# What Drives Exports? Empirical Evidence at the Firm Level

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# Empirical Evidence at the Firm Level

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*To my family and friends*

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Viroj Jienwatcharamongkhol
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# Contents

# Chapter 1

# Introduction

A central question in the international-trade literature is what factors drive firms' export behaviour. This topic has long held interest within the research community and among policymakers. This is partially because exporters are praised as significant contributors to domestic job creation and economic growth (due to their superior productivity), inasmuch as export-promoting policies are among the driving forces behind the proliferation of newly emerging countries. In recent years, richer data has become more accessible to researchers and this access helps generate new development of both theoretical models and empirical trade analyses. This is an exciting development: We are able to test predictions using real-world data at an unprecedented scale.

One distinct feature of firms' exporting is that there exists a large variation among firms in terms of participation and intensity. The majority of firms do not export. For firms that do, the size of exporting varies across destination markets. This variation of trade among firms implies an adjustment in firms' behaviour. The aim of this thesis is to the understand how firms engage in exporting, particularly in consideration of three aspects—product type, past trade experience, and investments in innovation activities.

This thesis consists of three chapters relating to determinants of firms' exporting. Chapter 2 investigates the distance effect on the exporting of homogeneous and differentiated products. Chapter 3 examines the interaction between past importing and productivity in affecting firms' export decisions. Chapter 4 uses a structural framework to provide empirical evidence linking innovation, productivity, and exporting. All chapters employ Swedish microdata for the analysis.

This introduction serves as an overview of the theme and provides a context that connects the three studies. Section 1.1 provides a brief summary of recent developments in the trade literature on export behaviour, with a focus on firm heterogeneity. Section 1.2 reviews the main findings from each chapter in this thesis.

## 1.1 Determinants of export behaviour

It is commonly believed that exporting is good for the economy. The belief is based on the observation that exporters are better firms, in almost every aspect that can be measured. Compared to nonexporters, they employ more, pay higher salaries, earn more profits, and so on. But the mechanism behind firms' export behaviour is still not fully understood.

The study of export behaviour has a root in the macroeconomic tradition, where theories and empirical studies analyse trade between nations. But beginning from the 1980s, the availability of microdata offers researchers an opportunity to examine trade at the firm level. Starting with the studies by Bernard et al. (1995) and Bernard and Jensen (1997, 1999), a growing number of studies provides microlevel evidence on the systematic difference of exporting firms compared to nonexporters in terms of size, age, productivity, ownership structure, and other firm-specific characteristics (Aitken et al., 1997; Roberts and Tybout, 1997, among others). An emergent challenge is that existing theories do not reflect real-world observations; a new theoretical development has been needed to remedy this. The assumption of a representative firm in the Heckscher–Ohlin model of comparative advantage between industries, for example, cannot account for the heterogeneity of firms within industries. In another example, the love-of-variety assumption for consumers' utility in the Krugman model (1979; 1980) of intraindustry trade implies that all firms engage in exporting, in stark contrast to real-world observations.

The influential work by Melitz (2003) became the first model to incorporate firms' productivity heterogeneity and monopolistic competition with increasing returns to scale. This model became a starting point for many trade studies that focused on the heterogeneity of firms. The construction of the model in its bare essentials is summarised below.[1]

Preferences of a representative consumer are assumed with a constant

[1] For a more detailed account and a discussion of various extensions of the model, please refer to Redding (2011) and Melitz and Redding (2014).

elasticity of substitution (CES) with value $\rho$ over goods $\omega$ in a set of $\Omega$,

$$U = \left[\int_{\omega\in\Omega} q(\omega)^{\rho}\mathrm{d}\omega\right]^{\frac{1}{\rho}}; 0 < \rho < 1, \tag{1.1}$$

and the price index is of the Dixit–Stiglitz love-for-variety type,

$$P = \left[\int_{\omega\in\Omega} p(\omega)^{1-\sigma}\mathrm{d}\omega\right]^{\frac{1}{1-\sigma}}; \sigma = \frac{1}{1-\rho} > 1,$$

where $\sigma$ is the elasticity of substitution between varieties of goods. The derived expenditure over varieties is

$$r(\omega) = R\left(\frac{p(\omega)}{P}\right)^{1-\sigma}, \tag{1.2}$$

where $R$ represents aggregate expenditure, which is equivalent to aggregate revenue of domestic producers, and $P$ is the price index.

The market structure is monopolistic competition and the production involves only labour, which is assumed to be inelastically supplied at its aggregate level $L$. Production technology is characterised by fixed and constant variable costs:

$$l = f + \frac{q}{\varphi}; f, \varphi > 0, \tag{1.3}$$

where $\varphi$ denotes a fixed productivity index that firms draw from a fixed distribution $g(\varphi)$ after paying sunk entry costs.

The first-order condition from the profit-maximisation problem yields equilibrium prices as the markup over marginal cost. Due to constant elasticity of demand between domestic and export markets, the equilibrium price of the export market is equal to the domestic price multiplied by variable trade costs:

$$p_{\mathrm{x}}(\varphi) = \tau p_{\mathrm{d}}(\varphi) = \frac{\tau}{\rho\varphi}, \tag{1.4}$$
$$p_{\mathrm{d}} = \frac{w}{\rho\varphi} = \frac{1}{\rho\varphi},$$

where $p_{\mathrm{x}}$ and $p_{\mathrm{d}}$ denote export prices and domestic prices, $\tau > 1$ is the standard iceberg-type trade cost, and $w$ is the numeraire wage rate for all countries.

Total revenue earned from domestic and export sales is, therefore,

$$r_{\mathrm{d}}(\varphi) = R(P\rho\varphi)^{\sigma-1}, \tag{1.5}$$
$$r_{\mathrm{x}}(\varphi) = \tau^{1-\sigma} r_{\mathrm{d}}(\varphi).$$

Because all firms already incur fixed costs, it is more profitable for firms to serve both domestic and export markets. Therefore, no firm will export without serving the domestic market. Then, for convenience, a firms' profit can be separated into domestic and export portions with the entire overhead costs in the domestic market and fixed exporting costs in the export market:

$$\pi_{\mathrm{d}}(\varphi) = \frac{r_{\mathrm{d}}(\varphi}{\sigma} - f_{\mathrm{d}}, \qquad (1.6)$$
$$\pi_{\mathrm{x}}(\varphi) = \frac{r_{\mathrm{x}}(\varphi)}{\sigma} - f_{\mathrm{x}},$$

where $f_{\mathrm{d}}$ denotes overhead costs of production and $f_{\mathrm{x}}$ country-specific per-period fixed costs.

The zero-profit cut-off condition, $\pi_{\mathrm{d}}(\varphi_{\mathrm{d}}^*) = \pi_{\mathrm{x}}(\varphi_{\mathrm{x}}^*) = 0$, implies the productivity cut-off level $\varphi^*$, written in the form of revenue as

$$\frac{r_{\mathrm{x}}(\varphi_{\mathrm{x}}^*)}{r_{\mathrm{d}}(\varphi_{\mathrm{d}}^*)} = \tau^{1-\sigma}\left(\frac{\varphi_{\mathrm{x}}^*}{\varphi_{\mathrm{d}}^*}\right)^{\sigma-1} = \frac{f_{\mathrm{x}}}{f_{\mathrm{d}}} \Leftrightarrow \frac{\varphi_{\mathrm{x}}^*}{\varphi_{\mathrm{d}}^*} = \tau\left(\frac{f_{\mathrm{x}}}{f_{\mathrm{d}}}\right)^{\frac{1}{\sigma-1}} > 1 \qquad (1.7)$$

Firms below the cut-off productivity level $\varphi_{\mathrm{d}}^*$ will then make negative profits and have to exit the market immediately: The relationship between the two productivity cut-offs, $\frac{\varphi_{\mathrm{x}}^*}{\varphi_{\mathrm{d}}^*} > 1$, implies that firms with lower productivity cannot afford the fixed export entry costs and must serve only the domestic market.

The Melitz model is prominent in that its features account for several empirical observations and that the many extensions and variants thereafter constitute an established line of research on their own. As a departure point, one line of research explores the Melitz model's assumption of fixed productivity. Because a firms' productivity is in general endogenous, several frameworks attempt to relax this assumption.

## 1.1.1 Multiproduct firms

The majority of firms are multiproduct firms, and there exists a substantial heterogeneity among products within these firms. To model multiproduct firms, Bernard et al. (2011) extend the Melitz model above by incorporating the continuum of products in the consumption choice, so that the utility of a representative consumer in country $j$ can be formulated as

$$U_j = \left[\int_0^1 q_{jk}^{\rho}\mathrm{d}k\right]^{\frac{1}{\rho}}; 0 < \rho < 1, \qquad (1.8)$$

where $k$ indexes products, $\rho$ denotes a constant elasticity of substitution, and the product continuum is normalised to the interval $[0, 1]$.

Each firm supplies differentiated products in the monopolistic market. The productivity consists of two elements: the ability common across products, $\varphi \in (0, \infty)$, and expertise specific to each product, $\lambda_i \in (0, \infty)$.

As in equation (1.7), there is a zero-profit cut-off for domestic firms and exporters. In this case, it depends on both firm ability and expertise:

$$r_{\mathrm{d}}(\varphi, \lambda^*_{\mathrm{d}}(\varphi)) = \sigma f_{\mathrm{d}}, r_{\mathrm{x}}(\varphi, \lambda^*_{\mathrm{x}}(\varphi)) = \sigma f_{\mathrm{x}}, \forall i. \tag{1.9}$$

In the case of asymmetric countries, Bernard et al. (2011) show that this framework yields a gravity equation for the extensive and intensive margins of trade, and the findings are consistent with the observed regularity in trade studies: There is a negative relationship between distance and the intensive margin of trade.

In a similar vein, chapter 2 of this thesis takes the network or search view pioneered by Rauch (1999) to analyse firms' export behaviour with regard to two product types, homogeneous and differentiated products. The argument being that the matching of international buyers and sellers is more costly for differentiated products, compared to homogeneous products. This is due to the fact that more transactions are required to exchange information regarding the nonstandardised characteristics of these products.

The analysis relies on the standard gravity model to estimate the effect of distance across these two product types. In its simple representation, firm–product exports can be expressed as

$$x_{ijk} = A\mathbf{Y}_j\mathbf{\Gamma}_{jk}\mathbf{T}_i, \tag{1.10}$$

where $A$ is a constant, $\mathbf{Y}$ denotes a vector of destination-country variables, $\mathbf{\Gamma}$ controls for domestic-country variables (or firm-specific characteristics in the case of one-sided gravity with unilateral trade flows), and $\mathbf{T}$ represents various trade costs.

### 1.1.2 The import–export nexus

Another regularity of observed trade is that most trading firms engage in both exporting and importing (see chapter 3), but theoretical development that recognises the role of importing is still rare. One exception is Kasahara and Lapham (2013), who develop a model of heterogeneous firms that decide whether or not to simultaneously import intermediate goods while exporting. In this model, the market is also characterised by a continuum of monopolistic firms producing horizontally differentiated products with labour and intermediate goods as factors of production.

Moreover, firms must pay per-period fixed overhead and trading costs, which consist of both fixed and sunk costs and can be written as

$$F(d_{it-1}, d_{it}) = \begin{cases} f & \text{for } (d^{\mathrm{x}}_{it}, d^{\mathrm{m}}_{it}) = (0,0) \\ f + f^{\mathrm{x}} + c^{\mathrm{x}}(1 - d^{\mathrm{x}}_{it-1}) & \text{for } (d^{\mathrm{x}}_{it}, d^{\mathrm{m}}_{it}) = (1,0) \\ f + f^{\mathrm{m}} + c^{\mathrm{m}}(1 - d^{\mathrm{m}}_{it-1}) & \text{for } (d^{\mathrm{x}}_{it}, d^{\mathrm{m}}_{it}) = (0,1) \\ f + \zeta[f^{\mathrm{x}} + f^{\mathrm{m}} + c^{\mathrm{x}}(1 - d^{\mathrm{x}}_{it-1}) & \\ \quad + c^{\mathrm{m}}(1 - d^{\mathrm{m}}_{it-1})] & \text{for } (d^{\mathrm{x}}_{it}, d^{\mathrm{m}}_{it}) = (1,1) \end{cases} \tag{1.11}$$

where $d_{it}$, and $d_{it-1}$ are current and past export and import statuses, and $\zeta$ denotes the parameter for cost complementarity between exporting and importing. This cost complementarity can explain the pattern observed in the data, in which the majority of trading firms engage in both exporting and importing activities. Because the upfront fixed costs of exporting are partially shared by importing, once the entry cost of importing is already paid, firms are more likely to engage in exporting at the same time.

In this thesis, I look at another aspect of the import–export nexus: the interaction between importing and productivity in influencing exporting. Among firms with the same level of productivity, those with past import experience are in a better position to exploit their access to international networks and are, therefore, more likely to export.

### 1.1.3 Innovation: Stochastic productivity and knowledge production

This strand of literature identifies research and development (R&D) and innovation-related activities as sources of productivity heterogeneity across firms. The complementarity, in this case, is between revenue-enhancing investments (such as technology adoption or R&D) and export entry, in which the investment increases productivity and return on exporting. At the same time, exporting raises incentives to invest further. Such a joint decision is captured in recent models in which firms' productivity is viewed as a stochastic process.

The model of stochastic productivity often starts with the cost function in which firm $i$'s short-run marginal cost is defined as

$$c_{it} = c(k_{it}, w_{it}, \varphi_{it}), \tag{1.12}$$

where $k$ denotes capital stock, $w$ price of inputs, and $\varphi$ productivity.

The domestic- and export-market revenue functions is given as

$$r_{\mathrm{d}} = \eta_{\mathrm{d}} + R_{\mathrm{d}} + (\rho_{\mathrm{d}} + 1)(k - \varphi); \eta = (\rho + 1) \ln \frac{\rho}{1 + \rho}$$
$$r_{\mathrm{x}} = \eta_{\mathrm{x}} + R_{\mathrm{x}} + (\rho_{\mathrm{x}} + 1)(k - \varphi) + z + \mu, \tag{1.13}$$

where $z$ represents firm-specific export demand shifters, such as number of destination markets and $\mu$ captures foreign demand shocks.

The evolution of firms' revenue productivity, $\varphi$, from recent papers can be summarised as

$$\text{Olley and Pakes (1996)}: \varphi = g(\varphi_{it-1}) + \varepsilon \tag{1.14}$$
$$\text{Doraszelski and Jaumandreu (2013)}: \varphi = g(\varphi_{it-1}, \iota_{t-1}) + \varepsilon \tag{1.15}$$
$$\text{Peters et al. (2013)}: \varphi = g(\varphi_{it-1}, \iota_{\mathrm{m}t-1}, \iota_{\mathrm{n}t-1}) + \varepsilon \tag{1.16}$$
$$\text{Aw et al. (2011)}: \varphi = g(\varphi_{it-1}, \iota_{t-1}, x_{it-1}) + \varepsilon$$
$$\mu = g(\mu_{it-1}) + \nu \tag{1.17}$$
$$\text{Maican et al. (2013)}: \varphi = g(\varphi_{it-1}, \iota_{t-1}) + \varepsilon$$
$$\mu = g(\mu_{it-1}, \iota_{it-1}) + \nu, \tag{1.18}$$

where $\iota$ represents the investment in R&D or innovation input, which can be further categorised as product and process innovation, $\iota_{\mathrm{m}}$ and $\iota_n$ respectively, $x_i$ is firm $i$'s exporting, $\varepsilon$ is an i.i.d. error term representing productivity shocks between periods $t-1$ and $t$, and $\nu$ is white noise.

In equation (1.14), firms' productivity is an ordinary AR(1) process, whereas the rest of these equations involve investments in innovation. In equation (1.17) past exporting accounts for learning by exporting.

