Multi-product exporters, productivity, and the margins of Malaysian exports: A firm-level panel data analysis

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Received February 13, 2023
Revised March 19, 2023
Accepted August 22, 2023

Abstract

This paper explores the importance of multi-product exporters and examines the relationship between firm productivity and export margins using export data from 1200 Malaysian manufacturing firms. To begin with, we divide the individual-level exports into two components, the number of export destinations (the extensive margin) and average exports per destination (the intensive margin). In addition, we use the Semykina and Wooldridge (2010) panel data estimation method which accounts for unobserved heterogeneity and sample selection to examine the relationship between firm productivity and export margins. Empirical findings suggest that more productive firms export more and have greater average export flows per destination. The evidence of more productive firms exporting to more destinations is inconclusive.

Keywords: International trade, Firm heterogeneity, Multi-product exporters, Firm productivity, Export margins.
JEL Classification Code: F1, F14, L11

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1. Introduction

"Firm heterogeneity," the recent advancement in trade theory is focused on two important arguments, (1) the existence of a fixed (sunk) cost before exporting and (2) the difference in productivity level decides the status of the firm at any point in time: exporter or not an exporter (Bernard & Jensen, 2004; Bernard et al., 2007a; Chaney, 2008; Helpman et al., 2008; Melitz, 2003; Melitz & Ottaviano, 2008). The theoretical models on firm heterogeneity show that endogenous firm heterogeneity and *ex ante* fixed costs of exporting drive the selection of the most productive firms into the export market (Melitz, 2003; Melitz & Ottaviano, 2008). Most recently, a great deal of interest has been shown by researchers in the multi-product firms in the trade literature (Bernard & Jensen, 2004; Bernard et al., 2011; De Loecker, 2007). Theoretically and empirically, this aspect of heterogeneity has been extensively studied as researchers look at how multi-product firms respond to foreign competition by endogenously shifting their product mix in favor of their core strengths, encouraged by lower costs and higher markups (Bernard et al., 2011; Bernard et al., 2014; De Loecker, 2011; Mayer et al., 2014).

This paper draws the theoretical motivation from the model outlined by Mayer et al. (2014). In a monopolistic competition setting, the model incorporates endogenous markups and a flexible manufacturing process. Typically, monopolistically competitive firms have one "core strength," i.e., a key product associated with the marginal cost selected at random from the productivity distribution, while they produce products outside their core strength at a higher marginal cost. The firms' products are ranked according to how far they are from their core strength: the further away a product is, the more the marginal costs of production for the product. The model shows that rising competition causes the distribution of markups across products to go downward, thus skewing the sales in favor of the best-performing products. When competition is tougher, firms respond to the tougher environment by reducing the number of products they produce and concentrating on their core products (Mayer et al., 2014, p. 496). Because firms choose better-performing products and discontinue fewer core products, a selection effect occurs. Products with core strength are produced in greater quantities because of resource allocation between products. The combined effect of the selection of better-performing firms and the allocation of resources towards core products increase aggregate productivity (Mayer et al., 2014, p. 525-527). The model makes several important predictions, two of which are key to this paper, (1) a greater level of firm productivity increases firm-level exports and the number of products sent abroad, and (2) multi-product exporters export to a range of destinations and export a given product in greater quantities to each of them (Mayer et al., 2014).

By utilizing panel data of 1200 Malaysian manufacturing firms for 3 years, we explore the participation of Malaysian multi-product firms in international trade and examine these testable predictions as mentioned above. To achieve this, firstly, we divide the firm-level exports into two components, (a) the number of export destinations served and (b) the mean size of export values per destination. Secondly, we utilize the panel feature of our data set to estimate firm-level productivity following the methodology outlined by Levinsohn and Petrin (2003). Thirdly, we examine the relationship between productivity and exports, and export margins. This paper is influenced by the works of Bernard et al. (2014) which examines the role of multi-product firms in Belgian manufacturing and estimates the relationship between productivity and both extensive and intensive margins of trade (Bernard et al., 2014). This paper complements previous studies of Bernard et al. (2014) with the following advances:

1) It incorporates a panel data estimation method that accounts for unobserved heterogeneity and sample selection to examine the relationship between firm productivity and exports and export margins.

2) Contrary to Bernard et al. (2014), this paper estimates the total factor productivity (*TFP*) by Levinsohn and Petrin (2003) method. The authors estimate the *TFP* as an index by comparing each firm in the cross-section to a hypothetical firm, which is defined as the average of all firms.

