E C O N O M I C S   B U L L E T I N

The Relationship Between Innovation, Productivity and Exports: Some Preliminary Evidence from the Malaysian Manufacturing Sector

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Abstract

The objective of this paper is to empirically examine the relationship between innovation, productivity and trade intensity using firm-level data from the Malaysian manufacturing sector. Evidence from this paper suggests the relationships between innovation, productivity and exports is a complex one. Exporting and industry technological characteristics may influence the decision to undertake RDbut has no effect on RDexpenditure. Only firm size has impact on both the decision and expenditure on R Variables such as RDexpenditure, firm size, exports and local ownership influences the propensity to innovate, be it product or process innovation. Product innovation is negatively related to productivity while process innovation is positively related to productivity.

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1. Introduction

Growth theories that have been proposed since the time of Adam Smith has consistently featured innovation, productivity and trade as key contributors of economic growth. In the *Wealth of Nations*, for example, Adam Smith argues that growth is driven by productivity gains from division of labour and specialization, the extent to which is limited by the size of market. Smith further argues that exports, which expands market size, is therefore a avenue for the growth of small economies. In the modern growth theories, technological innovation occupies a central role. In Solow (1956)'s seminal paper, exogenous technological innovation augments labour productivity to ensure long-term economic growth. Since the 1980s, attempts have been made to model technological innovations endogenously by either incorporating spillovers from investment in physical and human capital (Romer (1986)) or differences in the variety and quality of inputs (Romer (1990)). Endogenous growth theories have also been extended to relate trade or openness to growth by arguing that the source of productivity growth can come from other countries. The mechanism by which this occurs is the absorbing or imitating innovations from other countries made possible by trade or openness.

Despite the enormous amount of research undertaken on growth theories, there remain some disquiet over the robustness of these findings. This can be attributed to the restrictive assumptions and quality of data used is such studies (Romer (1994), p.20 and Pack (1994)). As a result, some have advocated more empirical work at the micro-level linking innovation, productivity and trade (e.g. (Edwards (1998)), p.396.). In recent years, scholars have been able to address this research challenge due to greater availability of firm or plant-level data. The literature that has emerged essentially seeks to empirically verify, using firm or plant-level data, the relationships between innovation, productivity and trade. However, most of such empirical studies focus primarily on analyzing the relationships between two of these three factors but not all three simultaneously. For example, much of the firm-level empirical literature have sought to understand the relationship between productivity and exports. In this literature, productivity improvements are not explicitly modeled as a consequence of technological innovations. There is thus a need to empirically examine the relationship between productivity, exports and trade within a single framework.

The objective of this paper is to empirically examine the relationship between innovation, productivity and trade using firm-level data from the Malaysian manufacturing sector. The outline for the rest of the paper is as follows. Section 2 discusses the related literature. This is followed by a discussion of the data and methodology used in this study in Section 3. Results from the econometric analysis are discussed in Section 4. Section 5 concludes.

2. Related Literature

One of the earliest contributions that examined the relationship between research, innovation and productivity using firm-level data is Crepon *et al*. (1998). Using data from the French manufacturing sector, the paper examined both (i) the impact of research on innovation and, (ii) the impact of innovation and research on productivity. The paper found that the probability of a firm undertaking research increases with its size, market share, diversification and with demand pull and technology indicators. Research intensity (measured by R&D expenditure) for a firm undertaking research increases with the same variables except for size. Innovation output, measured by patent numbers or innovative sales, increases with research intensity and with demand pull and technology indicators. Higher productivity is associated with higher innovation output.

Greenaway and Kneller (2004) provide a review of the microeconomic (theoretical) and microeconometric (empirical) literature on the benefits of exporting. Theoretically, there are many ways by which productivity at the firm level is associated with exports. In the presence of fixed (sunk) cost of entering exports markets, the more productive firms could self-select to enter such markets i.e. learning to export. Firms could also learn by exporting. This could be due to greater incentives for learning in export markets due to higher rates of return and / or greater competitive pressures in such markets. The empirical literature reviewed by the authors suggests that there is some evidence supporting the self-selection theory. However, the evidence on learning by exporting is fairly inconclusive. The authors cite a few theoretical conjectures that could explain these results. These conjectures include the importance of country size and distance from the technology frontier. The positive impact of entry into export markets on productivity is greater in countries with smaller domestic markets and for firms that are further away from the technology frontier.