Although R&D is highly correlated with innovation and is commonly used as a proxy for it, this is still not an ideal solution because not all investments yield a commercially valuable output. Separating input and output can disentangle the effect of innovation on actual firm performance.[2]

In chapter 4, I examine the structural link between innovation, productivity, and exporting using the knowledge-production framework. The

[2] According to the Oslo manual, innovation input can be categorised into six activities: an engagement in intramural R&D, extramural R&D, acquisition of machinery, acquisition of other external knowledge, training, and market introduction of innovation. (OECD & Statistical Office of the European Communities, Luxembourg, 2005).

original framework by Griliches (1998) and Pakes and Griliches (1984) assumes that an output of innovation is an indicator of knowledge increment, which is directly related to the differences in research expenditures. So, their structure provides an intermediate step between R&D and productivity, the innovation output.

In this thesis, the structural framework extends the work of Lööf and Heshmati (2006) to involve multistep equations. The relationship starts with the firm's decision to invest in an innovation input. Then, the result in the form of an innovation output is jointly determined with productivity and exporting. This structure can be represented by

$$g^* = x_1 + \varepsilon_1 \tag{1.19}$$

$$k^* = x_2 + \varepsilon_2 \tag{1.20}$$

$$i = k + e + IMR + x_3 + \varepsilon_3 \tag{1.21}$$

$$p = i + e + x_4 + \varepsilon_4 \tag{1.22}$$

$$e = p + x_5 + \varepsilon_5, \tag{1.23}$$

where $g^*$ and $k^*$ represent innovation input propensity and intensity, $i$ denotes innovation output, $p$ is the firm's total factor productivity, $e$ is export performance, $x_j$ are firm-specific controls, and $IMR$ is the inverted Mills' ratio obtained after the innovation-input selection process in equations (1.19) and (1.20).

In summary, from the Melitz model, several strands of literature have built upon the notion that productivity is not exogenously determined. The emergence of models that incorporate many features of firms is an attempt to reflect on the observed patterns in trade data. Multiproduct firms take into account varying adjustments in the firm's behaviour with respect to products. A cost complementarity between importing and exporting suggests a role of learning from the international network on successive engagement in trade. Last, but not least, research expenditures and the output of innovation activities are some sources of endogenous productivity growth. I hope that this thesis can contribute to the literature mainly by providing empirical evidence using highly detailed data and econometric tools to investigate these important export–firm traits. A specific detail of my contribution is also described in the next paragraph.

We have seen in the last decade an ongoing development to provide a more complete picture of firms' trading behaviour. Several puzzles have been solved—for example, the McCallum border puzzle (McCallum, 1995; Anderson and van Wincoop, 2003)—but there are still other areas in trade studies to be explored. In this regard, Melitz and Redding (2014) give some insights into promising topics for further research. Since firms differ in many aspects, recent theories have not yet fully investigated the roles of production technology and firms' internal organisation toward revenue variations across firms. Furthermore, we still have little understanding of the dynamic process of trade and its implications on the response to trade liberalisation. Another area for further research is the role of wholesale and retail distribution networks and how large multinationals affect the market where they operate.

## 1.2 Overview of the thesis

This section summarises each study's background, contribution to the existing literature, empirical strategy, data, and main findings.

### 1.2.1 Chapter 2: Distance Sensitivity of Exporting: A Firm–Product-Level Approach

Researchers have noted the negative relationship between distance and trade as one of the most robust empirical findings in the international trade literature (Leamer and Levinsohn, 1995). The explanation behind this regularity involves the costs of exporting, in which the amount can be fixed or it can vary by shipping distance. The fixed entry costs include transaction costs of having to deal with culturally or institutionally unfamiliar markets, whereas transportation costs and tariffs constitute the majority of the variable costs.

However, the impact of distance is not uniform across products: It varies in magnitude due to product characteristics. Rauch's (1999) network or search view argues that differentiated products assert greater distance sensitivity than homogeneous products. This is because, for standardised products, the trader can scan and obtain price information through trade publications without having to identify the producers, whereas it is more costly to compare differentiated products by their varying characteristics and features. Buyers and sellers must establish network ties to match orders across markets, thus increasing transaction costs.

Despite this argument, the empirical studies so far have found conflicting results. In this study, I intend to test the hypothesis that there are greater distance effects for differentiated products by employing a detailed dataset that matches firms with their exported products. The novelty of this study is that the firm–product level of analysis has not been used in previous studies. At this level, the results will reflect each individual firm's decisions on which products and how much to export to a particular country.

The analysis examines, for each firm, the decision to export (participation) and its intensity by considering three different cases: (i) export participation and export intensity are separate decisions, (ii) the firm's exporting is modelled as a one-step decision, in which there is no distinction between participation and intensity decisions, and (iii) the two export decisions are jointly estimated. For the first case, I estimate the model by probit and ordinary least squares estimators. The second case is estimated by the quasi-maximum likelihood estimator. Lastly, I use the zero-inflated beta and the Heckman selection maximum likelihood to estimate the last case.

The main findings are in contrast with the network or search view and suggest that homogeneous products exhibit greater distance sensitivity in both export participation and export intensity. Several robustness checks confirm the main findings—including various model specifications using one distance-related variable while excluding others, a sample of small- and medium-sized firms with 1–50 employees, and an unaffiliated-firms sample.

### 1.2.2 Chapter 3: Effects of Productivity and Importing on Firm-Level Exporting

The positive effect of productivity on firms' exporting is generally taken as given in international trade studies, but little is known about importing's role. It is well known that exporters are bigger, are more productive, earn more profits, and pay higher wages than nonexporters. Also, the majority of trading firms engages in both exporting and importing. However, the literature provides more explanations about the first fact than the latter. Productivity promotes a firm's exporting, whereas it is hypothesised that cost complementarity between importing and exporting facilitates two-way trading.

This study investigates the importance of previous imports as an export driver by analysing the interaction between importing and productivity. The hypothesis is that the effect of productivity on exporting is greater for firms with previous importing experience. For an equal increase in productivity among all firms, those with import experience are able to exploit their exposure to international markets and are more likely to engage in exporting, compared to firms with no previous importing. The argument is that importing stimulates learning about the seller's networks, market demand, and legal and institutional frameworks in the foreign markets.

This study contributes to the few empirical studies on the role of importing on firms' exporting in at least in two aspects: importing as a source of productivity heterogeneity and the cost complementarity between importing and exporting. The policy implication points to support for a free-trade policy, where importing raw materials can help stimulate domestic firms to obtain better supplies, be more productive, and begin exporting later.

I model firms' exporting as a function of past productivity, measured as total firm productivity (TFP), and past importing, while controlling for annual shocks and country fixed effects. I use the probit estimator for the participation decision, and the ordinary least squares and fixed-effects estimators for the intensity decision. As a robustness check, I use two alternative productivity measures, different lags, and an alternative sample with only export starters.

All results confirm a positive impact of the interaction effect between importing and TFP, and this effect is stable over time. The interaction effect matters more for export starters in both export decisions when compared to the full sample results.

### 1.2.3 Chapter 4: The Interdependence of Innovation, Productivity, and Exports

Exporting is a self-selection process where only highly productive firms can afford the costs of entering foreign markets. But early models often treat the source of this productivity as given, until recently. In this chapter, I look at the interdependence of innovation activities, productivity, and export performance at the firm level. R&D investments as an input of innovation activities are expected to be the main factor explaining the innovation output, which in turn leads to increased productivity. Then, a firm's productivity plays a role as a determinant of the export performance. Finally, exporting raises the firm's incentives to increase both innovation output and productivity. The findings can extend our understanding of the process that underlies how a firm enters export markets and, hopefully, will contribute to the discussion of innovation policy and its role in promoting exporting.

The empirical setting extends Lööf and Heshmati's (2006) structural model with an additional export equation. This framework provides an intermediate step between innovation input and productivity, disentangling innovation into input and output separately. It also corrects for a potential bias arising from firms' selection into innovation investments and allows for interdependence between innovation output, productivity, and exporting.

The dataset is a combination of two waves of the Swedish Community Innovation Survey (CIS), covering 2002–2004 and 2004–2006 within the manufacturing sector. It is complemented with a firm registry and export dataset to provide more information regarding firms' characteristics. The estimation involves two steps. In the first step, I estimate the selection and outcome of innovation input with a Heckman-type estimator. In the second step, I estimate innovation output, productivity, and export performance jointly with the three-stage least squares estimator. As a robustness check, I estimate the model using alternative specifications and using seemingly unrelated regression as an alternative model.

The results suggest that exporting is driven by firm productivity, which is in turn positively related to past innovation output. Depending on the specifications, innovation output is also positively related to innovation input. Lastly, exporting always increases innovation but only increase a firm's productivity when correcting for selectivity and simultaneity issues.

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# Chapter 2

# Distance Sensitivity of Exporting: A Firm–Product-Level Approach

## 2.1 Introduction

The negative relationship between distance and trade has been quoted as one of the most robust empirical findings in the international trade literature (Leamer and Levinsohn, 1995). Countries situated close to each other trade more intensively than countries that are farther apart. Such an effect can be caused by the exporter's transportation costs of shipping from home to the destination, so that the greater distance entails greater transportation costs. Large distance can also imply greater transaction costs of having to deal with culturally or institutionally unfamiliar markets, which in turn make it more difficult for exporters to establish the necessary network of distributors abroad. These costs can arise from procedural differences, communication misalignment, or legal complications. A more unfamiliar market entails higher transaction costs.

The different costs associated with distance imply that distance can influence exporting in various ways. The basic hypothesis is that, first, distance may affect the decision whether to export or not and decreases the extensive margin of exporting by reducing the number of firms present and the number of available products in a particular market abroad. That is, fewer firms are expected to choose to export to more-distant markets. This is because distance increases transaction costs; that is, the fixed and sunk entry costs of setting up contacts and distribution network in unfamiliar host countries abroad. Such cost increases lessen, in general, the number of firms that can afford these high entry costs (in other words, cross the productivity threshold) to become exporters (Melitz, 2003; Andersson, 2007) and, similarly, the number of products to be exported by each individual firm.

Second, distance also affects the intensity decision and decreases the intensive margin of exporting by reducing the size of each firm's exports. Lawless (2010) considers distance to mainly capture the variable costs. But there might also be some fixed costs in the distance. This is because, after entry, each firm has to incur some unknown per-period fixed costs to maintain a presence in the market (Segura-Cayuela and Vilarrubia, 2008) and also some market penetration costs of advertising to capture the market share (Arkolakis, 2008). A greater dissimilarity between sellers and buyers tends to increase uncertainty, increasing these per-period fixed costs and hence reducing the firm's intensive margin. Similarly for the marketing costs, producers from far away are less likely to be known to the consumers in the market and so must invest a considerable amount to publicise their products, presumably reducing each firm's export capacity.

The role of distance on transaction costs has been analysed in recent decades and quickly gained a place in the trade literature. A metastudy by Disdier and Head (2008) confirms the persistence of the distance effect and Grossman (1998) shows that the distance effect is of a greater magnitude than could be attributed to transportation costs alone. Recent studies regard distance not only in geographical units. The so-called intangible barriers of institutional and cultural (dis)similarities are additional dimensions affecting a firm's decision to export. The institutional differences between home and destination market can involve the protection of property rights and contract enforcement (Anderson and Marcouiller, 2002). An imperfect alignment would eventually impose additional transaction costs on the exporters due to informational frictions from the uncertainty (Huang, 2007). Accordingly, cultural similarities in terms of language, religion, and colonial ties are found to facilitate exporting because the trading partners can more easily communicate and share common understanding with each other (Rauch, 1999; Linders and De Groot, 2006; Lankhuizen et al., 2012).

However, the impact of distance is not uniform across products; its magnitude varies due to product characteristics. The pioneering work by Rauch (1999) introduces the network or search view and argues that differentiated products assert a greater sensitivity than homogeneous products. Rauch employs aggregated trade data and finds evidence that the elasticity of trade with respect to distance is greater for differentiated products. However, we can still find conflicting empirical results in other studies, so it is still uncertain whether homogeneous products are more sensitive to distance than differentiated products or the other way around. In Rauch's original study, moreover, there is no separation between the decision to export and the choice of how much to export. This paper aims to examine the distance effect at the firm–product level to provide empirical evidence for this puzzle.

In the case of homogeneous products, which are categorised as products on an organised exchange with the products referenced only by price in Rauch (1999), the products are standardised and can be compared by their prices without having to identify the producer's trademark. The trader can scan and obtain the price information through trade publications (or internet portals nowadays), easily matching buyers and sellers. This reduces the search costs in comparison to the differentiated products, whose characteristics vary in many dimensions, such as colour or technical features. Matching product characteristics across various markets necessarily includes identifying the producers.[1] The same connection as for homogeneous products must be made from the search process, so buyers and sellers need to establish network ties to match orders. This process increases the transaction costs. Therefore, differentiated products are expected to involve a greater sensitivity to distance and other intangible barriers. However, it can be argued that homogeneous products assert a greater distance sensitivity due to the competition of similarly produced homogeneous products from competing countries closer to the destination market, whereas the monopolistic nature of differentiated products enables firms to trade over great distances.

However, the literature that studies the distance effect on product exporting looks chiefly at the aggregate national level, not how each individual firm behaves. If we take a look from the firm's perspective, we can see that each individual firm faces four decisions: (i) whether to export, (ii) where to export, (iii) which products to export, and (iv) how much of each of these products to export. The first two questions are dealt with elsewhere (see, for example, Bernard and Jensen, 2004; Lawless and Whelan, 2008). The last two questions are the main focus of this paper. I examine the aforementioned participation and intensity decisions regarding exporting.

Rauch (1999) classifies products into three categories—organised ex-

[1] Take, for example, a case of price comparison for personal notebooks. You would need to gather information on many things, including the screen size, processor speed, RAM capacity, hard-drive capacity and reading technology, graphics card and memory, operating system version, and manufacturer.

change, reference priced, and differentiated—and estimates a gravity equation of aggregate bilateral trade for 63 selected countries in 1970, 1980, and 1990. The result of a higher distance effect for differentiated products supports his hypothesis that differentiated products assert higher trade costs besides transportation. Similar results from a different model specification is also obtained in Linders (2006) and Huang (2007).

On the other hand, Linders et al. (2005) find the opposite results, despite a rather *ad hoc* treatment of zeros in the data while estimating bilateral trade flows of 114 countries with the ordinary least squares (OLS) estimator. Möhlmann et al. (2010) uses an alternative estimation method on 55 countries using a Heckman selection model with country dummies instead of the standard OLS. Their given explanations are that differentiated products are produced in fewer places and preferably traded over a larger distance, and that the intangible costs are relatively less important for the products on an organised exchange. Lankhuizen et al. (2012) extend these papers using a finite mixture model in order to endogenously group the products into homogeneous segments sensitive to geographic distance in various dimensions. The data are from 72 countries in 2000. Among the findings for the eight segments, for example, machinery and transport products are sensitive to high geographic distance, while bulky goods and crude materials are less sensitive to geographic distance.

So far the analysis of distance sensitivity looks mainly at a static picture, but we know that exporting is a dynamic process and should be treated as such. Once an exporter gains access to a foreign market, the upfront fixed costs have already been paid, so it is reasonable that the costs associated with exporting to the same market should be lower in succeeding years. This is because (i) the institutions are rigid and any procedural changes tend to be slow and (ii), as a result, a firm learns to adapt to the market better—e.g., know which forms to submit or whom to contact for a tax refund—becoming more efficient in later years.

The idea that a firm learns from its past export experience is shared among many scholars. Helpman (1984), Grossman and Helpman (1993), and Clerides et al. (1998) formally show that learning by exporting may lead to a higher level of productivity. The technical or management expertise and best practices of international buyers lead exporting firms to increase their stock of knowledge. The increased knowledge then helps them to be more productive later. Additionally, the productivity gain leads to greater competitiveness in the foreign markets (Verhoogen, 2008).

In terms of importing experience, an establishment of contacts in the past also helps a firm to learn about the international markets. However, the empirical evidence at a disaggregated firm or plant level is mixed. Vogel and Wagner (2010) find no evidence of learning-by-importing productivity premia for German manufacturing firms. Whereas, Kasahara and Rodrigue (2008) find that importing foreign intermediate goods improves a firm's productivity.