More recently, at the industry level, Jongwanich (2020) investigated the importance of export margins of Thai exports in contributing the economic growth and discovered that the role of intensive margins is crucial in driving economic growth; however, the role of extensive margins both in terms of goods and countries are limited. In terms of goods, the extensive margins have a definitive effect on economic growth in the processed food, and textiles and apparel industries, while the significance of extensive margins in terms of new market destinations is conclusive only for the electronics sector (Jongwanich, 2020). We contribute to the emerging literature on multi-product firms by providing micro-level evidence of their importance in Malaysian exports and testing whether the theoretical predictions on multi-product firms hold. Our results find a positive significant relationship between productivity and individual exports and the intensive margin. These findings are in line with the theoretical predictions of Mayer et al. (2014).

The paper is organized as follows: Section 2 presents the motivations for the Panel data selection model and a review of the literature on determinants of firm export decisions, Section 3 reports the data source and a basic understanding of the data, Section 4 discusses the specifications on estimating total factor productivity (*TFP*) and the panel data selection model while Section 5 presents the empirical findings. Section 6 concludes.

2. Empirical Motivations

The section is roughly divided into two parts. Section 2.1 outlines the motivations for the panel data model in the presence of unobserved heterogeneity and sample selection and Section 2.2 provides a review of the determinants to be used in the selection equation.

2.1 Motivations for Panel Data Selection Model

In this paper, we use the data of 1200 firms for 3 years and we wish to study the relationship between productivity and exports, and exports are decomposed into export (country) margins. However, the export values of a firm are recorded only if the firm is an exporter at time *t*. The existing theoretical and empirical literature explains that within the industry, there lies heterogeneity in the sense that the productivity levels (or cost levels) are different across firms, at any point in time (Helpman et al., 2008; Mayer et al., 2014; Melitz, 2003; Melitz & Ottaviano, 2008; Melitz & Redding, 2014). Only the most productive firms that exceed the (unobserved) export productivity cutoff can enter the foreign market while others continue to produce for the domestic market. Hence, firm-specific productivity is the key determinant of firm export decisions. Similarly, there is conclusive evidence that productivity is positively related to export values and export margins as well (Bernard et al., 2014). Thus, some unobserved factors that affect the export values also affect the decision to export, such as productivity. This kind of selection will then influence export values through the error term and lead to inconsistent estimation if only the outcome equation is estimated alone. We draw motivation from the panel data estimation method proposed by Semykina and Wooldridge (2010), which takes sample selection and unobserved heterogeneity into consideration, to solve the selection problem (Semykina & Wooldridge, 2010). The estimation method offers a potentially helpful tool in this situation since it enables us to both test and correct for potential sample selection biases. We present a simplified explanation of the estimation method in the context of this paper.

Consider a correlated unobserved effects panel data model where export values ev_{it} are used as dependent variable (Eq. 1):

$$ev_{it} = x_{it}\beta + c_i + u_{it} \quad (1)$$

The selection equation (decision to export) is defined by a latent variable, $d^*{}_{it}$,

$$d^*{}_{it} = z_{it}\delta_t + k_i + e_{it};$$
$$d_{it} = 1[d^*{}_{it} > 0] = 1[z_{it}\delta_t + k_i + e_{it} > 0] \quad (2)$$

In Eq. 1, ev_{it} are export values and the vector x_{it} contains the explanatory variables that we observe irrespective of the firm's participation in exporting, including total factor productivity. Unobserved firm-level characteristics are contained in c_i and u_{it} is the error term. Eq. 2 describes a firm's decision to export, where $d^*{}_{it}$ is the latent propensity to export, 1[.] is an indicator function which equals one if there is export at time t and 0, otherwise. Usually, x_{it} is a subset of the vector z_{it} (Miranda & Rabe-Hesketh, 2006). Projecting k_i as a linear projection onto the time averages of z_{it}, denoted by $\bar{z}_i$, and an error term a_i, Eq. 2 can be expressed as (Eq. 3):

$$d_{it} = [z_{it}\delta_t + \bar{z}_i\xi_t + v_{it} > 0] \quad (3)$$

Where, $v_{it} = e_{it} + a_i$, a_i is independent of z_i, and allowed to be heterogeneously varied over time and no restrictions on v_{it}, and v_{is} for $s \neq t$. Like the selection equation, the unobserved effect in the outcome equation is modeled as a projection of c_i onto $(\bar{x}_i, v_{it})$ and an error term b_i. This specifically models the unobserved effect such that the correlation between c_i and $(\bar{x}_i, v_{it})$ is possible (Semykina & Wooldridge, 2010, p. 376-377; Wooldridge, 1995).

An estimator that allows v_{it} in Eq. 3 to be correlated with u_{it} and c_i in Eq. 1 can be obtained by (Eq. 4):

$$ev_{it} = \xi_t\bar{x}_i + x_{it}\beta + \eta_t\lambda_{it} + r_{it} \quad (4)$$

Where, $r_{it} = b_i + l_{it}$, l_{it} is the remaining part of the u_i after including the inverse Mills ratios (IMRs). The IMRs λ_{it} are predicted by estimating Eq. 3 with standard probit estimates for each period. The selection equation must contain at least one additional variable that affects the selection but is not part of the outcome equation (Semykina & Wooldridge, 2010, p. 378). According to the authors' instructions, standard errors that are robust to serial correlation and heteroskedasticity are calculated using a bootstrap procedure.