Griffith *et al*. (2006)} extends the work of Crepon *et al*. (1998) by using a larger set of data covering four European countries, namely, France, Germany, Spain and the United Kingdom. In their study, the authors found that firms' decisions to undertake research is influenced by size, availability of national funding, whether they operate in international markets and when there is greater use of methods to protect innovation. Unlike Crepon *et al*. (1998) the authors make a distinction between product and process innovations. The authors found that greater research effort makes firms more likely to become innovators. However, firms with higher investment per employee are more likely to be process innovators. In terms of protection of innovation, this is more important for process than product innovation. The sources of innovation differ for each type of innovation: suppliers are more important for process innovation and buyers are more important for product innovation. Finally, there were significant variations in the relationship between innovation and productivity in the paper.

The review by Greenaway and Kneller (2007) provides a theoretical and empirical survey on firm heterogeneity, exporting and productivity. Their paper provided a summary of the larger body of literature that goes beyond the debate on the direction of causality between productivity and export. The decision to participate in exporting is discussed in terms on the role of exchange rates (impact of devaluation/appreciation), policy innovation (trade liberalization, grants) and agglomeration effects (spillovers from other exporters, region or industry). In their paper, they reaffirm the importance of self-selection compared to learning. Of particular interest is their discussions on research that models the endogenous decision to start exporting. In such models, firms undertake investment in new technologies to achieve pre-entry (into export markets) productivity gains. Two papers of such nature, namely Baldwin and Gu (2004) and Aw *et al*. (2007), are discussed in greater detail in the next sub-section. Another important topic discussed in Greenaway and Kneller (2007) is that of exporting and foreign direct investment (FDI). In reviewing the literature on this topic, the authors find strong empirical evidence that multinationals have higher productivity compared to exporters. The degree of firm size distribution also has influence over the relative levels of exports to FDI.

In general, there has been relatively less emphasis on modeling of the innovation process in the literature on exports and productivity. In the classic paper by Melitz (2003), the process of innovation takes the form of a random productivity draw from an exogenous distribution. In this model, firms with productivity levels exceeding an endogenously determined productivity threshold will export their products. One of the earliest papers to include a more explicit treatment of innovation within models linking productivity to exports is that by Baldwin and Gu (2004). In their paper, the authors provide evidence that export market participation by Canadian firms was driven by trade liberalization. These exporting firms were also found to be more innovative via greater use of advanced technology and staff training. Another paper in international trade that examines the role of innovation in productivity and exports is Aw *et al*. (2007). The paper is methodologically different from that by Baldwin and Gu (2004) in that firms' exit decisions and productivity evolution are modeled endogenously and estimated using the Heckman's sample selection model. One of their key finding is that Taiwanese firms that engage in R&D and/or workers' training and export participation experience larger productivity increases than firms that only exports.

3. Model and Specification

This study uses a version of the structural models used in Crepon *et al*. (1998) and Griffith *et al*. (2006) for an empirical analysis of innovation, productivity and exports. There are two components in the model. First, research investment influences innovation output. Second, innovation output influences productivity. Such a model has the merit of reducing simultaneity and endogeneity problems. The standard specification comprises four equations. The first two sets of equations pertain to research activities.

First, firms have to decide whether to engage in R&D or not. The propensity of firm *i* to undertake innovation-related activities such as R&D is modeled as:

$$\mathrm{rd}_i^* = x_{0i}\,\beta_0 + e_{0i} \qquad (1)$$

where rd_i is the observed binary endogenous R&D variable, x_{0i} are the explanatory variables, β_0 the coefficient vector and e_{0i} the error term. The explanatory variables x_{0i}

include the degree of local ownership, market concentration (measured by the Herfindahl-Hirschman Index, HHI), exporting activity, technological characteristic of industry (whether how or high-medium technology), and firm size (in terms of total number of employees).

The R&D intensity of firm *i* is modeled as:

$$r_i^* = x_{1i}\,\beta_1 + e_{1i} \qquad (2)$$

where x_{1i} are the explanatory variables, β_1 the coefficient vector and e_{1i} the error term. Following Crepon *et al*. (1998) we assume $x_{0i} = x_{1i}$ i.e. the set of explanatory variables for the propensity to undertake R&D is the same as R&D intensity.

Both equations (1) and (2) are jointly estimated as a generalized Tobit model by maximum likelihood.