The novelty in this study is the greatly detailed data analysis. This is accomplished by examining distance sensitivity across product groups based on export decisions at the disaggregated firm–product level, which has not been done in previous studies. Studying the export decisions at this level yields an insight into the distance effect as reflected by each individual exporting firm and each type of product. I also account for the various dimensions of distance including cultural and institutional similarities. Moreover, because the process of exporting is dynamic, this paper considers the past experiences, both importing and exporting in a country, to find evidence of learning effects.

The rest of the chapter is organised as follows. The methodology section specifies the empirical strategy and the econometric estimation methods. The description of the data follows. The results section presents and discusses the findings. The last section concludes the study.

## 2.2 Methodology

### 2.2.1 Estimation

In order to explain the decision to export, empirical studies in international trade usually employ the gravity equation. Throughout the years, this equation has been tested and the general consensus is that it robustly exhibits the negative effect of distance. Since Tinbergen's (1962) pioneering work, a number of scholars have provided the theoretical foundation, including Anderson (1979), Anderson and van Wincoop (2003), Bergstrand (1985), and recently Egger and Pfaffermayr (2011) with an extension of the model.

The basic model used in this paper is formulated as

$$x_{ijkt} = \beta_0 \mathbf{Y}_{jt}^{\mathbf{B}_1} \boldsymbol{\Gamma}_j^{\mathbf{B}_2} \mathbf{T}_{i,t-1}^{\mathbf{B}_3} \delta_{ijk,t-1}^{\beta_4}, \tag{2.1}$$

where the dependent variable, $x_{ijkt}$, is the exporting by firm $i$ of product $k$ to country $j$ at time $t$. The independent variables are vectors of destination country variables ($\mathbf{Y}$), lagged firm-specific control variables ($\mathbf{\Gamma}_{t-1}$), distance variables ($\mathbf{T}$); and a lagged import variable ($\delta_{t-1}$). A list of all the variables and their description is in the appendix. The main equation for the estimation is a linearised form of the above equation:

$$x_{ijkt} = \beta_0 + \mathbf{Y}'_{jt}\mathbf{B}_1 + \mathbf{\Gamma}'_j\mathbf{B}_2 + \mathbf{T}'_{i,t-1}\mathbf{B}_3 + \beta_4\delta_{ijk,t-1} + \varepsilon_{ijkt}. \qquad (2.2)$$

The analysis focuses on the influence of distance on firms' decisions whether to export a product to a given market or not and how much to export. Therefore, each individual firm encounters two choice problems:

i) **Participation:** Each individual firm chooses to export a certain product, out of its product portfolio, to a certain country, out of its established networks, in each year. Hence, the possibility set of products and countries for each firm is defined from its own experience throughout the period of study. Instead of constructing the possibility set for each firm from all manufactured products and all countries, this approach means that a shoe company, for example, would not consider exporting automobile spare parts to foreign countries where it has no past or future contacts. This reduces the possibility set tremendously and makes the analyses manageable.[2]

ii) **Intensity:** At any given year, each individual firm that decides to export a particular product to a particular country also has another decision to make: how much to export.

In regarding the export decisions, I consider three different cases.

1. Export participation and export intensity are separate decisions. In order to estimate the two, I use probit regression and an OLS estimator. The dependent variable for export participation is a dummy indicating whether a firm exports a product to the destination country in the current year. The dependent variable for the intensity is total export value. The full dataset is used in the participation calculation, while only the observed positive exports are included in the intensity estimation. Including all zero exports in the intensity estimation would lead to a downward bias.

2. Exporting is modelled as a one-step decision in which there is no distinction between the participation and intensity decisions. This means that

[2] Alternatively, the possibility set will explode as we add more dimensions into the consideration. Consider a set of only 500 firms with 100 possible products shipping to 165 countries in a 10-year period. There would be 82.5 million observations in the dataset.

both zero exporting and the export amount are used in the estimation.[3] Wagner (2001) argues that firms consider the *ex ante* costs of exporting and choose the profit-maximising amount of exporting accordingly. Then, the occurrence of zero export quantity is merely the result of the average total costs exceeding the profit-maximising price. So no participation decision is involved. The export quantity, in this case, is a ratio between total export value in the current year of a product to a country and total sales of the firm. Due to the fractional-response nature of the variable, I use the quasi-maximum likelihood estimator (QMLE), proposed by Papke and Wooldridge (1996) and discussed in Wagner (2001). The traditional Tobit estimator is not suitable in this case because the nonexport zeros here are not censored (Baum, 2008). The range of the dependent variable is strictly from 0 to 1. Censoring the zeros away from the sample leads to an upward bias.

3. The two export decisions are jointly estimated. The zeros are a consequence of an economic reality: Low-productivity firms cannot afford the high cost of exporting and self-select themselves out of the export arena. Therefore, these zeros can provide important information for the analysis. Unlike in the second case where there is no distinction between the two export decisions, the zeros in this case are generated from a self-selection process that is different from the intensity decision. The zero-inflated beta (ZOIB) estimator (Cook et al., 2008) takes into account such an inflation process in estimating the export intensity. Alternatively, I use Heckman's (1979) selection maximum likelihood estimator as a robustness check.[4] Normally, in order to consistently estimate a Heckman selection model, there

[3] One common issue that arises from this approach is the frequent occurrence of zero observations. The problem of frequent zeros is typical in trade data including mine: The zeros account for 94.7% of total observations. The problem arises because the estimation model has a linearised form (by logarithmic transformation), causing any zeros in the original dataset to be undefined. There are several alternative estimation methods that deal with data with frequent zeros—for example, zero-inflated Poisson (ZIP), zero-inflated negative binomial (ZINB), and pseudo-Poisson maximum likelihood (PPML; Santos Silva and Tenreyro, 2006)—but such models are mainly appropriate for count data with only debatable evidence of superiority over Heckman (Martínez-Zarzoso, 2013; Martin and Pham, 2008).

[4] Both outcome and selection equations can be either jointly estimated, with maximum likelihood, or estimated as a two-step approach, with maximum likelihood in the first stage and normal OLS in the second. I take the first approach: Verbeek (2008) points out that the OLS standard errors from the two-step estimator are incorrect, whereas the maximum likelihood provides a consistent and asymptotically efficient estimator.

should be an addition of at least one variable in the selection equation. I choose to include the human capital variable, which is the fraction of employees with more than three years of university studies. The argument for human capital as the exclusion variable follows. In order for the firm to export to a new market, it requires certain specific knowledge or network connections, usually embedded in high-ranking personnel in a managerial position, to establish a contractual transaction. The firm's push factor, such as a profitability goal or an expansion strategy, dominates. Whereas after the initial entry, it becomes a routine process which can be executed by lower-ranking administrative personnel to fulfil the export orders. At this point, the pull factor, such as the country's consumer demand, becomes more important. Hence, the human capital is more important in the entry decision and becomes not so important in determining how much to export.

### 2.2.2 Empirical strategy

In preparation for the dataset, I follow the approach from a paper on local export spillovers in France by Koenig et al. (2010). The main advantage is the focus on the within transformation of each of firms' decision possibility set to avoid exhausting the analyses with an explosively large dataset.

To begin, I exclude firms with zero employees and firms with zero or negative sales or value added because the log-linearised model renders these observations undefined. This leaves a total of 23,943 manufacturing firms, of which 6,007 firms are exporters. Next, I include only the active firms that appear throughout the ten-year period of study with at least one export start. I exclude firms with temporary exits because of a computation constraint: Using all exporters would lead to a total of 98,375,860 observations, which is too large to perform an analysis. Excluding temporary exits reduces the total from 6,007 to 2,151 exporting firms.

Next, I match the firms with countries and products with positive export values to form firm–country–product triads. I then exclude the triads that persist for the whole ten-year period, which accounts for 22 out of the total 31,375 triads or roughly 0.07%. So the possibility set of a triad will include at least one start during the entire period. Lastly, I fill the possibility sets for each individual firm with its respective possible countries, products, and years. This procedure leaves a total of 395,900 observations for the analyses. The justification is that firms that persistently export the same product to the same country are already paying the upfront fixed entry costs so the comparison to new entrants would be incorrect. To control for any experiences a firm has in the country, regardless of products, I also include a dummy equal to 1 if the firm has exported to that country before and 0 if it is a new export country.

From the basic equation to estimate (2.2), there are sets of country, distance, firm-specific, and previous-import variables. The country variables include the nominal gross domestic products (GDP) and the GDP per capita of only the destination countries. Usually in the gravity equation, the model also includes these variables for the home country. Since the analysis is executed for exporters registered in Sweden only, there is no variation across firms in the dataset. The gravity equation here is therefore one sided.

The estimation includes several distance variables. These variables constitute both the tangible and intangible barriers to trade. First, the main variable of interest is the geographical distance measured in kilometres from Sweden. The measurement is a weighted great-circle distance accounting for the main trading and financial cities of each country. Second, the contiguity or common-border dummy takes a value of 1 if a destination country shares a border with Sweden, and 0 otherwise. It controls for trade between neighbouring countries, which tends to be disproportionally high and will potentially bias the result. Third, I include the landlocked dummy due to the fact that transportation costs are higher for countries without a direct access to the sea. Fourth, a dummy indicating countries with English as the official language is included. Since there are no other countries sharing Swedish as the official language, the traders have to use English as the main *lingua franca*. It should be relatively easier for Swedish firms to trade with countries that are native English speakers than otherwise. Last, I control for the regional trade agreement. This is because a streamlined institutional system and an abandonment of tariffs within the common trade area will induce gross trade creation through integration, as evidenced by Aitken (1973) and Carrère (2006) among others.[5]

The firm-specific variables control for firms' heterogeneity. I include value added at year's end and human capital in the estimation equation.

[5]I also considered including a dummy indicating EU membership states to account for the reporting policy that excludes any firms with annual importing from or exporting to EU members below 1 million euros from the database. But due to a high collinearity between the regional-trade-agreement and EU dummies, the latter is redundant.

Human capital is calculated as the highly educated workers' share of the workforce within a firm, employees who graduated above the secondary-education level. To avoid an endogeneity problem, I lag these variables by one year. To control for corporate affiliation, I also include dummies denoting a firm's affiliation to domestic or multinational corporations. Nonaffiliation is used as a reference group to avoid the dummy-trap problem. Initially, I aim to include dummies for destination countries in the full model, as is recommended by many scholars (Anderson and van Wincoop, 2003; Feenstra, 2002; Mátyás, 1997; Redding and Venables, 2004) to account for unobserved country-specific attributes. However, due to computational difficulties, the probit and Heckman estimations did not converge.

Although the original dataset contains all firms in Sweden, I work only with the manufacturing sector, excluding the service sector, because I want to focus only on firms that export what they are producing. Many firms within the service sector are intermediaries or trading firms, but few direct exporters. The manufacturing sector includes the industries indicated by the two-digit NACE revision 1.1 codes 15 to 36.[6] The distribution of exporters per total producers and the share of exporting per total sales for each industry is presented in the appendix.

### 2.2.3 Data

I merged three datasets to generate the data for this analysis. First, the firm-level export–import data contains the export value and weight of products defined as the 8-digit Swedish equivalent of harmonised system (HS) for each individual firm. Second, the firm-characteristics variables, including value added, affiliation, and several other variables. Both datasets are linked by a unique firm identification, encoded by Statistics Sweden, and contain the population of all firms registered at the Swedish Tax Agency.[7] These two datasets are complemented by country and distance variables, available from *Centre d'Étude Prospectives et d'Information Internationales* (CEPII). The period of analysis is the ten years from 1997 to 2006 and includes in total 2,151 manufacturing firms and 2,553 unique products. The variables in use

[6]NACE stands for *Nomenclature des Activités Économiques dans la Communauté Européenne* or Classification of Economic Activities in the European Union.

[7]The databases are part of Statistics Sweden's Microdata On-line Access (MONA) service. All analyses are executed via remote access to the data. For information regarding the access to the database, please refer to Statistics Sweden at `www.scb.se`.

Table 2.1: Share of Swedish exported products in value

| Year | Homogeneous Products | Differentiated Products |
|---|---|---|
| 1997 | 12.51 | 87.49 |
| 1998 | 12.05 | 87.95 |
| 1999 | 10.26 | 89.74 |
| 2000 | 7.46 | 92.54 |
| 2001 | 12.69 | 87.31 |
| 2002 | 11.90 | 88.10 |
| 2003 | 12.42 | 87.58 |
| 2004 | 13.25 | 86.75 |
| 2005 | 9.60 | 90.40 |
| 2006 | 9.37 | 90.63 |

and descriptive statistics are listed in the appendix.

The product classification used in this paper refers to Rauch (1999), in which the products are categorised as homogeneous or differentiated. The products on organised exchanges or with reference prices according to the Standard International Trade Classification (SITC) at the five-digit level are identified by looking them up in trade publications. The largest share of global trade value determines the category that the products belong to at the four-digit aggregation.[8] Rauch's classification is then converted to the EU Combined Nomenclature (CN).[9] The share of the two categories in my sample over time is presented in Table 2.1. Similar to Rauch (1999), most of the exported products are differentiated and their share is increasing.

## 2.3 Results

The results are presented as three cases. The first case separates the export participation apart from export intensity decision. In the second case, firms' exports are decided in one step. Lastly, both export decisions are jointly determined. Throughout this section, the discussion will focus on two main topics, namely the statistical and economic significances. To save space, the

[8]For this division, there are conservative and liberal classifications, in which the former minimises the number of products either belonging to an organised exchange or having a reference price and the latter maximises this number. This does not affect my results because I mainly look at homogeneous products as a whole.

[9]The classification is available from Jon Haveman, `www.macalester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/TradeData.html#Rauch`. The conversion is from SITC to HS and lastly to CN, similar to Persson (2013), but the classification in this paper is based on SITC rev. 2 while Persson's study is based on SITC rev. 3.

Table 2.2: Probit and OLS results by product groups

| Variables | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Probit (*ExportDummy*) | | | OLS (*ExportValue*) | | |
| | All | Homog. | Diff. | All | Homog. | Diff. |
| *GDP* (log) | 0.004*** | 0.001* | 0.005*** | 0.184*** | 0.087*** | 0.200*** |
| | (0.000) | (0.001) | (0.000) | (0.013) | (0.029) | (0.014) |
| *GDPPerCapita* (log) | 0.001 | 0.000 | 0.000 | 0.172*** | −0.010 | 0.193*** |
| | (0.001) | (0.001) | (0.001) | (0.023) | (0.055) | (0.026) |
| *Distance* (log) | −0.026*** | −0.027*** | −0.026*** | −0.254*** | −0.406*** | −0.251*** |
| | (0.001) | (0.002) | (0.001) | (0.031) | (0.078) | (0.034) |
| *Contiguity* | 0.026*** | 0.028*** | 0.025*** | −0.883*** | −0.524*** | −0.934*** |
| | (0.001) | (0.002) | (0.001) | (0.042) | (0.106) | (0.046) |
| *Landlocked* | −0.013*** | −0.005 | −0.015*** | −0.398*** | −0.464*** | −0.338*** |
| | (0.002) | (0.003) | (0.002) | (0.064) | (0.171) | (0.068) |
| *EnglishDummy* | 0.007*** | 0.001 | 0.008*** | 0.381*** | 0.668*** | 0.316*** |
| | (0.001) | (0.003) | (0.002) | (0.058) | (0.171) | (0.061) |
| *RegionalTradeAgreement* | −0.018*** | −0.019*** | −0.018*** | 0.104* | −0.083 | 0.126* |
| | (0.002) | (0.003) | (0.002) | (0.060) | (0.142) | (0.066) |
| *ValueAdded* (log)(lag) | 0.003*** | −0.000 | 0.003*** | 0.211*** | 0.123* | 0.228*** |
| | (0.001) | (0.002) | (0.001) | (0.031) | (0.074) | (0.034) |
| *Uninational* | −0.011*** | −0.008*** | −0.013*** | 0.022 | 0.039 | 0.035 |
| | (0.001) | (0.002) | (0.001) | (0.031) | (0.069) | (0.035) |
| *DomesticMNE* | −0.007*** | −0.009*** | −0.009*** | 0.466*** | 0.509*** | 0.436*** |
| | (0.001) | (0.002) | (0.001) | (0.042) | (0.111) | (0.046) |
| *ForeignMNE* | −0.029*** | −0.025*** | −0.030*** | 0.255*** | 0.147 | 0.306*** |
| | (0.002) | (0.003) | (0.002) | (0.076) | (0.158) | (0.085) |
| *ImportDummy* (lag) | 0.002*** | 0.003** | 0.003*** | 0.140*** | 0.105 | 0.163*** |
| | (0.001) | (0.002) | (0.001) | (0.028) | (0.068) | (0.031) |
| *CountryExperience* | 0.000 | 0.005*** | −0.001 | 0.019 | 0.027 | 0.037 |
| | (0.001) | (0.002) | (0.001) | (0.030) | (0.071) | (0.032) |
| Observations | 355,612 | 85,284 | 270,328 | 19,021 | 3,688 | 15,333 |
| $R^2$ | 0.056 | 0.079 | 0.053 | 0.159 | 0.123 | 0.181 |

**Note:** The number in the table represents the marginal effects. All regressions include constants, year and industry dummies but are not reported. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

results displayed here will be the marginal effects for an interpretation of the economic significance. The statistical results and estimated coefficients of the distance variable are displayed in Tables 2.10 and 2.11 in the appendix.