2.2 Determinants of Firm Export Decisions

According to the new "new trade theory," productivity is the key firm-specific factor that enables a firm to start exporting. A firm can access the export market if its level of productivity is greater than the export productivity cut-off (Bernard & Jensen, 1999, 2004; Bernard et al., 2007b; De Loecker, 2007; Melitz, 2003). Thus, a greater level of productivity is essential to start exporting. The decision to export is also influenced by other factors including firm age, firm size, foreign ownership, R&D, capital intensity, and so on (Dueñas-Caparas, 2006; Greenaway et al., 2007; Jongwanich & Kohpaiboon, 2008; Lawless, 2013).

Typically, larger firms are likely to be able to bear the costs of exporting. As exporting is costly, smaller firms may encounter difficulties in getting market updates, initiating marketing campaigns abroad, managing currency fluctuations, etc. (Dueñas-Caparas, 2006; Jongwanich & Kohpaiboon, 2008). Therefore, firm size and decision to export are generally considered to be positively related.

Since experienced firms can benefit from their accumulated expertise and compete in a foreign market in a better way, the age of the firm can have a significant impact on export decisions. On the contrary, the core strengths of mature firms may become rigid, and younger firms may become more adaptable and aggressive in serving foreign markets (Correa et al., 2007; Dueñas-Caparas, 2006; Jongwanich & Kohpaiboon, 2008; Mañez* et al., 2004;

Seenaiah & Rath, 2018; Srinivasan & Archana, 2011). Hence, the relationship between firm .age and export can be ambiguous

Furthermore, foreign shareholders can bring access to new export markets, new products, etc., so, having foreign ownership may be favorable for a firm to widen its contact abroad and find potential markets for its products (Cole et al., 2010; Greenaway et al., 2007; Vinh & Duong, 2020).

The capital intensity sometimes referred to as the capital-to-labor ratio usually captures industry features and a nation's comparative advantage. In developing nations where labor is inexpensive compared to capital, a low level of capital intensity suggests that more labor is used and firms that manufacture labor-intensive products are more likely to compete with foreign firms in the export market. Contrarily, in developed nations, firms that manufacture capital-intensive products are more likely to be exporters in line with their country's comparative advantage (Jongwanich & Kohpaiboon, 2008; Srinivasan & Archana, 2011).

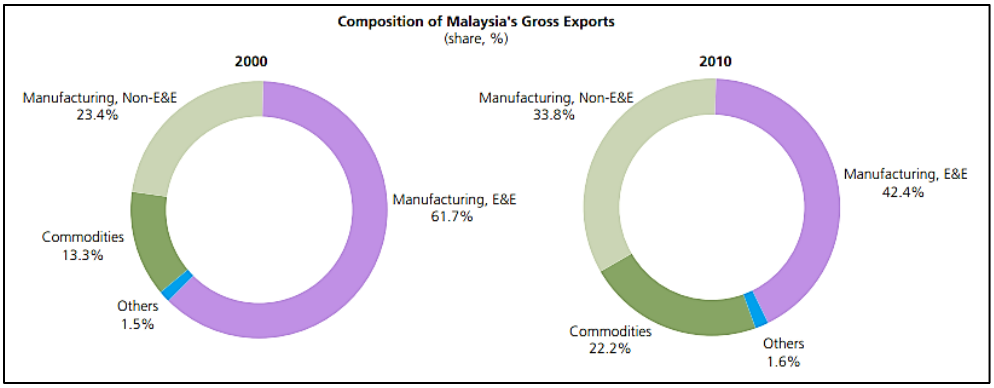
Firms with better research and development capabilities are likely to be exporters as R&D might enable a firm to upgrade its products in line with the overseas demand (Seenaiah & Rath, 2018; Srinivasan & Archana, 2011). Firms may invest in R&D and improve their productivity to ensure that self-selection to exporting is possible (Aw et al., 2007). Thus, we expect a positive relationship between R&D investments and the propensity to export.