Next, we model the innovation production function as:

$$g_i^* = \beta_2\, r_i^* + x_{2i}\,\beta_3 + e_{2i} \qquad (3)$$

where $g_i^*$is the binary innovation indicator (i.e. taking the value of 0 or 1), r_i^* the latent innovation effort and x_{2i} represents the other explanatory variables which include size of firm (proxied by total employment), export activity and local ownership. The estimation of equation (3) is carried out by carrying out probit estimations using the predicted value of R&D intensity (r_i^*). Following Griffith *et al*. (2006), separate estimates are carried out for product and process innovations.

The final component of the model involves the use of an augmented Cobb-Douglas production function to measure productivity:

$$q_i = \alpha_1\, k_i + \alpha_2\, s_i + \alpha_3\, g_i^* + \alpha_4 w_i + e_i \qquad (4)$$

where q_i is labour productivity (natural log of value-added per worker), k_i the investment intensity proxied by fixed asset per worker, s_i percentage of employees with college/university degrees, g_i^* is the predicted innovation input and w_i the firm size.

3.4 Data

The cross-section data for this study comes from the *National Survey of Innovation* conducted by the Malaysian Science and Technology Information Centre (MASTIC), Ministry of Science, Technology and Innovation. The reference period for the survey is 2002-2004. Data pertaining to turnover, employment and export share of sales are for year 2004. In the survey questionnaire, firms are asked whether they innovate or not based on definitions of innovation that are used in the *Oslo Manual*. Innovation can involve product or/and process innovation. The reference period for response to this question is 2002-2004.

The total number of observations in our sample data is 485 firms of which 261 carry out some form of innovation while 224 firms do not innovate at all. Of the 261 innovating firms, 190 firms carry out both product and process innovation while 27 firms and 44 firms carry out only product innovation and process innovation, respectively. Of the 485 firms, 341 firms (70.3% of total) export their products. Of these 341 firms, 210 firms obtain equal to or more than 50 percent of their revenues from exports. A total of 376 firms (77.5%) have majority local ownership (i.e. having local equity ≥ 50%). **Table 1** provides additional summary statistics of the data used for this study. The innovation profile for the manufacturing sector is summarized in **Table 2**.

Data on industry market concentration comes from a separate source, namely the Department of Statistics. The estimates of the Herfindahl-Hirschman Index (HHI) are for year 2000. The scale adopted for the HHI is from zero to one, where a unit value is obtained in the monopoly case. 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. The weights used are based on turnover figures for the various industries obtained from the Department of Statistics' *Census of Manufacturing Industries 2001.*

The variable representing technological characteristic of industry (whether how or high-medium technology) comes from Hatzichronoglou (1997) who provides a classification scheme for manufacturing industries that we can use for this purpose.

4. Empirical Results

The results from the research equation estimated using the Heckman selection method provide some insight on both the decision to undertake R&D and on the amount of expenditure on R&D. The firms' decision to undertake R&D is positively influenced by three variables (i.e. statistically significant), namely, export, firm size, and perception of industry's technology (**Table 3**). However, in terms of R&D expenditure, only firm size has a positive effect.

Estimates from the innovation equation (**Table 4**) provide us with an idea of the important determinants of the propensity to innovate for both product and process innovation. All the variables (R&D expenditure, firm size, exports and local ownership) are statistically significant and with the expected signs i.e. positively related to product and process innovation. Based on the values of the coefficients, these variables have a greater impact on process innovation compared to product innovation. Such findings are consistent with the view that developing countries are driven more by process innovation than product innovation.

In terms of sources of productivity, the four statistically significant variables include investment intensity, product innovation, process innovation and labour quality (**Table**

5). The positive values of the coefficients for investment intensity and labour quality indicate that higher investment intensity and labour quality are associated with higher levels of productivity.

Interestingly, the signs of the coefficients signs for the two innovation variables are different. This suggests that product innovation and process innovation impact productivity differently. Product innovation is negatively related to productivity while process innovation is positively related to productivity. These results seem to justify many of the assumptions on innovation in the productivity-trade literature, namely productivity is driven mainly by process innovations.

5. Conclusion

Innovation, productivity and exports have long be considered the cornerstones of economic growth. Earlier empirical studies have primarily attempted to examine the roles and contributions of these factors to growth using macroeconomic or industry-level data. The greater availability of plant or firm level data has generated a new branch of empirical literature focusing on microeconometric investigations of the relationship between the three variables. This study has attempted to investigate the relationship between innovation, productivity and exports in the Malaysian manufacturing sector using data from the *National Survey of Innovation 2002-2004*.