### 2.3.1 Separate participation and intensity decisions

Table 2.2 displays the regression results using standard probit for the participation decision (Columns 1–3) and OLS for export intensity (Columns 4–6), measured as total export value. The OLS results are limited to observations with positive exporting. The result for the overall products is displayed first (Columns 1 and 4) followed by separate regressions for homogeneous and differentiated products. Here I control for both annual shocks and industry heterogeneity. The probit results are presented with the marginal effects for a convenient interpretation.

The GDP variable shows a positive and significant effect in almost all regressions, meaning that market size positively affects both export decisions. Concerning the magnitude of the GDP effect on export participation, a 100% increase in the destination country's GDP leads to an increase of 0.1%–0.5% in the probability of exporting, holding other variables at their mean values, a rather small impact. On the other hand, the positive effect on export intensity, measured as total value, is approximately 8.7%–20%, which is a sizeable increase. Moreover, differentiated products experience a greater GDP effect than homogeneous products. The effect of GDP per capita is only significant on the intensity of differentiated products—roughly 19.3% for a 100% increase in the GDP per capita of the destination country.

Regarding various distance and intangible-barrier variables, distance, landlockedness, and regional trade agreement have negative impacts on participation, whereas negative impacts on the intensity come from distance, contiguity, and landlockedness. This suggests a high cost of exporting and local competition. In contrast, the positive impacts of English language, contiguity (on participation), and trade agreement (on intensity) suggest institutional similarity. In terms of magnitude, the effect on exporting is greatest when the border is shared between the trading countries, approximately 3 percentage point increase in the probability of exporting and a huge decrease (52%–93%) in the total value of differentiated products. Comparing across products, homogeneous products display greater distance effects in both decisions; that is, a 0.2% difference in the probability of exporting and a 15 percentage point difference in total value, while the results are mixed for other variables. This contradicts the network or search view that exporting of differentiated products depend more on familiarity than homogeneous products. Note also that the sizes of these distance coefficients for the export intensity are lower than in other studies: 0.1%–0.9% in most variables, compared to 0.6%–1.2% in Rauch (1999) and Linders (2006). This is because the one-sided gravity equation I employ here includes unilateral trade flows from Sweden to the rest of the world only, unlike the bilateral trade flows used in other studies.

The value-added variable confirms the Melitz model on firms' productivity and exporting. The positive coefficients imply that a higher productivity leads to a slightly greater probability of exporting and a greater export size, especially for differentiated products (a 23% increase in total value for every 100% increase in value added). An affiliation with a domestic corporate group or a multinational (MNE) negatively impacts the decision to participate but positively impacts the export intensity. Belonging to a Swedish

MNE increases export value by roughly 50%, with a 30% increase in the case of foreign MNEs. These negative results on participation contradict the expectation that most international trade flows from MNEs and, thus, an affiliation with one should induce firms to export. One possible explanation is that the permanent exporters, which may consist mainly of firms affiliated with corporations and MNEs, are excluded from the data.

For trade-experience variables, a firm's importing any products from the destination the year before has a complementary effect for both types of products, inducing export participation by 0.2%–0.3% and export intensity by 11%-16%. Moreover, a firm's market presence from exporting, regardless of products, in the destination country before positively impacts the decision to export for homogeneous products only (0.5%), but export value in succeeding years for both types of products is unaffected by export experience in the country, possibly due to capacity limitations.

### 2.3.2 One-step export decision

In this case, a firm only considers how much to export and zero exporting is a result of a profit-maximising calculation. However, the problem of frequent zeros prompts a consideration of an alternative estimator. The calculated marginal effects from the Papke–Wooldridge quasi-maximum likelihood estimator (QMLE) is presented in Table 2.3.

Statistically speaking, when we look at the raw coefficients in Table 2.11, the *GDP*variable exhibits a positive effect, similar to the previous result. But GDP per capita shows a negative sign and is only slightly significant for homogeneous products. Similar to the previous results, homogeneous products exhibit a greater negative distance effect on export value per total sales. In contrast, contiguity is not significant while regional trade agreement shows the greatest effect among intangible barrier variables (in terms of coefficient size, although not reported). Furthermore, value added does not have any impact on exporting, while corporate-group affiliation and import experience have strong negative impacts in contrast to the OLS results.

However, when we evaluate the economic impact in Table 2.3, the differentiated products have a greater distance impact on exporting, which is in line with the network or search hypothesis. A 100% increase in distance reduces the export/total sales ratio by 1.09 basis points or almost twice the 0.57 basis point for homogeneous products. The magnitude of impact

Table 2.3: Papke-Wooldridge QMLE results

| Variables | (7) | (8) | (9) |
|---|---|---|---|
| | QMLE (Export/Total Sales) | | |
| | All | Homog. | Diff. |
| *GDP* (log) | 0.269*** | 0.086*** | 0.332*** |
| | (0.023) | (0.030) | (0.029) |
| *GDPPerCapita* (log) | −0.051 | −0.066* | −0.049 |
| | (0.051) | (0.036) | (0.070) |
| *Distance* (log) | −0.957*** | −0.566*** | −1.087*** |
| | (0.054) | (0.065) | (0.070) |
| *Contiguity* | 0.047 | 0.011 | 0.062 |
| | (0.084) | (0.063) | (0.114) |
| *Landlocked* | −0.178* | 0.175 | −0.297*** |
| | (0.090) | (0.227) | (0.096) |
| *EnglishDummy* | 0.944*** | 0.385* | 1.094*** |
| | (0.173) | (0.216) | (0.217) |
| *RegionalTradeAgreement* | −0.856*** | −0.519*** | −0.904*** |
| | (0.136) | (0.151) | (0.170) |
| *ValueAdded* (log)(lag) | 0.054 | −0.033 | 0.079 |
| | (0.088) | (0.060) | (0.115) |
| *Uninational* | −0.690*** | −0.302*** | −0.787*** |
| | (0.047) | (0.061) | (0.062) |
| *DomesticMNE* | −0.748*** | −0.166*** | −0.971*** |
| | (0.047) | (0.061) | (0.062) |
| *ForeignMNE* | −0.927*** | −0.508*** | −0.959*** |
| | (0.041) | (0.059) | (0.052) |
| *ImportDummy* (lag) | −0.303*** | −0.224*** | −0.283*** |
| | (0.054) | (0.064) | (0.068) |
| *CountryExperience* | 0.019 | 0.131** | −0.025 |
| | (0.062) | (0.056) | (0.081) |
| Observations | 355,612 | 85,284 | 270,328 |

**Note:** The number in the table represents the marginal effects. Both the coefficients and standard errors are multiplied by 10,000 for convenience. To make the calculation of the marginal effects possible, year and industry dummies are excluded, which should only impact the results slightly as the difference in the estimated raw coefficients between regressions with and without the dummies is at the third digit at most. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

is also similar in the *RegionalTradeAgreement* variable and corporate affiliations, 0.30–0.51 basis points for homogeneous and 0.79–0.97 basis points for differentiated products.

### 2.3.3 Joint participation and intensity decisions

Instead of treating zero exporting as same as the positive export amount, these zeros could be generated from a self-selection process. Hence, an alternative estimation method is required to deal with these zeros. I present the marginal effects from the zero-inflated beta (ZOIB) regression first in Table 2.4, followed by Heckman selection results in Table 2.5. The dependent variable is export value per total sales for the ZOIB regression and total export value for the Heckman regression.

The inflation of zeros is estimated in Columns 10–12 in Table 2.4 and the interpretation of coefficient signs is different from the rest of this chapter. This means that a bigger GDP will have a negative impact on the firm to have zero exporting. This is equivalent to say that it has a positive impact on the probability of exporting in the probit regression.

Regarding the statistical inference, all the variables show the same significance but with opposite signs as the probit results with the import dummy as the only exception (see columns labelled "Probit" and "ZOIB–Export" in Table 2.10). Referring to the estimated coefficient of the distance variable in Table 2.11, the coefficient for homogeneous products is greater, but in Table 2.4 we can see again that the economic impact is greater for differentiated products (0.024 compared to 0.022 percentage point), meaning that an increase in distance will lead to a slightly more probability of zero exporting for differentiated products. Similar to probit results earlier, this difference between product groups is very small. In terms of other variables, the marginal effects calculated from ZOIB in general are slightly smaller in absolute value than probit.

For export intensity, the statistical signs and significance differ from the QMLE results for GDP per capita, contiguity, value added, and country experience (Table 2.10). In terms of magnitude, QMLE results tend to have a larger coefficient size in all variables, both statistically and economically. The estimated coefficient for distance is higher for homogeneous products, but the marginal effect is higher for differentiated products, as in the QMLE estimate. When we turn to the Heckman results in Table 2.5, the selection

Table 2.4: Zero-inflated beta results

| Variables | (10) | (11) | (12) | (13) | (14) | (15) |
|---|---|---|---|---|---|---|
| | | Zero Inflate | | | ZOIB (Export/Total Sales) | |
| | All | Homog. | Diff. | All | Homog. | Diff. |
| *GDP* (log) | $-0.004^{***}$ | $-0.001$ | $-0.005^{***}$ | $0.172^{***}$ | $0.026^{**}$ | $0.231^{***}$ |
| | (0.000) | (0.001) | (0.000) | (0.012) | (0.011) | (0.016) |
| *GDPPerCapita* (log) | $-0.002^{***}$ | $-0.002^{**}$ | $-0.002^{***}$ | $0.090^{***}$ | $0.044^{*}$ | $0.101^{***}$ |
| | (0.001) | (0.001) | (0.001) | (0.018) | (0.019) | (0.023) |
| *Distance* (log) | $0.024^{***}$ | $0.022^{***}$ | $0.024^{***}$ | $-0.766^{***}$ | $-0.436^{***}$ | $-0.872^{***}$ |
| | (0.001) | (0.001) | (0.001) | (0.037) | (0.037) | (0.048) |
| *Contiguity* | $-0.023^{***}$ | $-0.023^{***}$ | $-0.022^{***}$ | $0.271^{***}$ | $0.235^{***}$ | $0.249^{***}$ |
| | (0.001) | (0.002) | (0.001) | (0.038) | (0.040) | (0.048) |
| *Landlocked* | $0.011^{***}$ | $0.005^{*}$ | $0.013^{***}$ | $-0.346^{***}$ | $-0.144^{**}$ | $-0.422^{***}$ |
| | (0.001) | (0.003) | (0.002) | (0.041) | (0.045) | (0.054) |
| *EnglishDummy* | $-0.006^{***}$ | $0.001$ | $-0.008^{***}$ | $0.340^{***}$ | $0.051$ | $0.416^{***}$ |
| | (0.002) | (0.003) | (0.002) | (0.061) | (0.065) | (0.079) |
| *RegionalTradeAgreement* | $0.019^{***}$ | $0.017^{***}$ | $0.019^{***}$ | $-0.592^{***}$ | $-0.339^{***}$ | $-0.618^{***}$ |
| | (0.002) | (0.003) | (0.002) | (0.061) | (0.069) | (0.077) |
| *ValueAdded* (log)(lag) | $-0.005^{***}$ | $-0.002^{**}$ | $-0.006^{***}$ | $-0.053^{**}$ | $-0.015$ | $-0.062^{*}$ |
| | (0.001) | (0.001) | (0.001) | (0.026) | (0.025) | (0.035) |
| *Uninational* | $0.009^{***}$ | $0.004^{***}$ | $0.010^{***}$ | $-0.550^{***}$ | $-0.176^{***}$ | $-0.663^{***}$ |
| | (0.001) | (0.001) | (0.001) | (0.028) | (0.025) | (0.036) |
| *DomesticMNE* | $0.008^{***}$ | $0.006^{***}$ | $0.009^{***}$ | $-0.574^{***}$ | $-0.202^{***}$ | $-0.735^{***}$ |
| | (0.001) | (0.002) | (0.001) | (0.030) | (0.028) | (0.040) |
| *ForeignMNE* | $0.021^{***}$ | $0.007^{***}$ | $0.025^{***}$ | $-0.916^{***}$ | $-0.348^{***}$ | $-1.034^{***}$ |
| | (0.001) | (0.002) | (0.001) | (0.038) | (0.031) | (0.050) |
| *ImportDummy* (lag) | $0.002^{***}$ | $-0.001$ | $0.003^{***}$ | $-0.191^{***}$ | $-0.097^{***}$ | $-0.182^{***}$ |
| | (0.001) | (0.001) | (0.001) | (0.024) | (0.025) | (0.031) |
| *CountryExperience* | $-0.004^{***}$ | $-0.009^{***}$ | $-0.002^{**}$ | $0.065^{***}$ | $0.127^{***}$ | $0.029$ |
| | (0.001) | (0.001) | (0.001) | (0.021) | (0.022) | (0.028) |
| Observations | 355,612 | 85,284 | 270,328 | 19,021 | 3,688 | 15,333 |