3. The Data

The data comes from a productivity and investment climate survey conducted by the World Bank for 1200 Malaysian manufacturing firms in 2007 and covers the information for three fiscal years from 2004 to 2006. The study relies on publicly available firm-level data from the World Bank, especially the enterprise survey data. Though the World Bank has made the enterprise survey data available up to 2019, most of the data are on productivity and investment climate. The most recent datasets made available do not contain export-related data to analyze multi-product exporters. Before around 2010, the questionnaires used by the World Bank were quite detailed and used to contain export-related information in general with occasional information on multi-product firms. After a thorough examination of the data available from 2002 to 2017 for multiple countries, this dataset was found appropriate for the analysis here. Benchmarking the productivity, investment climate, and competitiveness in Malaysia was the aim of the study. A total of 1200 firms were chosen for the final study from the sampling frame of 3322 manufacturing firms that were taken from the Central Register of Establishments (SIDAP) recorded by the Department of Statistics, Malaysia. The total sample size for each sector was decided based on practical factors because the study comprises extensive questionnaires and the authorities wished to complete the study in a limited amount of time (WB, 2007, p. 3). However, the documents do not explicitly mention what kind of factors were taken into consideration. For the manufacturing sector, only establishments with more than 10 employees are covered and the sampling frame is stratified by region, state, and industry. The study has a geographical coverage of six regions: four in Peninsular Malaysia and two in East Malaysia. The details of the locations and industries are given in the appendices section.

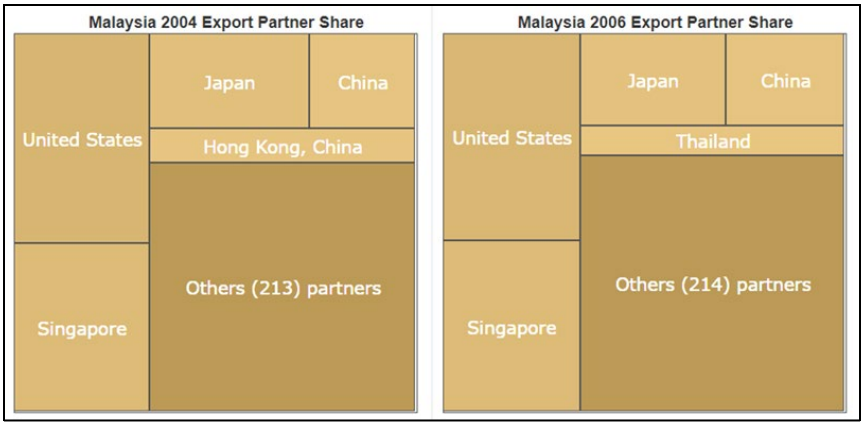
3.1 Stylized Facts on Multi-product Firms

We highlight some details regarding the Malaysian export environment in the first decade of the twenty-first century before explaining the existence of multi-product firms. In Malaysia, the services sector makes up the majority of GDP contribution followed by manufacturing, agriculture, and mining sectors (WTO, 2006, p. 5). Since the '00s, industrial exports have been the main driver of export growth; other sectors performed less well, with agriculture lagging (WB, 2023; WTO, 2006). Malaysia continued to liberalize its trade policy from 2001 to 2006, and during that time exports of goods averaged roughly 110 percent of the GDP (WB, 2022; WTO, 2006, p. 1; Yusuf & Nabeshima, 2009, p. 38). The simple average tariff across all products in 2006 was 6.95 percent, down from an 8.01 percent tariff in 2001. Likewise, the trade-weighted average tariff decreased from 5.06 in 2001 to 3.68 in 2006. Malaysia's exports are mostly made up of manufactured items, particularly electrical and electronics (E&E) products (WTO, 2006, p. 11-13). From 2004 to 2006, the export composition relatively remains unchanged with monolithic integrated circuits, parts, and accessories of automatic data process, petroleum oils, digital auto data process, and natural gas products accounting for the majority of export revenue (WTO, 2006, p. 7). In the latter half of the decade, however, there was a steady rise in the share of non-electrical and electronics (Non-E&E) products. **Figure 1** compares the composition of Malaysia's gross exports between 2000 to 2010.



Source: BankNegara, 2011, p. 32
Figure 1. Composition of Malaysia's gross exports, 2000 vs. 2010

Between 2004 and 2006, Malaysia's main trading partners continued to be the United States, Japan, Singapore, and China, which together accounted for more than half of the country's exports (WB, 2023). Also, over half of Malaysia's exports were with other East Asian economies and continued to grow during the period (WTO, 2006, p. 13). The expansion of intra-Asian exports was centered mostly on commodities like palm oil, mineral fuels, and petrochemicals whereas developed countries continued importing electrical and electronics products from Malaysia. By 2006, Thailand replaced Hong Kong as the fifth largest importer of Malaysian products (WB, 2023). In a nutshell, fewer products and fewer partners made up most of Malaysia's export revenue from 2004 to 2006. **Figure 2** presents a comparative overview of Malaysia's export partner share between 2004 and 2006.



