the highest impact of innovation of 83.3% on Productivity, followed by Food & Beverage (62.9%), and Transport Equipment (54.8%). Capital Intensity coefficient is significant across all sub-sectors, except Transport Equipment. However labor quality does not show any significant impact on productivity in Machinery and Equipment sub-sector. As compared to overall manufacturing firms, the productivity determinant for firm sub-sectors can vary and not all variables significantly contribute to productivity.

CONCLUSIONS AND RECOMMENDATION

The relationship between innovation and productivity has been widely discussed and often it is associated with economic growth. Frequently, developed countries have used this formulation to sustain their economic growth and the positive outcome is evident in many literatures. Emulating from the experience of developed countries, the emerging new industrialized countries like Japan, Singapore, Hong Kong, South Korea and Taiwan geared their policy strategically towards innovation as a mean to enhance productivity and economic growth. Hence, this study has attempted to observe the impact of innovation on productivity. This paper also has able to identify the determinants of innovation by using Innovation function model. Importantly, by using R&D model, the findings were able to split into two R&D categories which are based the R&D expenditure and the R&D decision.

Table 7 Production function for selected manufacturing sub-sectors

Variables	**Labour productivity**						
	F&B	**Chemical**	**P&R**	**Metal**	**Machinery**	**E&E**	**Transport**
Capital intensity	0. 1893***	0. 2560***	0. 1752***	0.1875***	0.1821***	0.2384***	0.0354
	(0. 0274)	(0. 0320)	(0.0265)	(0.0432)	(0.0445)	(0.0360)	(0.0434)
Labour quality	0. 1901***	0. 3917***	0. 1900***	0. 1805**	0.1020	0. 3070***	0. 0757***
	(0.0387)	(0.0667)	(0.0371)	(0.0718)	(0.0631)	(0.0581)	(0.0757)
Predicted innovation	0. 6293***	0. 8333***	0. 3215***	0. 5158***	0.5088***	0. 2747***	0. 5483**
	(0.0454)	(0.0848)	(0.0459)	(0.0837)	(0.0699)	(0.0561)	(0.0976)
Constant	10.5711***	10.2915***	9.8003***	10.2722***	10.2257***	9.4185***	11.7832***
	(0. 3731)	(0.4365)	(0.3461)	(0.5917)	(0.5244)	(0.4471)	(0.5596)
R-Squared	0.4313	0.5641	0.2137	0.5110	0.3223	0.3178	0.2572
Number of firms	663	306	581	158	238	351	158

Note: Standard errors in parentheses; *** p<0.01, ** P<0.05, * P<0.1

The interaction of innovation and productivity alone is not sufficient and its must be complemented with higher investment in both physical and human capital. In this study, the link between R&D, innovation and productivity have been observed through a complex interaction via the structural model which comprises the three steps modelling. The results reveal that, export-oriented firms, size of firm, type of industry and market size heavily influence the decision to engage in R&D and at the same time firm allocates some significant amount of expenditure for R&D. As firms spent some significant amount of expenditure to R&D, it would create greater drive to innovate by introducing more efficient process or by creating higher value added products. With this kind of innovative activities coupled with the support of quality labor as well as implementation of the state-of-the-art technology would therefore able firms to accelerate their productivity.

In the case of small and medium enterprises (SMEs) are focusing on domestic market, it is likely that they would lose the temptation to invest and innovate; and consequently generate a lower return in comparison to large firms. Empirical evidence also proves that innovation contributed significant impact on productivity especially for firms engaging in high R&D investment.

Hence, in response to recent concerns on slow economic growth performance as well as low productivity growth in Malaysia, some remedial measures by emphasizing the role of innovation in the industry could be implemented. This study provides evidence that the percentage of innovative firms is too low which is about 11.8%. Thus it is timely for Malaysia's industries to engage in innovation in order to accelerate productivity to greater heights. The support from the government is essential especially in giving financial support and intellectual property (IP) protection in order to encourage industry to innovate. SMEs as an engine of growth in this country should be given greater focus and the potentials of manufacturing sub-sectors such as E&E, Chemicals, Food and Beverages and Transport equipment should be explored to accelerate higher productivity.

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APPENDIX 1

Variable Definition

Variable name	Explanation
R&D expenditure	DRND=1 if R&D expenditure > 0 (Binary)
Export	DEX= 1 if Export > 0 (Binary)
Firm size	Small firms, Labour 6 to 50 (Dummy) Medium firms, Labour 51 to 150 (Dummy) Large firms, Labour >150 (Dummy)
Market size	Sales divided by total sales of sub-sector (in Log)
Sub-sector	Apparel (Dummy for industry 2-digit code - 18) Basic Metal (Dummy for industry 2-digit code - 27) Chemical (Dummy for industry 2-digit code - 27) E&E (Dummy for industry 2-digit code – 30 + 31 + 32) Food & Beverage (Dummy for industry 2-digit code - 15) Machinery (Dummy for industry 2-digit code - 29) Plastics & Rubber (Dummy for industry 2-digit code - 25) Textile (Dummy for industry 2-digit code - 17) Transport (Dummy for industry 2-digit code: 34 + 35)
Innovation	Patent (1 if have patent > 0 (Binary)
Labour productivity	Added Value per Employee (in log)
Quality labour	ratio of college/university degree to total employee (in log)
Capital intensity	Fixed asset per employee (in log)