**Note:** The number in the table represents the marginal effects. Both the coefficients and standard errors in the ZOIB columns (13–15) are multiplied by 10,000 for convenience. To make the calculation of the marginal effects possible, year and industry dummies are excluded, which should only impact the results slightly since the difference in the estimated raw coefficients between regressions with and without the dummies is at the third digit at most. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 2.5: Heckman selection results

| Variables | (16) | (17) | (18) | (19) | (20) | (21) |
|---|---|---|---|---|---|---|
| | Selection (*ExportDummy*) | | | Outcome (*ExportValue*) | | |
| | All | Homog. | Diff. | All | Homog. | Diff. |
| *GDP* (log) | 0.004*** | 0.001 | 0.005*** | 0.193*** | 0.085*** | 0.211*** |
| | (0.000) | (0.001) | (0.000) | (0.013) | (0.029) | (0.015) |
| *GDPPerCapita* (log) | 0.002*** | 0.003** | 0.002*** | 0.186*** | 0.113** | 0.194*** |
| | (0.001) | (0.001) | (0.001) | (0.023) | (0.053) | (0.026) |
| *Distance* (log) | −0.023*** | −0.022*** | −0.024*** | −0.274*** | −0.347*** | −0.273*** |
| | (0.001) | (0.001) | (0.001) | (0.031) | (0.076) | (0.034) |
| *Contiguity* | 0.026*** | 0.027*** | 0.025*** | −1.016*** | −0.730*** | −1.063*** |
| | (0.001) | (0.002) | (0.001) | (0.042) | (0.103) | (0.046) |
| *Landlocked* | −0.011*** | −0.006** | −0.013*** | −0.483*** | −0.800*** | −0.402*** |
| | (0.001) | (0.003) | (0.002) | (0.068) | (0.181) | (0.071) |
| *EnglishDummy* | 0.006*** | −0.001 | 0.007*** | 0.364*** | 0.640*** | 0.306*** |
| | (0.001) | (0.003) | (0.002) | (0.060) | (0.171) | (0.063) |
| *RegionalTradeAgreement* | −0.018*** | −0.017*** | −0.017*** | 0.113* | 0.050 | 0.150** |
| | (0.002) | (0.003) | (0.002) | (0.060) | (0.139) | (0.066) |
| *ValueAdded* (log)(lag) | 0.006*** | 0.003** | 0.006*** | 0.160*** | 0.156** | 0.159*** |
| | (0.001) | (0.001) | (0.001) | (0.031) | (0.075) | (0.034) |
| *Uninational* | −0.010*** | −0.005*** | −0.011*** | −0.035 | 0.275*** | −0.079** |
| | (0.001) | (0.001) | (0.001) | (0.031) | (0.069) | (0.035) |
| *DomesticMNE* | −0.008*** | −0.006*** | −0.009*** | 0.556*** | 0.700*** | 0.508*** |
| | (0.001) | (0.002) | (0.001) | (0.041) | (0.104) | (0.044) |
| *ForeignMNE* | −0.023*** | −0.009*** | −0.027*** | 0.194*** | 0.699*** | 0.129 |
| | (0.001) | (0.002) | (0.001) | (0.069) | (0.120) | (0.084) |
| *ImportDummy* (lag) | −0.002*** | 0.002 | −0.003*** | 0.182*** | 0.097 | 0.223*** |
| | (0.001) | (0.001) | (0.001) | (0.028) | (0.066) | (0.030) |
| *CountryExperience* | 0.004*** | 0.009*** | 0.002*** | −0.018 | 0.066 | −0.014 |
| | (0.001) | (0.001) | (0.001) | (0.027) | (0.065) | (0.030) |
| *HumanCapital* (lag) | −0.008** | −0.010 | −0.011*** | | | |
| | (0.003) | (0.008) | (0.004) | | | |
| Observations | 355,596 | 85,277 | 270,319 | 19,021 | 3,688 | 15,333 |

**Note:** The number in the table represents the marginal effects, where the selection columns represent the marginal effects for the probability of the dependent variable being observed and the outcome columns represent the expected value of the dependent variable conditional on being observed. To make the calculation of the marginal effects possible, year and industry dummies are excluded, which should only impact the results slightly since the difference in the estimated raw coefficients between regressions with and without the dummies is at the third digit at most. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

equation exhibits fundamentally similar results as with the probit with only the addition of the human capital variable.

For the export intensity, we can see from Table 2.10 (in the "Heckman Export Value" column) that the signs are similar to ZOIB in the country-specific (GDP and GDP per capita), distance, and barrier variables (distance, landlockedness, and so on) but not for firm-specific variables (corporate affiliation, import experience). Furthermore, the results suggest that differentiated products have a greater distance sensitivity in the intensity decision, whereas the effect is positive and insignificant for homogeneous products. However, economically, homogeneous products have a greater distance impact than differentiated products in the intensity decision. According to Table 2.5, a 100% change in distance will decrease exporting of homogeneous products by 35%, compared to 27% for differentiated products. The results for the other variables are similar to the probit and OLS results.

In summary, GDP, distance, landlockedness, and English language appear to be statistically robust across all estimators, showing the expected results in nearly all regressions and samples. This implies that, regardless of product, the greatest value of trade will likely happen with big and nearby destination countries with sea access and English as an official language.

For the distance variable, homogeneous products appear to feel a greater effect in both the participation and intensity decisions when logged total export value is the dependent variable. This finding is similar to Linders et al. (2005), Möhlmann et al. (2010), and Rauch (1999) before the adjustment for the transportability of differentiated products. However, I find results that support the network or search hypothesis when I evaluate the economic significance of the regressions and when the ratio of exporting to total sales is the dependent variable.

The reason for this counterintuitive finding could be that homogeneous products are more standardised and competition from rivals close to the destination market is fiercer than with the more unique differentiated products. Once entered, producers of homogeneous products are more likely to ship in large quantity, so distance has a significant impact on how much to export. Having a look at the dataset, the average unit price, simply taken as value divided by weight, of differentiated products is 255.86% more than that of homogeneous products, but the homogeneous products are heavier by 136.39%. This means that homogeneous products are bulkier and producers are more likely to compete in price, whereas differentiated products are charged a more monopolistic price.

Trade experiences appear to have a pattern among all the estimators. Import experience shows a positive impact on export participation, with roughly the same magnitude as GDP, which suggests that experience in a country is as important as the potential market size. Similarly, past export experience in a country is also a factor in the decision to participate, but only for homogeneous products. This is mainly due to the characteristics of differentiated products: Any previous knowledge is not applicable for an introduction of a new differentiated product, even to the same market.

### 2.3.4 Robustness check

For a robustness check, I run several specifications of the gravity model on the full and subsamples in all of the estimators used in this chapter. First, I run all the estimators using the full sample but with only one distance variable while excluding other intangible barrier variables. This is to see the overall effect of distance prior to accounting for the intangible barriers. Second, the sample is reduced to include only small- and medium-sized firms (SMEs) with 1–50 employees. Lastly, I rerun the estimation on nonaffiliated firms. Because small and nonaffiliated firms often have limited resources, excluding large firms will give a more precise look into the effects of distance. The distance coefficients from all regressions are summarised in Table 2.11 in the appendix.

The conclusions of greater distance effects for homogeneous products hold for all model specifications in both export decisions with the sole exception of the Heckman results for export intensity, in which homogeneous products are not significantly impacted. When the intangible barrier variables are excluded, the distance coefficient is lower in all of the regressions, except a positive and significant estimate for homogeneous products in the Heckman sample.

Because most of the firms are small, the SMEs sample only slightly decreases the coefficient estimates in nearly all regressions. A similar pattern is also observed in nonaffiliated-firms sample. This suggests that the distance effects are exaggerated by the inclusion of large firms. One possible explanation is that large corporate firms require a more careful consideration among the managers and directors within the companies before a decision can be executed. A greater extent of committed resources can then follow such a decision.

## 2.4 Conclusion

Although distance plays an important role in firms' export decisions, we still have not fully understood the mechanism behind its impact. In this study, I look at the distance sensitivity of firms' export participation and export intensity across different product groups, namely homogeneous and differentiated products. Using Sweden's detailed firm–product-level data, the investigation deals with actual decisions made by each individual firm for each exported product. The findings are in contrast with the network or search view. Homogeneous products exhibit a greater distance sensitivity in both export participation and export intensity. This finding can be attributed to the competition of standardised products from different producers near the destination market. Only when the economic impact is evaluated do we see in some model specifications the results that support the hypothesis.

Past trade experiences are more important for homogeneous products in terms of export participation. But, for intensity, only import experience matters. This suggests that a learning effect also differs across products.

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## 2.5 Appendix

### 2.5.1 Variable descriptions

| Variable | Description | Source | Exp. Sign |
|---|---|---|---|
| *ExportDummy* | Dummy taking value of 1 if the firm has positive exporting of a product to destination country at current year, 0 otherwise. | Author generated | |
| *ExportValue* | Total amount exported in current SEK. | Statistics Sweden | |
| *ExportPerSales* | Ratio of a firm's export value and total sales. | Statistics Sweden | |
| *GDP* | Gross Domestic Product of the destination country in current USD (log). | CEPII | + |
| *GDPPerCapita* | GDP per capita of the destination country (log). | CEPII | + |
| *Distance* | Weighted distance as measured in kilometres from Sweden, calculated using the great circle distance between major cities as weight (log). | CEPII | − |
| *Contiguity* | Dummy taking value of 1 if the destination country shares a border with Sweden. | CEPII | + |
| *Landlocked* | Dummy taking value of 1 if the destination country does not have coastline. | CEPII | − |
| *EnglishDummy* | Dummy taking value of 1 if one of the official languages in the destination country is English. | CEPII | + |
| *RegionalTradeAgreement* | Dummy taking value of 1 if the regional trade agreement is in effect. | CEPII | + |
| *ValueAdded* | The Firm's value added per employee in SEK (log and lagged one year). | Statistics Sweden | + |
| *HumanCapital* | Fraction of employees graduated at the university level (lagged one year). | Statistics Sweden | +/− |
| *Uninational* | Dummy taking value of 1 if the firm belongs to a Swedish corporation group | Statistics Sweden | + |
| *DomesticMNE* | Dummy taking value of 1 if the firm belongs to a Swedish multinational enterprise | Statistics Sweden | + |
| *ForeignMNE* | Dummy taking value of 1 if the firm belongs to a foreign multinational enterprise | Statistics Sweden | + |
| *ImportDummy* | Dummy taking value of 1 if the firm imported from the destination country the year before. | Author generated | + |
| *CountryExperience* | Dummy taking value of 1 if the firm already exported to the country previously. | Author generated | + |

### 2.5.2 Descriptive statistics

| Variable | Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| *ExportDummy* | 395,900 | 0.05 | | 0 | 1 |
| *ExportValue* | 20,814 | 675,424.80 | 2,479,948 | 1 | 125,036,227 |
| *ExportPerSales* | 395,900 | 0.0001 | 0.002 | 0 | 0.80 |
| *GDP* | 395,361 | 910,098.90 | 2,149,115 | 367.2 | 13,201,819 |
| *GDPPerCapita* | 395,202 | 24,864.0 | 17,153.82 | 84.56 | 89,563.63 |
| *Distance* | 395,900 | 2,531.94 | 3,196.99 | 450.08 | 17,389.62 |
| *Contiguity* | 395,900 | 0.25 | | 0 | 1 |
| *Landlocked* | 395,900 | 0.09 | | 0 | 1 |
| *EnglishDummy* | 395,900 | 0.15 | | 0 | 1 |
| *RegionalTradeAgreement* | 395,900 | 0.73 | | 0 | 1 |
| *ValueAdded* | 395,900 | 30,120.62 | 151,299.30 | 3 | 5,593,307 |
| *HumanCapital* | 395,900 | 0.06 | 0.11 | 0 | 1 |
| *Uninational* | 395,900 | | 0.46 | 0 | 1 |
| *DomesticMNE* | 395,900 | 0.21 | | 0 | 1 |
| *ForeignMNE* | 395,900 | 0.11 | | 0 | 1 |
| *ImportDummy* | 395,900 | 0.63 | 0.48 | 0 | 1 |
| *CountryExperience* | 395,900 | 0.56 | 0.50 | 0 | 1 |

The mean value for dummy variables indicates the percentage of ones.

### 2.5.3 Participation of Swedish exports

| SNI | Industry | TP | NE | ES | AP | AD |
|---|---|---|---|---|---|---|
| 15 | Food products; beverages and tobacco | 1,296 | 18.9 | 17.57 | 11.08 | 6.97 |
| 16 | Tobacco products | 3 | 33.33 | 3.58 | 23.82 | 29.82 |
| 17 | Textiles and textile products | 380 | 41.84 | 18.58 | 12.16 | 8.10 |
| 18 | Wearing apparel; dressing and dyeing of fur | 102 | 51.96 | 26.6 | 32.83 | 7.57 |
| 19 | Leather; luggage, handbags, and footwear | 65 | 58.46 | 19.98 | 8.23 | 5.71 |
| 20 | Wood and wood products except furniture | 1,540 | 31.75 | 25.32 | 4.94 | 5.23 |
| 21 | Pulp, paper and paper products | 218 | 78.44 | 31.96 | 11.55 | 17.86 |
| 22 | Publishing, printing and reproduction of recorded media | 1,958 | 18.74 | 5.03 | 4.75 | 4.36 |
| 23 | Coke, refined petroleum products and nuclear fuel | 16 | 56.25 | 49.21 | 14.70 | 11.29 |
| 24 | Chemicals, chemical products and man-made fibres | 308 | 75 | 32.24 | 20.74 | 16.37 |
| 25 | Rubber and plastic products | 718 | 58.91 | 23.15 | 9.17 | 9.05 |
| 26 | Other nonmetallic mineral products | 401 | 39.9 | 18.14 | 10.07 | 8.34 |
| 27 | Basic metals | 226 | 64.6 | 35.07 | 15.98 | 15.92 |
| 28 | Fabricated metal products except machinery | 4,272 | 27.88 | 16.04 | 6.70 | 5.98 |
| 29 | Machinery and equipment n.e.c. | 2,069 | 48.53 | 29.55 | 13.79 | 13.41 |
| 30 | Office machinery and computers | 90 | 36.67 | 34.4 | 13.31 | 14.15 |
| 31 | Electrical machinery and apparatus n.e.c. | 527 | 49.91 | 21.03 | 12.62 | 10.27 |
| 32 | Radio, television and communication equipment and apparatus | 192 | 45.83 | 31.05 | 15.47 | 10.29 |
| 33 | Medical, precision and optical instruments, watches and clocks | 747 | 37.88 | 36.77 | 15.53 | 16.97 |
| 34 | Motor vehicles, trailers and semitrailers | 366 | 59.56 | 26.15 | 20.76 | 9.42 |
| 35 | Other transport equipment | 353 | 36.26 | 28.54 | 15.17 | 7.35 |
| 36 | Furniture; manufacturing n.e.c. | 859 | 45.52 | 18.27 | 8.52 | 6.88 |
| | Average | 759 | 46.19 | 24.92 | | |

TP—Total producers, NE—Number of exporters, ES—Export/Sales,
AP—Average producers, AD—Average number of destinations

### 2.5.4 Country list

| ISO2 | Country Name | Distance* | ISO2 | Country Name | Distance* |
|---|---|---|---|---|---|
| AE | United Arab Emirates | 4,859.49 | DK | Denmark | 450.08 |
| AF | Afghanistan | 4,644.21 | DO | Dominican Republic | 8,006.54 |
| AL | Albania | 1,995.41 | DZ | Algeria | 2,709.28 |
| AM | Armenia | 2,899.19 | EC | Ecuador | 10,457.59 |
| AN | Netherland Antilles | 8,441.07 | EE | Estonia | 595.36 |
| AO | Angola | 7,644.17 | EG | Egypt | 3,412.79 |
| AR | Argentina | 12,404.68 | ER | Eritrea | 5,250.37 |
| AT | Austria | 1,228.47 | ES | Spain | 2,486.55 |
| AU | Australia | 15,385.40 | ET | Ethiopia | 5,847.94 |
| AW | Aruba | 8,587.53 | FI | Finland | 604.91 |
| BA | Bosnia & Herzegovina | 1,644.60 | FJ | Fiji | 15,252.19 |
| BB | Barbados | 7,930.83 | FO | Faroe Islands | 1,303.04 |
| BD | Bangladesh | 6,912.31 | FR | France | 1,616.32 |
| BE | Belgium | 1,151.50 | GA | Gabon | 6,577.58 |
| BF | Burkina Faso | 5,408.34 | GB | United Kingdom | 1,292.80 |
| BG | Bulgaria | 1,912.32 | GE | Georgia | 2,708.50 |
| BH | Bahrain | 4,526.21 | GH | Ghana | 6,005.78 |
| BI | Burundi | 7,027.18 | GI | Gibraltar | 2,956.84 |
| BJ | Benin | 5,803.46 | GL | Greenland | 3,368.65 |
| BM | Bermuda | 6,456.30 | GM | Gambia | 5,712.82 |
| BN | Brunei Darussalam | 10,069.25 | GN | Guinea | 5,966.61 |
| BO | Bolivia | 11,201.18 | GR | Greece | 2,353.03 |
| BR | Brazil | 10,185.49 | GT | Guatemala | 9,539.39 |
| BS | Bahamas | 7,808.63 | HK | Hong Kong | 8,368.68 |
| BW | Botswana | 9,199.48 | HN | Honduras | 9,338.07 |
| BY | Belarus | 986.48 | HR | Croatia | 1,519.27 |
| CA | Canada | 6,347.80 | HT | Haiti | 8,142.33 |
| CG | Congo | 7,007.02 | HU | Hungary | 1,315.38 |
| CH | Switzerland | 1,422.90 | ID | Indonesia | 10,632.05 |
| CI | Côte d'Ivoire | 6,129.18 | IE | Ireland | 1,549.43 |
| CL | Chile | 12,956.19 | IL | Israel | 3,315.60 |
| CM | Cameroon | 5,907.75 | IN | India | 6,308.11 |
| CN | China | 7,276.97 | IQ | Iraq | 3,552.56 |
| CO | Colombia | 9,491.13 | IR | Iran | 3,765.08 |
| CR | Costa Rica | 9,629.91 | IS | Iceland | 2,047.33 |
| CU | Cuba | 8,246.69 | IT | Italy | 1,833.43 |
| CV | Cape Verde | 5,794.42 | JM | Jamaica | 8,463.56 |
| CY | Cyprus | 2,955.68 | JO | Jordan | 3,358.22 |
| CZ | Czech Republic | 1,009.36 | JP | Japan | 8,226.76 |
| DE | Germany | 929.32 | KE | Kenya | 6,957.80 |
| KH | Cambodia | 8,820.19 | PL | Poland | 848.39 |
| KP | North Korea | 7,371.20 | PT | Portugal | 2,821.62 |