Source: WB, 2023
Figure 2. Composition of Malaysia's export partner share, 2004 vs. 2006

Now, we outline some stylized facts about the multi-product exporters in Malaysia and present them in **Table 1**. Multi-product exporters constitute most firms. 67 percent of all exporters are multi-product firms, they account for 80 percent of the total export value from 2004 to 2006. Relatively few firms export more than 10 products, but these 17 percent of firms still account for 42 percent of total exports. These results are in line with what is documented by other researchers such as Bernard et al. (2014) for Belgium, Bernard et al. (2009) for the USA, and others (Bernard et al., 2009; Bernard et al., 2014). The average number of export destinations per firm is 1.88, which is relatively low compared to other countries in the existing literature. There is no substantial variation in the average number of destinations as outlined in Column (7). The average exports per firm seem to vary substantially and have an increasing pattern with the number of products exported. On average, exporters with more than 40 products export significantly more than those with a lesser number of products (Column 6) which is in line with the findings of Bernard et al. (2014) for Belgian firms. Average exports per destination do not vary significantly up to 40 products, however, it seems to vary significantly when compared between the exporters with more than 40 products and those with a lesser number of products (Column 8).

Table 1 Summary statistics of firm-level exports: 2004-2006

No. of products exported	Exporters: All firms		Value of Exports		Average exports per firm (MYR in Millions)	Average no. of export destinations per firm	Average exports per destination (MYR in Millions)
	N	% of total	Value (MYR in Millions)	% of total			
1	660	33	10,343.31	20	15.64	1.67	4.89
2 -10	990	50	19,903.32	38	20.10	1.88	5.02
11 - 40	196	10	10,756.04	12	29.61	2.08	5.18
>40	114	07	15,327.48	30	134.45	1.89	32.81
Total	**1,960**	**100**	**56,330.15**	**100**	**49.95**	**1.88**	**11.97**

Note:

1. A product is defined as a ten-digit Combined Nomenclature product based on the Malaysia Standard Industrial Classification (MSIC).
2. The appendices section contains information on the exporting firms for each of the years.

Source: Author's estimations

4. Empirical Strategy

This section is broadly divided into two parts, (4.1) productivity estimation and (4.2) productivity and export margins.

4.1 Productivity Estimation

We estimate the firm-level total factor productivity (*TFP*) following the methodology outlined by Levinsohn and Petrin (2003). A firm's technology described by the Cobb-Douglas production function such as (Eq. 5):

$$Y_{it} = \mathrm{X}_{it} A_{it}^{\beta_a} L_{it}^{\beta_l} K_{it}^{\beta_k} M_{it}^{\beta_m} \quad (5)$$

Where, Y_{it} , the output in a firm *i* at time *t*, is a function of its age, A_{it}, labor, L_{it}, capital, K_{it}, and intermediate inputs, M_{it}. Here, X_{it} refers to the unobserved total factor productivity that varies across firms and periods. Taking the log of Eq. (5), we express the production function equation as (Eq. 6):

$$y_{it} = \beta_0 + \beta_a a_{it} + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + e_{it} \quad (6)$$

Where the dependent variable is the revenue at the firm level, deflated by industry-level producer price indices at a two-digit level (the data extracted from CEIC) and explanatory variables are the age of the firm, the total number of full-time workers, the net value of fixed assets, and intermediate input expenses of the firm i at time t used for constructing the variables age, labor, capital, and materials respectively.

Here, $e_{it} = \omega_{it} + \mu_{it}$, where the error e_{it} is composed of two terms (a) firm-specific efficiency ω_{it}, which is known only to the firm, not publicly known, and (b) μ_{it} , the unexpected shock that can affect productivity (Not known to the firm, not publicly known, either). Levinsohn and Petrin (2003) suggest using intermediate inputs as a proxy for unobserved productivity. The demand for intermediate inputs can be expressed as $m_{it} = m_t(\omega_{it}, k_{it})$ and this demand function can be replaced in the production function by inverting it. So, productivity can be a function of m and k, i.e., $\omega_{it} = \omega_t(m_{it}, k_{it})$. Then, the free variables can be estimated using semiparametric techniques followed by a Generalized Method of Moments technique to estimate for m and k. The methodology has two assumptions, (1) productivity follows a first-order Markov process, and (2) capital results in productivity with a lag. When productivity follows a first-order Markov process, it is expressed as $\omega_t = E\{\omega_t|\omega_{t-1}\} + \xi_t$, the innovation term ξ_t is uncorrelated to the capital (Levinsohn & Petrin, 2003). The production function parameters for each firm are consistently estimated using this method.