Results from the structural models provide insights into the complex relationships between innovation, productivity and exports. Exporting and industry technological characteristics may influence the decision to undertake R&D but has no effect on R&D expenditure. Only firm size has impact on both the decision and expenditure on R&D. All the variables (R&D expenditure, firm size, exports and local ownership) are statistically significant determinants of the propensity to innovate, be it product or process innovation. These variables have greater impact on process innovation compared to product innovation. Investment intensity, product innovation, process innovation and labour quality are all significant explanatory variables in the productivity equation. Interestingly, product innovation is negatively related to productivity while process innovation is positively related to productivity.

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Table 1: Descriptive Statistics

Variable	N	Mean
% Local Ownership	474	74.79
Total Employment	474	246.53
Fixed Asset (RM, million)	457	49
% Turnover Exported	443	39.43
Total Turnover (RM, million)	471	64
No. Graduate Employees	465	20

Table 2: Innovation Profile in the Malaysian Manufacturing Sector, 2002-2004

Industry	**Number of Firms**		
	Innovation	**No Innovation**	**Total**
Food Products and Beverages	30	35	65
Textiles	8	3	11
Wearing Apparel; Dressing and Dyeing of Fur	6	15	21
Tanning and Dressing of Leather; Luggage, Handbags, Saddelery, Harness and Footwear	8	5	13
Wood; Products of Wood and Cork Except Furniture; Articles of Straw and Plaiting Materials	22	18	40
Paper and Paper Products	9	7	16
Publishing, Printing and Reproduction of Recorded Media	11	16	27
Coke, Refined Petroleum Products and Nuclear Fuel	1	3	4
Chemicals and Chemical Products	16	12	28
Rubber and Plastic Products	38	23	61
Other Non-Metallic Mineral Products	6	13	19
Basic Metals	11	8	19
Fabricated Metal Products, Except Machinery and Equipment	27	21	48
Machinery and Equipment N.E.C.	7	8	15
Office, Accounting and Computing Machinery	5	3	8
Electrical Machinery and Apparatus N.E.C	8	6	14
Radio, Television and Communication Equipment and Apparatus	25	8	33
Medical, Precision and Optical Instruments, Watches & Clocks	4	2	6
Motor Vehicles, Trailers and Semi Trailers	5	2	7
Other Transport Equipment	3	3	6
Furniture Manufacturing N.E.C.	9	12	21
Recycling	2	1	3
Total	**261**	**224**	**485**

Table 3: Research Equation

Coefficient	(1) R&D Expenditure	(2) Select
Local Ownership	-0.437	-0.204
	(0.58)	(0.17)
HHI	0.000310	0.0000113
	(0.00031)	(0.000086)
Export > 0%	-0.644	0.939***
	(1.73)	(0.24)
High-Medium Tech	0.338	0.638***
	(1.09)	(0.19)
Size	-0.00101**	0.000304**
	(0.00049)	(0.00012)
Constant	13.41***	-2.123***
	(4.03)	(0.32)
Observations	474	474

Standard errors in parentheses
*** pí0.01, **pí0.05, *pí0.1

Table 4: Innovation Equation

COEFFICIENT	(1) Product Innovation	(2) Process Innovation
R&D Expenditure	0.700***	1.119***
	(0.21)	(0.23)
Size	0.00116***	0.00171***
	(0.00026)	(0.00028)
Export > 0%	1.361***	1.746***
	(0.19)	(0.20)
Local Ownership	0.303*	0.690***
	(0.18)	(0.19)
Constant	-10.63***	-16.64***
	(2.97)	(3.17)
Observations	474	474

Standard errors in parentheses
*** pí0.01, **pí0.05, *pí0.1

Table 5: Productivity Equation

COEFFICIENT	(1) Ouput	(2) Output
Investment Intensity	0.309*** (0.043)	0.321*** (0.044)
Product Innovation	-2.053*** (0.76)	-2.186*** (0.79)
Process Innovation	1.655*** (0.61)	1.650*** (0.63)
Labour Quality	1.931*** (0.61)	1.981*** (0.62)
No. of Employees	-0.000314* (0.00018)	
1-49 Employees		0.224 (0.25)
50-99 Employees		0 (0)
100-249 Employees		0.309 (0.27)
250-999 Employees		0.200 (0.27)
≥ 1000 Employees		0.478 (0.45)
Constant	7.043*** (0.49)	5.827*** (0.91)
Observations R^2	315 0.22	315 0.22

Standard errors in parentheses
*** pí0.01, **pí0.05, *pí0.1