| ISO2 | Country Name | Distance* | ISO2 | Country Name | Distance* |
|---|---|---|---|---|---|
| KR | South Korea | 7,682.77 | PY | Paraguay | 11,477.31 |
| KW | Kuwait | 4,107.62 | QA | Qatar | 4,653.14 |
| KY | Cayman Islands | 8,589.82 | RW | Rwanda | 6,884.48 |
| KZ | Kazakhstan | 3,774.62 | SA | Saudi Arabia | 4,479.74 |
| LB | Lebanon | 3,148.39 | SD | Sudan | 5,100.44 |
| LC | Saint Lucia | 7,928.13 | SG | Singapore | 9,782.64 |
| LK | Sri Lanka | 7,849.86 | SI | Slovenia | 1,420.52 |
| LT | Lithuania | 676.56 | SK | Slovakia | 1,176.30 |
| LU | Luxembourg | 1,207.73 | SL | Sierra Leone | 6,101.36 |
| LV | Latvia | 591.22 | SM | San Marino | 1,678.00 |
| LY | Libya | 2,993.48 | SN | Senegal | 5,613.46 |
| MA | Morocco | 3,274.22 | SO | Somalia | 6,638.56 |
| MD | Moldova, Rep.of | 1,580.09 | SR | Suriname | 8,366.51 |
| MG | Madagascar | 9,152.54 | SV | El Salvador | 9,548.48 |
| MH | Marshall Islands | 12,283.25 | SY | Syrian Arab Republic | 3,084.28 |
| MK | Macedonia | 1,950.69 | TC | Turks & Caicos Is. | 7,815.33 |
| MO | Macau (Aomen) | 8,201.04 | TG | Togo | 5,878.81 |
| MT | Malta | 2,558.88 | TH | Thailand | 8,415.42 |
| MU | Mauritius | 9,593.82 | TJ | Tajikistan | 4,346.91 |
| MV | Maldives | 7,861.62 | TK | Tokelau | 14,475.37 |
| MW | Malawi | 8,326.36 | TN | Tunisia | 2,582.25 |
| MX | Mexico | 9,357.39 | TO | Tonga | 15,710.15 |
| MY | Malaysia | 9,568.98 | TR | Turkey | 2,453.42 |
| MZ | Mozambique | 9,058.94 | TT | Trinidad & Tobago | 8,286.25 |
| NA | Namibia | 8,993.66 | TW | Taiwan | 8,551.70 |
| NC | New Caledonia | 15,294.21 | TZ | Tanzania | 7,468.98 |
| NE | Niger | 5,062.04 | UA | Ukraine | 1,616.60 |
| NG | Nigeria | 5,721.76 | UG | Uganda | 6,634.94 |
| NI | Nicaragua | 9,522.18 | US | U.S.A. | 7,440.51 |
| NL | Netherlands | 1,009.40 | UY | Uruguay | 12,286.37 |
| NO | Norway | 502.69 | UZ | Uzbekistan | 4,141.06 |
| NP | Nepal | 6,223.75 | VC | St Vincent | 8,018.46 |
| NZ | New Zealand | 17,389.62 | VE | Venezuela | 8,692.38 |
| OM | Oman | 5,162.00 | VG | British Virgin Is. | 7,718.33 |
| PA | Panama | 9,511.23 | VN | Viet Nam | 8,727.68 |
| PE | Peru | 11,219.56 | YE | Yemen | 5,474.30 |
| PF | French Polynesia | 15,277.91 | YU | Serbia & Montenegro | 1,686.69 |
| PH | Philippines | 9,639.51 | ZA | South Africa | 9,838.57 |
| PK | Pakistan | 5,294.92 | ZM | Zambia | 8,207.19 |
| RO | Romania | 1,640.88 | ZW | Zimbabwe | 8,722.59 |
| RU | Russian Federation | 2,081.84 | | **Total countries** | **165** |

* Great-circle distance in kilometres from Sweden weighted by the population of major cities.

Table 2.10: Summary of signs and magnitude comparison for the estimated coefficients

| Estimator | Probit | OLS | QMLE | ZOIB | | Heckman | |
|---|---|---|---|---|---|---|---|
| Dependent variable | Export | Export Value | Export Value/Sales | Export* | Export Value/Sales | Export | Export Value |
| *GDP* | + / D | + / D | + / D | − / D | + / D | + / D | + / D |
| *GDPPerCapita* | 0 | + / D | − / H | 0 | + / D | 0 | + / D |
| *Distance* | − / H | − / H | − / H | + / H | − / H | − / H | − / D |
| *Contiguity* | + / H | − / D | 0 | − / H | − / D | + / H | − / H |
| *Landlocked* | − / D | − / H | − / D | + / D | − / D | − / D | − / D |
| *EnglishDummy* | + / D | + / H | + / D | − / D | + / H | + / D | + / H |
| *RegionalTradeAgreement* | − / H | + / D | − / H | + / H | − / H | − / H | 0 |
| *ValueAdded* | + / D | + / D | 0 | − / D | − / D | + / D | + / D |
| *Uninational* | − / D | 0 | − / H | + / D | − / H | − / D | + / H |
| *DomesticMNE* | − / H | + / H | − / D | + / H | − / D | − / H | + / H |
| *ForeignMNE* | − / H | + / D | − / H | + / H | − / H | − / H | + / H |
| *ImportDummy* | + / D | + / D | − / H | − / H | − / H | + / H | + / D |
| *CountryExperience* | + / H | 0 | + / H | − / H | 0 | + / H | 0 |
| *HumanCapital* | | | | | | − / H | |

**Note:** The coefficient signs are represented as + (positive and significant at $p < 0.1$ or less in at least one product type), − (negative and significant), 0 (not statistically significant for all product types). The product type that has a greater magnitude in absolute value is either H for homogeneous or D for differentiated. * The interpretation of the sign is the opposite of the rest of the table.

Table 2.11: Distance coefficients from all model specifications

| Model Specification | (22) All | (23) Homog. | (24) Diff. | (25) All | (26) Homog. | (27) Diff. |
|---|---|---|---|---|---|---|
| | | | *Main sample* | | | |
| Probit & OLS | $-0.270^{***}$ | $-0.348^{***}$ | $-0.265^{***}$ | $-0.270^{***}$ | $-0.348^{***}$ | $-0.265^{***}$ |
| *with no dummies* | (0.031) | (0.076) | (0.034) | (0.031) | (0.076) | (0.034) |
| Probit & OLS | $-0.240^{***}$ | $-0.304^{***}$ | $-0.231^{***}$ | $-0.249^{***}$ | $-0.374^{***}$ | $-0.251^{***}$ |
| *with industry dummies* | (0.008) | (0.019) | (0.009) | (0.031) | (0.078) | (0.034) |
| Probit & OLS | $-0.242^{***}$ | $-0.304^{***}$ | $-0.230^{***}$ | $-0.276^{***}$ | $-0.372^{***}$ | $-0.269^{***}$ |
| *with year dummies* | (0.008) | (0.019) | (0.009) | (0.031) | (0.076) | (0.034) |
| Probit & OLS | $-0.249^{***}$ | $-0.317^{***}$ | $-0.238^{***}$ | $-0.254^{***}$ | $-0.406^{***}$ | $-0.251^{***}$ |
| *with both dummies* | (0.008) | (0.019) | (0.009) | (0.031) | (0.078) | (0.034) |
| QMLE | | | | $-1.030^{***}$ | $-1.298^{***}$ | $-0.999^{***}$ |
| *with both dummies* | | | | (0.060) | (0.160) | (0.065) |
| Zero-Inflated Beta | $0.569^{***}$ | $0.760^{***}$ | $0.538^{***}$ | $-0.121^{***}$ | $-0.155^{***}$ | $-0.125^{***}$ |
| *with both dummies* | (0.019) | (0.049) | (0.021) | (0.012) | (0.029) | (0.013) |
| Heckman | $-0.248^{***}$ | $-0.316^{***}$ | $-0.237^{***}$ | $-0.333^{***}$ | 0.028 | $-0.371^{***}$ |
| *with both dummies* | (0.008) | (0.019) | (0.009) | (0.040) | (0.152) | (0.046) |
| | | | *Main sample: One distance variable* | | | |
| Probit & OLS | $-0.233^{***}$ | $-0.332^{***}$ | $-0.221^{***}$ | $-0.055^{***}$ | $-0.177^{***}$ | $-0.071^{***}$ |
| *with both dummies* | (0.006) | (0.015) | (0.006) | (0.020) | (0.059) | (0.022) |
| QMLE | | | | $-0.611^{***}$ | $-0.884^{***}$ | $-0.594^{***}$ |
| *with both dummies* | | | | (0.042) | (0.122) | (0.044) |
| Zero-Inflated Beta | $0.529^{***}$ | $0.789^{***}$ | $0.493^{***}$ | $-0.025^{***}$ | $-0.058^{***}$ | $-0.032^{***}$ |
| *with both dummies* | (0.014) | (0.036) | (0.015) | (0.008) | (0.021) | (0.009) |
| Heckman | $-0.232^{***}$ | $-0.331^{***}$ | $-0.219^{***}$ | $-0.182^{***}$ | $0.304^{**}$ | $-0.239^{***}$ |
| *with both dummies* | (0.006) | (0.015) | (0.006) | (0.049) | (0.146) | (0.045) |
| | | | *SMEs sample: 76.4% of total observations* | | | |
| Probit & OLS | $-0.228^{***}$ | $-0.277^{***}$ | $-0.222^{***}$ | $-0.252^{***}$ | $-0.288^{***}$ | $-0.265^{***}$ |
| *with both dummies* | (0.009) | (0.023) | (0.010) | (0.033) | (0.091) | (0.035) |
| QMLE | | | | $-1.009^{***}$ | $-1.135^{***}$ | $-0.989^{***}$ |
| *with both dummies* | | | | (0.062) | (0.161) | (0.068) |
| Zero-Inflated Beta | $0.524^{***}$ | $0.656^{***}$ | $0.505^{***}$ | $-0.117^{***}$ | $-0.118^{***}$ | $-0.121^{***}$ |
| *with both dummies* | (0.021) | (0.056) | (0.023) | (0.013) | (0.035) | (0.014) |
| Heckman | $-0.227^{***}$ | $-0.314^{***}$ | $-0.233^{***}$ | $-0.343^{***}$ | 0.031 | $-0.365^{***}$ |
| *with both dummies* | (0.009) | (0.020) | (0.009) | (0.040) | (0.151) | (0.046) |
| | | | *Nonaffiliated-firms sample: 37.4% of total observations* | | | |
| Probit & OLS | $-0.221^{***}$ | $-0.324^{***}$ | $-0.204^{***}$ | $-0.266^{***}$ | $-0.468^{***}$ | $-0.267^{***}$ |
| *with both dummies* | (0.014) | (0.037) | (0.015) | (0.045) | (0.151) | (0.047) |
| QMLE | | | | $-0.949^{***}$ | $-1.171^{***}$ | $-0.939^{***}$ |
| *with both dummies* | | | | (0.082) | (0.273) | (0.087) |
| Zero-Inflated Beta | $0.501^{***}$ | $0.762^{***}$ | $0.462^{***}$ | $-0.115^{***}$ | $-0.213^{***}$ | $-0.111^{***}$ |
| *with both dummies* | (0.031) | (0.091) | (0.033) | (0.018) | (0.058) | (0.019) |
| Heckman | $-0.247^{***}$ | $-0.315^{***}$ | $-0.237^{***}$ | $-0.338^{***}$ | 0.013 | $-0.386^{***}$ |
| *with both dummies* | (0.008) | (0.020) | (0.009) | (0.058) | (0.162) | (0.058) |

**Note:** The independent variables for the "Main sample" and "SMEs sample" regressions include *GDP*, *GDPPerCapita*, *Distance*, *Contiguity*, *Landlocked*, *English*, *RegionalTradeAgreement*, *ValueAdded*, *Uninational*, *DomesticMNE*, *ForeignMNE*, *ImportDummy*, and *CountryExperience*. The "Main sample: One distance" regressions exclude *Contiguity*, *Landlocked*, *English*, and *RegionalTradeAgreement*. The "Nonaffiliated-firms sample" excludes *Uninational*, *DomesticMNE*, and *ForeignMNE*. There is no distinction between export participation and export intensity decisions in the QMLE regressions, but the results are listed in the export intensity columns for convenience. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

# Chapter 3

# Effects of Productivity and Importing on Firm-Level Exporting

## 3.1 Introduction

There are two well-known facts in international trade. First, most firms do not export, and those that do are typically highly performing firms. Exporters are bigger, are more productive, earn more profits, and pay higher wages than nonexporters. Second, the majority of trading firms are two-way traders, meaning that exporters also engage in importing. The recent trade literature focuses more on the first fact than the second. Productivity promotes exporting at the firm level for both the extensive (total number of firms in a market) and intensive (total export amount per firm) margins.[1] The cost complementarity between importing and exporting helps firms be two-way traders and several studies find that past importing is a good predictor of current exporting, but the evidence in the opposite direction is mixed (Aristei et al., 2013; Muûls and Pisu, 2009). Studies of the role of importing in explaining firms' exporting are still rare, however.

I investigate previous importing as an export driver by analysing the interaction between importing and productivity. The hypothesis is that the effect of productivity on exporting is greater for firms with previous importing experience. This interaction effect is motivated by the idea that importing stimulates learning, either about the seller's networks, market demand, or the destination country's legal and institutional frameworks.

To test this hypothesis, I model firms' past exporting as a function of productivity—measured by total factor productivity (TFP)—importing, and the interaction between TFP and importing. A positive result for this interaction is an indication of a productivity-enhancing effect on exporting

[1]See Wagner (2007) for a survey of comparative cross-country studies.

for firms with previous importing. The empirical analysis employs firm-level data within Sweden's manufacturing sector during 1997–2006.

This paper contributes to the limited number of empirical studies at the firm level on importing and its effect on exporting. The relationship between importing, productivity, and exporting helps advance our understanding of at least two aspects of firms' behaviour, namely importing as a source of productivity heterogeneity, and the cost complementarity between importing and exporting. Not only are the entry costs into importing and exporting partially shared for the majority of traders, but importing experience also interacts with firms' productivity to boost firms' engagement in exporting. For an equal increase in productivity across all firms, those with importing experience are able to exploit their experience of international markets and are more likely to export, compared to firms with no previous importing. From a policy perspective, a positive importing–productivity interaction on exporting can provide an argument for a free-trade policy: In a sense, loosening import restrictions might help stimulate domestic firms to export later.

The organisation of the chapter is as follows. Conceptual framework on the relationship between productivity, importing, and exporting is presented in section 3.2. Section 3.3 describes the empirical strategy, followed by a description of the data. The results are presented in section 3.5, and section 3.6 concludes.