Table 2 reports the average value of a range of firm-level characteristics (in natural logarithmic form) for the exporters. These characteristics include total factor productivity (*TFP*), number of full-time employees, and capital intensity (defined as the net value of fixed assets per employee). To test whether the greater level of productivity, capital intensity, and full-time employment are statistically significant for all levels of the exporting firms that are classified by the number of products exported, we perform a series of bivariate linear regressions and report the results in **Table 3**. Eq. (7) is used to estimate the results in Column (1).

$$x_{it} = \alpha + \beta mpe_{it} + \varepsilon_{it} \quad (7)$$

Where, x_{it} refers to firm-specific characteristics that include total factor productivity, capital intensity, and full-time employment; all in logs. The variable mpe_{it} takes the value 1 if the exporter is a multi-product exporter at time *t* and 0, otherwise. Likewise, Columns (2), (3), and (4) of

Table 3 report the results of the following equations (8) to (10) respectively.

$$x_{it} = \alpha + \beta mpe^{2to10}{}_{it} + \varepsilon_{it} \quad (8)$$

$$x_{it} = \alpha + \beta mpe^{11to40}{}_{it} + \varepsilon_{it} \quad (9)$$

$$x_{it} = \alpha + \beta mpe^{>40}{}_{it} + \varepsilon_{it} \quad (10)$$

Where:

$mpe^{2to10}{}_{it}$ takes the value 1 if the exporter is exporting 2 to 10 products and 0; if exporting a single product at time *t*.

$mpe^{11to40}{}_{it}$ takes the value 1 if the exporter is exporting 11 to 40 products and 0; if exporting 2 to 10 products at time *t*.

$mpe^{>40}{}_{it}$ takes the value 1 if the exporter is exporting more than 40 products and 0; if exporting 11 to 40 products at time *t*.

Comparing the results in **Table 2** and **Table *3***, there is enough evidence that firm productivity and full-time employment are greater for most levels of the exporting firms classified by the number of products exported. Only in Column (3), the differences in terms of *TFP* and full-time employment are not statistically significant. The fact that full-time employment, which is generally referred to as an indicator of firm size is increasing with the number of exported products, indicates that multi-product firms are larger relative to the firms exporting a single product. The differences in capital intensity are not statistically significant for all levels of the exporting firms classified by the number of products exported (**Table *3***).

Table 2 Summary statistics of firm-specific characteristics

Number of products exported	ln(*Total factor productivity*)	ln(*Capital intensity*)	ln(*Employment*)
Total exports: All firms			
1	6.530	11.474	3.931
2 to 10	6.727	11.533	4.327
11 to 40	6.817	11.675	4.442
Greater than 40	6.924	11.79	4.802

Note:

1. Productivity is estimated according to Levinsohn and Petrin (2003) method.
2. Employment is proxied with the number of full-time workers.
3. Capital intensity is defined as the net value of fixed assets per full-time worker.
4. All the values mentioned are firm-level sample averages, taken from all exporting firms in the panel.

Source: Author's estimations

Table 3 Statistical significance of firm-characteristics for all levels of the firms classified by the number of products exported

Firm-level characteristics	Multi-product exporters premia (1)	Exporters with 2 to 10 products Vs. Single product exporters (2)	Exporters with 11 to 40 products Vs. Exporters with 2 to 10 products (3)	Exporters with more than 40 products Vs. Exporters with 11 to 40 products (4)
1. ln(*TFP*)	0.098*	0.097*	0.106	0.298**
	[0.010]	[0.054]	[0.080]	[0.127]
Observations	1,960	1,650	1,186	310
R Squared	0.001	0.001	0.001	0.01
2. ln(*Capital Intensity*)	0.067	0.066	0.080	0.203
	[0.061]	[0.004]	[0.091]	[0.151]
Observations	1,960	1,650	1,186	310
R Squared	0.001	0.001	0.001	0.01
3. ln(*Employment*)	0.297***	0.262***	0.022	0.326**
	[0.064]	[0.067]	[0.104]	[0.151]
Observations	1,960	1,650	1,186	310
R Squared	0.01	0.009	0.001	0.01

Note: 1. *, **, and *** indicate statistical significance at the 10, 5, and 1 percent levels, respectively.
2. Standard errors are reported in parentheses.

Source: Author's estimations

Table 4 lists the firm-specific characteristics that distinguish exporters from non-exporters. The summary indicates that the firm-specific characteristics of non-exporters are lower compared to the exporters, which is in line with the existing empirical findings. All the values mentioned are firm-level sample averages. The first row reflects the values taken from all exporting firms in the panel whereas the second row is for all non-exporting firms in the panel.