## 3.2 Conceptual framework

### 3.2.1 Productivity as a driver of exporting

One stylised fact in trade studies is that exporting firms are a minority—most firms do not export. Once they start to export, it is often observed that they are highly performing firms with a high productivity. Melitz (2003) and Bernard et al. (2003) attribute this higher productivity among exporters to exporting's fixed costs of entry. Besides the variable transport costs, each individual firm has to pay upfront fixed costs to establish an international network of buyers. Only relatively more productive firms can afford these entry costs and *self-select* themselves into exporting.

Eaton et al. (2004) are among the first to document this phenomenon among French manufacturing firms, and later studies find a similar pattern.

Table 3.1: Productivity premia of Swedish manufacturing trading firms, 1997–2006

| Variable | (1) *TFP* | (2) *Size* | (3) *VA* | (4) *GP* |
|---|---|---|---|---|
| *EXP* only | 0.055*** | 0.765*** | 0.095*** | 0.079*** |
| | (0.004) | (0.008) | (0.004) | (0.003) |
| *IMP* only | 0.085*** | 0.713*** | 0.118*** | 0.104*** |
| | (0.006) | (0.012) | (0.006) | (0.005) |
| *EXP* and *IMP* | 0.137*** | 1.969*** | 0.221*** | 0.185*** |
| | (0.004) | (0.008) | (0.004) | (0.003) |
| Observations | 159,998 | 160,226 | 160,226 | 160,226 |
| $R^2$ | 0.509 | 0.372 | 0.115 | 0.150 |

**Note:** *TFP*—Log total factor productivity calculated using the methodology of Levinsohn and Petrin (2003), *Size*—Log total employees, *VA*—Log value added per employee, *GP*—Log gross profit per employee. *EXP* only—Dummy, 1 if a firm exports but does not import, 0 otherwise. *IMP* only—Dummy, 1 if a firm imports but does not export. *EXP* and *IMP*—Dummy, 1 if a firm both exports and imports. The data include 71,569 firms from the manufacturing sector (NACE codes 15–36). Firm size (except in column 2), year and industry dummies, and constants are included but not reported. Robust standard errors in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The empirical discovery of the export *premia*, or a gain in productivity among exporters, confirms the prediction from this strand of literature, which is sometimes called the self-selection literature. Wagner's (2007) survey of 54 firm-level studies covering 34 countries concludes that "exporters are more productive than nonexporters, and the more productive firms self-select into export markets" (p. 66).

Another nonmutually exclusive relationship is that exporting makes firms productive. This opposite direction of causality is argued to be a consequence of a knowledge flow from international buyers and competitors, and an intense postentry competition (Wagner, 2007). In the same survey, Wagner finds mixed evidence for learning by exporting across several studies, and points out that exporting does not necessarily improve firms.

The greater productivity among Swedish exporters can be clearly seen in Table 3.1, which includes importing and two-way trading activities for comparison. Four performance measures, namely TFP, firm size, value added per employee, and gross profit per employee, are regressed on trade status variables indicating whether a firm (i) only exports, (ii) only imports, and (iii) both exports and imports in the current year. Using data of all manufacturing firms, the regression results exhibit a positive and significant effect of being a trader after controlling for firm size and year and industry fixed

Table 3.2: Composition of Swedish manufacturing firms, 1997–2006

| | Nonimporters | | Temporary importers | | Persistent importers | | Total | |
|---|---|---|---|---|---|---|---|---|
| | % | ATFP | % | ATFP | % | ATFP | % | ATFP |
| Nonexporters | **39.22** | 5.69 | 6.55 | 5.91 | 0.21 | 6.17 | 45.98 | 5.73 |
| Temporary Exporters | 11.43 | 5.87 | **20.45** | 6.13 | 2.45 | 6.30 | 34.33 | 6.05 |
| Persistent Exporters | 1.00 | 5.95 | 6.37 | 6.24 | **12.32** | 6.68 | 19.69 | 6.50 |
| Total | 51.65 | 5.74 | 33.37 | 6.11 | 14.98 | 6.61 | 100.00 | 5.99 |

**Note:** Columns labeled "%" present the percentage of 71,569 Swedish manufacturing firms (NACE codes 15–36) with nonzero employees. ATFP = average total factor productivity (log) calculated using Levinsohn and Petrin's (2003) methodology.

effects. Exporting implies a 5.5% increase in TFP, a 76.5% bigger firm, 9.5% more value added per employee, and 7.9% more profit, compared to nonexporters. The results are higher for importing than exporting, except for firm size (71.3%). This suggests that the productivity threshold is higher for importing than for exporting in the case of Sweden. Consistent with other studies, two-way trading implies the biggest premia, especially for firm size where the effect is almost triple compared to nontraders.[2]

### 3.2.2 Import–export complementarity

When we observe trading activities of all firms, we also find that two-way traders—those who engage in both importing and exporting—constitute the majority among all traders. This phenomenon is well demonstrated in the co-occurrence of trade activities in Table 3.2 for the composition of Swedish manufacturing firms during 1997–2006. In this table, the fraction of the total firms and the average TFP are cross-tabulated by their trading activities. Firms are categorised as non-, temporary, and persistent importers or exporters. From the table, we can see the co-occurrence of the two trading activities. Most (39.22%) of the nonimporters (51.65% of the total) also do not export. Similarly, the majority of temporary importers are also temporary exporters, and the majority of persistent importers are also persistent exporters. Observe, however, that there are more nonimporters than nonexporters; in terms of the number of firms, Sweden tends to export more than it imports. Andersson et al. (2008) finds a similar pattern. From Table 3.1

[2] A separate set of regressions using a trader's status (whether a firm is an exporter, importer or two-way trader or not, regardless of years) shows similar results with slightly lower coefficient estimates. This suggests that *active* participation has a greater effect on productivity. Results on these separate regressions can be provided upon request.

we can also see that the productivity threshold (the entry costs) of importing is higher than that of exporting. This is a unique case. Typically, we would find that firms are more likely to import than export due to cheaper operating costs and the institutional familiarity of the domestic market.

Note also that when firms become more engaged in trade activities, their productivity on average also increases, which is consistent with the observations from the previous subsection. From the same table, nonimporters who are persistent exporters have a higher average TFP than nonexporters, 5.95 versus 5.69. The same pattern can be observed for nonexporters, in which the average TFP is 6.17 for persistent importers versus 5.69 for nonimporters. The highest average TFP is found in persistent importers who are also persistent exporters.

Investigating Chilean firms, Kasahara and Lapham (2013) find in all six industries under study that most trading firms are two-way traders and in almost all industries the probability of switching from nontrader status is highest among importers.[3] This means that among firms that have not engaged in any trade previously, most of them are more likely to try out the import markets first. In all six industries, firms that import in the previous period are more likely to continue with only importing than to exit trading, start two-way trading or switch entirely to export only in the current period. But, on the other hand, this pattern is not observed among exporters (Kasahara and Lapham, 2013, Tables 3 and 4).

Aristei et al. (2013) investigate the two-way relationship between exporting and importing in 26 transitioning economies in Eastern Europe using the bivariate probit estimator for the decision to export as explained by previous importing status and vice versa. They finding no effect of past exporting on current importing, but past importing increases the probability of foreign sales. This effect, however, vanishes after controlling for productivity and other firm characteristics. In contrast, in Muûls and Pisu's (2009) study of Belgian firms, the two trading activities have mutually positive effects.

Despite this regularity, only a few studies offer an explanation for two-way trading. This phenomenon is typically attributed to sunk costs because they are complementary for both importing and exporting. Firms that have already paid to enter an import (export) market will be more likely to export (import) later because a part of the upfront cost is shared between the two.

[3] The six industries under their study of Chilean firms are wearing apparel, plastic products, food products, textiles, wood products, and fabricated metals.

For example, the networks established for importing can partially be used for exporting as well, and vice versa. Furthermore, since these sunk costs are paid before entering the import or export market, only the most productive firms will be two-way traders (Kasahara and Rodrigue, 2008).

Kasahara and Rodrigue (2008) also argue that cost complementarity is not the only reason for the prevalence of two-way traders. Exposure to an international market via importing can lead to learning that helps facilitate a firm's exporting later.

### 3.2.3 Productivity–importing interaction

When a firm starts to import, it must invest in resources to establish the necessary networks and gain knowledge of the international market. This can be contact networks of foreign vendors and distributors, the customer demands, or the local legal and institutional frameworks such as bureaucratic and administrative processes. The information exchanges and interactions can lead to a learning experience for the firm. Compared with other firms with no previous importing, the experienced firm can combine its knowledge of the international market and its productivity to gain an easier access to the export market later.

To illustrate the point, imagine two identical firms with similar characteristics, Firm 1 and Firm 2, that distribute their products domestically. The only difference between the firms is that Firm 2 imported a product last year, while Firm 1 did not. A sudden change, say an oversupply of raw materials that reduces the input price, happens this year that instantly raises the productivity of both firms equally. Now each firms wants to expand its market reach abroad. Are the firms equally likely to export successfully? Perhaps not. The literature suggests that Firm 2 is more likely to engage in exporting than Firm 1.

When the productivity shock happens, Firm 2 is in a better position to take advantage of its learning about importing processes and realise the returns by using both the existing and newly acquired resources more efficiently. This learning lowers Firm 2's risks of failure in seeking access to the export markets. On the other hand, Firm 1 has to start the whole exporting process from scratch. The productivity effect on a firm's exporting, hence, is greater if it has previous importing experience.

There are at least two advantages to considering the interaction effect between productivity and importing. First, such inclusion allows the researcher to distinguish productivity effects between firms with and without importing experience. Moreover, we can evaluate the effects in comparison to the firm's importing. In the next section, I outline the strategy of empirically testing the productivity-enhancing effects of importing on a firm's exporting.

## 3.3 Empirical strategy

### 3.3.1 Estimation model

In the empirical specification, I model firm $i$'s exports to country $j$ at time $t$ as a function of past productivity (TFP) and importing while controlling for annual shocks and country fixed effects, as well as various firm- and country-specific characteristics to capture trading costs. Formally,

$$\begin{aligned}\Pr(DEXP_{ijt} = 1) = \Phi(&\alpha_1(IMP_{i,t-1} \times TFP_{i,t-1}) + \alpha_2 TFP_{i,t-1} \\ &+ \alpha_3 IMP_{i,t-1} + \mathbf{x}'_{ijt}\beta_1 + \delta_{1i} + \delta_{1j} + \delta_{1t} + \varepsilon_{1ijt}), \quad (3.1)\end{aligned}$$

$$\begin{aligned}EXP_{ijt} = \gamma_1(IMP_{i,t-1} \times TFP_{i,t-1}) &+ \gamma_2 TFP_{i,t-1} + \gamma_3 IMP_{i,t-1} \\ &+ \mathbf{x}'_{ijt}\beta_2 + \delta_{2i} + \delta_{2j} + \delta_{2t} + \varepsilon_{2ijt}. \quad (3.2)\end{aligned}$$

The dependent variable for the export participation in equation (3.1), *DEXP*, is an indicator of the export decision and takes a value of 1 if a firm exports and 0 otherwise. For the export intensity, equation (3.2), the dependent variable, *EXP*, is the extent of exporting in terms of total value in logarithmic form. The main independent variables are lagged importing ($IMP_{t-1}$), lagged productivity ($TFP_{t-1}$), and the interaction between the two ($IMP_{t-1} \times TFP_{t-1}$). The controls consist of firm-specific variables (*FirmSize*, *Uninational*, *DomesticMNE*, and *ForeignMNE*), country-specific variables (*GDP* and *Population*), and dummies for industry ($\delta_i$), country ($\delta_j$), and year ($\delta_t$). Size and corporate group affiliation are associated with the financial and other resources, which are usually related to firms' export behaviour in the sense that large firms are more likely to export than smaller ones, so it is important to include them in the regression. The country-specific controls indicate market size (*GDP*) and demand (*Population*). Year and industry dummies are included to control for annual shocks and unobserved heterogeneity within the industries. Instead of using regional dummies as in other trade studies, I include the country dummies to capture the trade resistance term (Anderson and van Wincoop, 2003).

The model features unilateral trade flows, with exports originating from one country. Since the entry costs are market specific (Andersson, 2007), an aggregation of export activities over trading partners would compound with the effects of productivity and importing and thus would bias the results.

For the participation equation, I use the probit estimator because the dependent variable is a binary choice: to export or not. For the intensity equation, I estimate with pooled ordinary least squares (OLS) and fixed-effects (FE) estimators. The estimation for the intensity equation does not include zero exporting because the logarithmic transformation of the dependent variable renders these zeros undefined. The difference between OLS and the FE estimator is that the latter accounts for unobserved heterogeneity that is constant over time. I make two assumptions on the individual-specific effect, the fixed- and random-effects assumptions. For the fixed-effects model, the individual-specific effects are correlated with independent variables, whereas they are uncorrelated in the random-effects model. The Hausman test indicates that the FE estimator is more appropriate, but the results for the random-effects estimation are available upon request.

There is a potential omitted-variable bias from nonrandomly dropping many zero observations (Heckman, 1979).[4] Alternatively, I could use a Heckman-type estimator to deal with the bias from the frequent zeros. In terms of sign and significance, the results do not generally differ between the pooled OLS estimator that drops the zeros and the Heckman estimator. I include the Heckman results in the appendix. In order to estimate the Heckman model, it is advisable to include at least one exclusion variable, which determines the selection equation and not the outcome equation. Here, I choose human capital, measured as the fraction of workers with at least three years of university education. The motivation for this is as follows. In order to export to a new market, a firm requires certain specific knowledge or network connections, usually embedded in high-ranking personnel in a managerial position, to establish a contractual transaction. After the initial entry, the process becomes more routine and can be executed by lower-ranking administrative personnel to fulfil the export orders. Hence, the human capital is more important in the entry decision and becomes

[4]The zeros account for 94.44% of observations.

less important in determining how much to export (Jienwatcharamongkhol, 2013).

The main focus of this paper is the interaction effect between productivity and importing. In order to estimate equations (3.1) and (3.2), the main variables are de-meaned before interacting (following Rajan and Zingales, 1998; Balli and Sorensen, 2010). I discuss the methodology and its implications in more detail in the appendix.

There are several productivity measures in use by empirical researchers, including value added per employee and gross profit per employee, which can be considered crude measures of productivity. In contrast, TFP accounts for the effects of total outputs that are not caused by the inputs of production; that is, it is a residual from the estimation of firms' production function. I follow Levinsohn and Petrin's (2003) methodology to calculate the TFP. The detailed discussion of the methodology is also in the appendix.

In the results section, two alternative productivity measures are used as a robustness check. The first is TFP calculated by following the Olley and Pakes's (1996) methodology. The main difference is the use of proxy variables. For the Levinsohn–Petrin approach, the intermediate inputs are the proxy variable, whereas the Olley–Pakes approach uses the investment variable instead. For the presentation of the main results, I choose the Levinsohn–Petrin approach because there are almost no missing values in all the variables for the estimation of firms' production function. In contrast, the investment variable contains zeros for around 3% of firms, making the estimation incomputable for these firms. The second alternative measure is value added per employee, which merely captures the labour productivity.

## 3.4 Data

### 3.4.1 Dataset construction

The estimation dataset has three dimensions—firm, country, and time—so there are several adjustments to make the computation manageable. First, only firms with 50 or more employees are included. Firms, in this case, refers to those with positive turnover. Because firms with import and export experience within the EU member states not exceeding a certain threshold (varying by year due to the adjustment) are not obliged to report their trade activities to Statistics Sweden, many observations (mainly from small firms) are excluded from the sample automatically. Moreover, the vast number of small firms contributes a tiny share of all trade. Including them would explode the dataset tremendously and render the computation impossible.

Next, I exclude nonexporters from the dataset, also due to the computational constraint.[5] The included firms are therefore the persistent and temporary exporters. The total number of firms is 6,368 in this sample. The next step is to construct the dataset:

1. Each individual firm is matched with all 196 countries, forming a set of firm–country dyads.[6] This generates the list of countries to which each individual firm can export.