Table 4 Firm characteristics (Exporters vs. Non-exporters)

Particulars	ln(*Total factor productivity*)	ln(*Capital intensity*)	ln(*Employment*)	Obs.
Exporters: All firms	6.749	11.618	4.375	1,960
Non-exporters: All firms	6.330	10.990	3.670	1,385

Source: Author's estimations

4.2 Productivity and Export Margins

As explained in Section 2.1, we adopt the panel data estimation method that accounts for unobserved heterogeneity and selection (Semykina & Wooldridge, 2010). Hence, our selection equation with a binary dependent variable d_{it} (that takes the value 1 if there is export at time *t* and 0, otherwise) has the following form (Eq. 11):

$$d_{it} = \alpha_0 + \alpha_1 age_{it} + \alpha_2 labor_{it} + \alpha_3 ci_{it} + \alpha_4 tfp_{it} + \alpha_5 rd_{it} + \alpha_6 fo_{it} + industry_i + state_i + c_i + u_{it} \quad (11)$$

Here, the explanatory variables are:

age_{it} = Age of the firm at time *t* (in years and logs).
$labor_{it}$ = The total number of full-time employees at time *t* (in logs).
ci_{it} (Capital intensity) = The net value of fixed assets per full-time employee at time *t* (in logs).
tfp_{it} (Total factor productivity) = Productivity of the firm at time *t* (in logs).
rd_{it} (Research and development) = Total number of dedicated employees working on research and development at time *t* (in logs).
fo_{it} (Foreign ownership) = A dummy variable that takes the value of 1 if the ownership of the firm is shared with a foreign national at time *t* and 0; otherwise.
$industry_i$ and $state_i$ are industry and state-fixed effects.

The outcome equation of our analysis that examines the relationship between firm productivity and exports is (Eq. 12):

$$ln(ev_{it}) = \beta_0 + \beta_1 age_{it} + \beta_2 labor_{it} + \beta_3 ci_{it} + \beta_4 tfp_{it} + \beta_5 fo_{it} + industry_i + state_i + \eta_t \lambda_{it} + r_{it} \quad (12)$$

Where, ev_{it} is the value of the exports *(*in MYR*)* of the firm *i* at time *t*. The IMRs λ_{it} are calculated by estimating Eq. 11 with standard probit estimates for each period. Importantly, rd_{it} is the identifier which is an explanatory variable in the selection stage and is excluded from the outcome stage estimation. Theoretically, the selection of firms for exporting is the outcome of an R&D process with an uncertain outcome. The costs of R&D are irreversible, meaning that it influences entry to the market and after exporting, it is sunk. Hence, this is a reliable identifier to use. Similarly, the specifications of the outcome equations where extensive and intensive margins are used as dependent variables respectively are (Eq. 13 and Eq. 14) :

$$ln(em_{it}) = \gamma_0 + \gamma_1 age_{it} + \gamma_2 labor_{it} + \gamma_3 ci_{it} + \gamma_4 tfp_{it} + \gamma_5 fo_{it} + industry_i + state_i + \eta_t \lambda_{it} + r_{it} \quad (13)$$

$$ln(im_{it}) = \theta_0 + \theta_1 age_{it} + \theta_2 labor_{it} + \theta_3 ci_{it} + \theta_4 tfp_{it} + \theta_5 fo_{it} + industry_i + state_i + \eta_t \lambda_{it} + r_{it} \quad (14)$$

Where: em_{it}= The total number of export destinations served by firm *i* at time *t.*
im_{it} = The average value of exports (in MYR) per destination by firm *i* at time *t.*

We outline the correlation matrix of the explanatory variables used in the models in **Table 5**.

Table 5 Correlation matrix

Variables	Age	TFP	RD	Capital Intensity	Labor	Foreign Ownership
Age	1					
TFP	0.13	1				
RD	0.05	0.22	1			
Capital Intensity	0.11	0.42	0.09	1		
Labor	0.07	0.56	0.29	0.10	1	
Foreign Ownership	-0.05	0.27	0.11	0.19	0.36	1

Source: Author's estimations

5. Empirical Findings

The estimations of outcome equations (12), (13), and (14) are shown in **Table 6** where Eq. (11) serves as the selection equation in each case. Columns (1), (2), and (3) report the outcome equation estimates where the dependent variables are exports, extensive margin, and intensive margin respectively.

The relationships between the variable *Age* and exports, and intensive margin are negative and significant at a 1 percent level (Columns 1 and Column 3). The variable *FO* is positive and significant in Column (1) and Column (3). This suggests that foreign-owned firms export more than domestic firms do, and the average value of exports per foreign-owned firm is higher than the average value of exports by domestic firms. However, the variable *FO* is negative and significant at the 10 percent level in Column (2). This means foreign-owned firms export to lesser destinations when compared to domestically owned ones. The coefficients associated with our primary variable of interest, *TFP* and exports, and intensive margin are significant at a 1 percent level. This is in line with the findings of existing studies on goods and country margins of trade (Bernard et al., 2014). Our findings on *TFP* in Column (1) and Column (3) suggest that more productive firms export more and have greater average export flows per destination. A 1 percent increase in *TFP* is associated with a 1 percent increase in firm exports while average exports to each destination rise by 1.03 percent when *TFP* increases by 1 percent. Unexpectedly, the coefficient of *TFP* and extensive margin is negative, but not significant. In all three sets of outcome equation regressions, the coefficients associated with *Labor*, and *Capital intensity* are positive, but not statistically significant. Finally, Wald tests on the joint significance of the IMRs in Columns (2) and (3) indicate that selection is important; only estimating the outcome equation is inconsistent.

Table 6 Firm productivity and export margins

Particulars	(1) Export values	(2) Extensive Margin	(3) Intensive Margin
Age	-0.409*** [0.072]	0.024 [0.034]	-0.434*** [0.086]
Labor	0.122 [0.143]	0.075 [0.165]	0.046 [0.179]
Capital intensity	0.121 [0.103]	0.007 [0.057]	0.113 [0.137]
TFP	1.007*** [0.063]	-0.025 [0.029]	1.032*** [0.076]
Foreign Ownership	0.448*** [0.090]	-0.062* [0.032]	0.510*** [0.099]
Constant	-4.572*** [0.587]	-4.572*** [0.502]	-4.572*** [0.750]
Number of obs.	3,345	3,345	3,345
Clusters	1,115	1,115	1,115
Bootstrap Replications	50	50	50
	Wald tests on the joint significance of		
3 IMRs	1.57	35.32***	21.54***
2 Time dummies	11.38**	76.92***	23.66***
12 Industry dummies	31.06**	17.47*	69.97***
9 State dummies	11.67*	28.00***	24.09**

Note:

1. Standard errors are reported in parentheses.
2. * Significance at ten, ** at five, and *** at one percent.
3. Standard errors are robust to serial correlation and heteroskedasticity.
4. χ^2 test statistics for the joint significance of the variables are reported.

Source: Author's estimations

The major limitation of this paper is that it is unable to capture how these firms' productivity responds to changes in trade costs. However, our empirical specification in the outcome stage that examines the relationship between productivity and export margins is consistent with the specification adopted by other researchers, e.g. (Bernard et al., 2014). As the data source only records the exports and number of countries served by the firm, we could only observe how many destinations the exporters are exporting to and the mean size of their exports per destination. The closest paper to this is Bernard et al. (2014) which examines the effect of trade cost changes such as distance, real exchange rates, etc. on the goods margins of Belgian trade. However, the authors have transactional information on the goods and export destinations. This dataset does not have a record of the exact destinations and how many products are exported to each destination. The transactional level information on firms, products, and exact destinations is often private, and accessing the microdata library can be expensive. Hence, given these constraints, this paper presents reasonable results on the relationship between firm productivity and export (country) margins by accessing a public data source.

6. Conclusion

Using panel data from 1200 Malaysian manufacturing firms for 3 years, this paper explores the significance of multi-product firms. Considering the theoretical hypotheses on multi-product firms presented by Mayer et al. (2014), it examines the role of multi-product firms in Malaysia. Multi-product firms in the data constitute 67 percent of all exporting firms and account for 80 percent of total exports. Relatively few firms export more than 10 products, but these 17 percent of firms still account for 42 percent of total exports. The multi-product firms have higher productivity and full-time employment. It further divides the individual exports into two components, (1) the number of export destinations and (2) the mean size of exports per destination and examines the relationship between firm productivity and exports and export margins. It adopts the Semykina and Wooldridge (2010) panel data estimation method which accounts for unobserved heterogeneity and sample selection to estimate the coefficients. The empirical findings suggest that more productive firms export more and have higher average export flows per destination. However, the relationship between productivity and extensive margin is inconclusive.

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Appendix-I Manufacturing Activities Covered in the PICS Study

Manufacturing	Employment Threshold
Food Processing (15)	More than 10 employees
Textiles (17)	
Garments (18)	
Wood & Wood Products (20)	
Chemicals & Chemical Products (24)	
Rubber and Plastics (25)	
Machinery and Equipment (29)	
Office, Accounting, & Computing Machinery (30)	
Electrical Machinery & Apparatus (31)	
Electronics (Equipment & Components) (32)	
Motor Vehicles and Parts (34)	
Furniture (36)	

Appendix-II Geographical Coverage of the Survey

Region	State	Town
Peninsular Malaysia		
1. Klang Valley (Central)	Kuala Lumpur	Kuala Lumpur
	Selangor	Kelang
	Melaka	Petaling and Melaka Tengah
2. North	Pulau Pinang	Pulau Pinang
	Kedah	Kulim
3. South	Johor	Johor Bharu, Batu Pahat, and Muar
4. East	Terengganu	Kuala Terengganu and Kemaman
East Malaysia		
5. Sabah	Sabah	Kota Kinabalu
6. Sarawak	Sarawak	Kuching

Appendix-III Summary of Firms Across Years

Year	Exporters	Non-exporters	Total Firms
2004	648	467	1,115
2005	653	462	1,115
2006	659	456	1,115
Total	**1,960**	**1,385**	**3,345**

Note: Of the 1200 surveyed firms, we dropped those firms with incomplete data during the final stages of analyses.