2. The constructed dyads are then matched with the years those firms existed (firm–country–year triads).

3. The triads are merged with data on the firms' trade (export and import), characteristic (total employees, corporate affiliation, etc.), and country variables.

The total number of observations is 7,186,536. However, due to the lagged variables on the right-hand side and some missing values in some of the variables, the actual number of observations is lowered by around 45% to approximately 3.8 million observations.

### 3.4.2 Data description

The disaggregated firm-level data for the main estimation model in equations (1) and (2) come from three databases. The first database is the trade data from Statistics Sweden, which contains the export and import value of all products at the 8-digit level, the Swedish equivalent of the harmonised system (HS) classification. This database is then aggregated to firms' total exports and imports shipped between Sweden and partner countries.

The second database, also from Statistics Sweden and providing firms' characteristics, is a registry of firm information linked to the National Tax Office and includes such variables as total employees, turnover, sales, net

[5] A trade-off from excluding these nonexporters, around 65,000 firms, is an upward bias in the estimates because there are only firms with positive exporting in the estimated sample.

[6] There are 225 countries in total but the data on many variables are not available for 19 of them. The list of countries is in the appendix.

Table 3.3: Variable descriptions

| Variable | Description | Exp. sign |
|---|---|---|
| Dependent variable | | |
| $DEXP_{ijt}$ | Export status: 1 if firm $i$ exports any products to country $j$ at time $t$ and 0 otherwise. | |
| $EXP_{ijt}$ | Log total export value from firm $i$ to country $j$ at time $t$ in constant SEK. | |
| Independent variables | | |
| $TFP_{i,t-1}$ | Log total factor productivity at time $t-1$ estimated by firm $i$'s production function according to the Levinsohn–Petrin methodology. | + |
| $IMP_{i,t-1}$ | Log total import value to firm $i$ at time $t-1$ in constant SEK. | + |
| $TFP_{i,t-1} \times IMP_{i,t-1}$ | The interaction term of $TFP_{i,t-1}$ and $IMP_{i,t-1}$. | + |
| Firm-specific controls | | |
| $FirmSize_{it}$ | Log total number of employees. | + |
| $Uninational_i$ | Dummy variable: 1 if firm $i$ belongs to a Swedish corporate group that does not have any subsidiaries abroad, 0 otherwise. | + |
| $DomesticMNE_i$ | Dummy variable: 1 if firm $i$ belongs to a Swedish multinational firm, 0 otherwise. | + |
| $ForeignMNE_i$ | Dummy variable: 1 if firm $i$ belongs to a foreign-owned multinational firm, 0 otherwise. | + |
| Country-specific controls | | |
| $GDP_{jt}$ | Log gross domestic product of country $j$ in USD. | + |
| $Population_{jt}$ | Log total population of country $j$. | + |

and gross profits, and so on. The databases are cross referenced by unique firm-identification numbers anonymously generated by Statistics Sweden to protect the identity of the actual firms.

The third data source, Centre d'Études Prospectives et d'Informations Internationales (CEPII), provides country-level variables. For more details on its variables, see the appendix of Head et al. (2010). Table 3.3 lists all variables and their expected signs. The descriptive statistics and correlation matrix are displayed in the Appendix.

# 3.5 Results

## 3.5.1 Main results

In this section, I start with the discussion about the statistical signs and significance of the variables. I then present and discuss the economic significance. The main results are presented in Table 3.4. For export participation, the interaction term, $TFP \times IMP$, shows positive and significant coefficients. This confirms the hypothesis and suggests that productivity has a disproportionate positive effect on export participation when firms have imported in a previous period. Looking at the direct effects, past importing also show a positive sign.[7] The main difference between this and the study on Chile in Aristei et al. (2013) is the strong significance, even after controlling for firm and country characteristics. In Aristei et al. (2013), the coefficients gradually lose significance with each added control. The above results, on the other hand, are similar to those of Belgium (Muûls and Pisu, 2009), but the model specification for the probit equation is different. Muûls and Pisu (2009) employ a dynamic model, which includes past exporting as an additional independent variable. Similar to the other two studies, *TFP*is positive in both export decisions, except for the FE results.

Almost all of the control variables show the expected sign. Market size and demand, *GDP*and *Population*, have a positive impact on export behaviour as predicted. Firm size and domestic and foreign MNE affiliation are also positive and significant, suggesting that access to resources can help firms export. The affiliation variables are not significant in the fixed-effects result, which is expected.[8] A counterintuitive result is found in *Uninational*. Being affiliated to a Swedish corporate group is expected to have a positive and significant impact on exporting, but the regression results show the opposite. From the data descriptives in the appendix, we can see that 22% of observations belong to Swedish corporations and that the variable is always negatively related to other variables, including both TFP and importing. This might suggest that Swedish corporation groups depend mostly on the domestic market for inputs, resulting in a limited variety of inputs. Combining this with low productivity makes them less likely to export. A more detailed look into these firms may offer a better explanation, but I leave it

[7] A note on the interpretation: The coefficient estimate for *IMP* displayed in column 6 of Table 3.4 is the effect of productivity on export intensity, conditioned on the *TFP* variable being *zero*. The same applies for the *TFP* variable. Because the estimator is a standard OLS and export and import values are in logarithmic form, we can infer that a doubling increase in *IMP* will increase exporting by 12% on the condition that productivity is at zero. A similar interpretation applies to the fixed-effects results in column 7. However, the interpretation for export participation is more complicated because the marginal effects for probit are calculated differently. For convenience, the average marginal effects are listed in column 5 in Table 3.4. Here, a doubling increase in *IMP* will increase the likelihood of export participation by 0.6%, while setting productivity at the *mean* value.

[8] The fixed-effects estimator captures the variation within each individual firm, so the variables that have a small variation over time usually do not exhibit a significant effect on the dependent variable.

for future research since it is not the focus of this study.

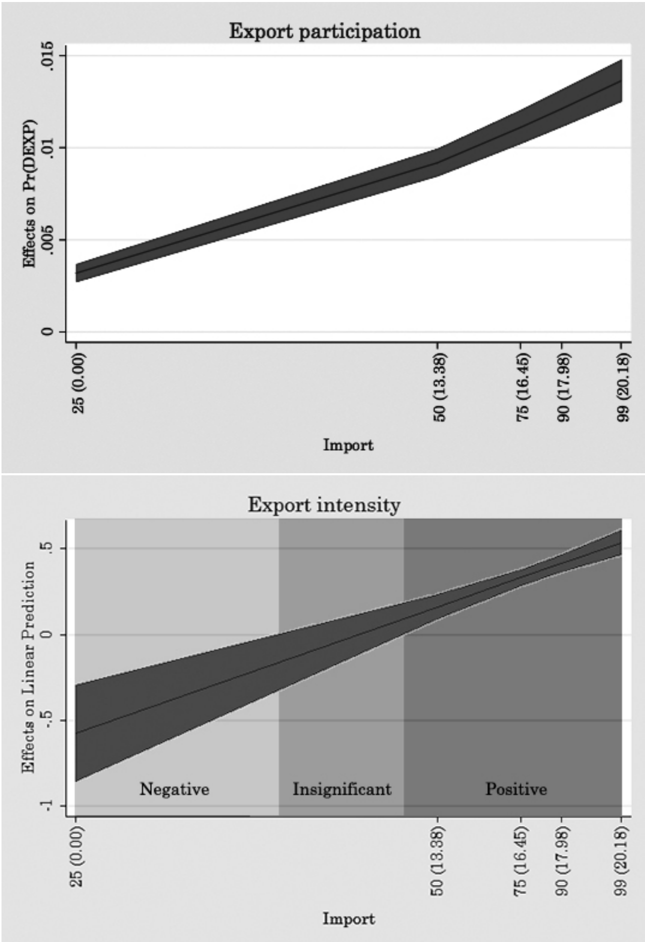
Since there are two variables interacting with each other—i.e., *TFP* and *IMP*—the economic significance (as calculated by marginal effects) of one variable is evaluated in relation to another interacting variable. So, the marginal effects of *TFP* is $\frac{\partial \ln EXP}{\partial TFP} = \gamma_3 + \gamma_2 IMP$. This means that the effects of *TFP* can range from negative to positive depending on the chosen value of *IMP*. It is therefore insufficient to choose only one value of *IMP* to represent the productivity effects. For this reason, I graph the marginal effects of productivity evaluated across the observed range of importing from the $25^{\text{th}}$ to $99^{\text{th}}$ percentile (Figure 3.1).[9] The slope indicates the marginal change of past productivity on current exporting according to total import value. The results' significance can be seen from the two-tailed 95% confidence intervals (grey areas) above and below the sloping line. The effect is significant whenever both intervals are above or below the zero line. For the export intensity, the graph is derived from the OLS results.

From Figure 3.1, export participation is significant throughout the entire distribution of imports, while the export intensity is significant from approximately the $47^{\text{th}}$ percentile and above. This means that the impact of productivity is generally positive for the participation of firms into exporting but it is not uniform for the intensity and can be described in three stages. First, at the lower end of the import-intensity distribution, from zero importing until approximately the $38^{\text{th}}$ percentile, firms might not yet benefit from learning and must allocate their limited resources to either importing or exporting, but not both. Hence, the negative impact on export intensity in the current period. Second, in the middle range, from the $38^{\text{th}}$ to around $47^{\text{th}}$ percentile, there is no significant impact on exporting. Finally, in the higher end of the import-intensity distribution, the $47^{\text{th}}$ percentile and above, a positive return of learning from past importing facilitates current exporting.

The same pattern is also observed when we analyse the effects of importing. In the appendix, Figure 3.3 exhibits the marginal effects of past importing on current exporting. Similar to the productivity effect, importing has a positive impact on export participation throughout the entire distribution of the productivity. For export intensity, the impact of importing is positive throughout the distribution and significant from the $25^{\text{th}}$ percentile and above. This means that past importing has a positive impact on ex-

[9] The graph starts at 25% because there are many zero observations in the import variable.

Figure 3.1: The marginal effects of productivity on current exporting (Probit and OLS)




porting at all productivity levels. This finding corresponds with the robust positive impact of importing in many studies.

In the following section, I include several tests to check for the results' robustness. Two alternative TFP measures are used. First, the TFP is estimated with the Olley–Pakes methodology. Second, I use value added per employee, a crude measure of labour productivity. Also, I run the regressions with alternative lag years to examine the timing response and persistency of the effects. Last, I run the main specification with a restricted sample

Table 3.4: Regression results of export propensity and intensity

| | (5) | (6) | (7) |
|---|---|---|---|
| | Export participation | Export intensity | |
| Variable | Probit | OLS | FE |
| *TFP* × *IMP* | 0.002*** | 0.074*** | 0.026*** |
| | (0.000) | (0.008) | (0.004) |
| *TFP* | 0.010*** | 0.119*** | 0.020 |
| | (0.000) | (0.023) | (0.016) |
| *IMP* | 0.006*** | 0.118*** | 0.043*** |
| | (0.000) | (0.012) | (0.007) |
| *GDP* | 0.019*** | 0.409*** | 0.802*** |
| | (0.002) | (0.111) | (0.111) |
| *Population* | 0.004 | 0.798* | 0.213 |
| | (0.019) | (0.451) | (0.426) |
| *FirmSize* | 0.020*** | 0.467*** | 0.677*** |
| | (0.000) | (0.021) | (0.023) |
| *Uninational* | −0.006*** | −0.052** | −0.035 |
| | (0.001) | (0.026) | (0.031) |
| *DomesticMNE* | 0.022*** | 0.242*** | −0.031 |
| | (0.001) | (0.036) | (0.020) |
| *ForeignMNE* | 0.020*** | 0.287*** | 0.024 |
| | (0.001) | (0.033) | (0.021) |
| Observations | 3,821,379 | 311,419 | 311,419 |
| $R^2$ | 0.466 | 0.305 | 0.028 |
| Firm–Country dyads | | | 78,201 |

**Note:** The numbers represent the marginal effects. All regressions include unreported year, industry and country dummies. The dependent variable for export participation takes 1 when firm exporting is positive. The dependent variable for export intensity is log total export value. The estimators are probit, pooled OLS, and fixed effects, respectively. *TFP*, *IMP* and the interaction term are in natural log and lagged one year. *GDP*, *Population* and *FirmSize* are in natural log. Standard errors clustered by country are displayed in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The $R^2$ value for the probit in column 5 is the pseudo $R^2$.

Table 3.5: Regressions using $TFP_{OP}$ according to the Olley–Pakes methodology as an alternative measure

| Variable | (8) Export propensity Probit | (9) Export intensity OLS | (10) FE |
|---|---|---|---|
| $TFP_{OP} \times IMP$ | 0.002*** | 0.034*** | 0.002 |
| | (0.000) | (0.006) | (0.003) |
| $TFP_{OP}$ | 0.008*** | −0.008 | 0.045*** |
| | (0.000) | (0.021) | (0.017) |
| $IMP$ | 0.007*** | 0.151*** | 0.052*** |
| | (0.000) | (0.010) | (0.006) |
| Observations | 3,811,904 | 311,220 | 311,220 |
| $R^2$ | 0.464 | 0.300 | 0.027 |
| Firm–Country dyads | | | 78,162 |

**Note:** All regressions include unreported country- and firm-specific variables; year, industry, and country dummies; and constants. The estimators are probit, pooled OLS, and fixed effects, respectively. $TFP_{OP}$, $IMP$ and the interaction term are in natural log and lagged one year. Standard errors clustered by country are displayed in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The probit $R^2$ value in column 8 is the pseudo $R^2$.

that only contains export-starting firms. This is to exclude firms that paid the upfront fixed costs in previous years.

### 3.5.2 Robustness checks

### 3.5.3 Alternative TFP measure: Olley–Pakes TFP

As an alternative to the TFP variable estimated by the Levinsohn–Petrin methodology, the results in Table 3.5 use the Olley–Pakes methodology. The variable is denoted by $TFP_{OP}$. The interaction term shows positive results in both export-participation and export-intensity equations, but it is not statistically significant for the FE estimator. Similarly, the *IMP* variable shows positive and significant results in both equations. On the other hand, $TFP_{OP}$ shows mixed results: positive for the probit and FE estimations but negative and insignificant for the OLS result. In terms of the estimate size, both the interaction and $TFP_{OP}$ variables have smaller estimates than the main results in Table 3.4, especially in the export intensity. Whereas the *IMP* variable shows an increase in the estimated size. The difference in the results from Table 3.4 to 3.5 seems to be driven by the choice of *TFP* variable. Other explanatory variables show similar results with a slightly different estimated size; these variables are not reported for brevity.

Table 3.6: Regressions using value added per employee (*VA*) as an alternative measure

| | (11) | (12) | (13) |
|---|---|---|---|
| | Export propensity | Export intensity | |
| Variable | Probit | OLS | FE |
| *VA* × *IMP* | 0.001* | 0.058*** | 0.011*** |
| | (0.000) | (0.008) | (0.004) |
| *VA* | 0.019*** | 0.469*** | 0.067*** |
| | (0.001) | (0.031) | (0.018) |
| *IMP* | 0.007*** | 0.126*** | 0.050*** |
| | (0.000) | (0.011) | (0.007) |
| Observations | 3,825,859 | 311,646 | 311,646 |
| $R^2$ | 0.466 | 0.307 | 0.027 |
| Firm–Country dyads | | | 78,238 |

**Note:** All regressions include unreported country- and firm-specific variables; year, industry, country dummies; and constants. The estimators are probit, pooled OLS, and fixed effects, respectively. *VA*, *IMP* and the interaction term are in natural log and lagged one year. Standard errors clustered by country are displayed in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The probit $R^2$ value in column 11 is the pseudo $R^2$.

### 3.5.4 Alternative TFP measure: Value added per employee

Table 3.6 presents the next test results. When value added per employee, denoted *VA*, is used as a productivity measure, the results for all variables are similar to the main results in Table 3.4 in both export decisions. The difference is the estimated size. The productivity variable *VA* shows a much greater size than *TFP*—more than double in export participation and more than triple in export intensity. The interaction variable, *VA* × *IMP*, on the other hand, shows a marked decrease in the estimated size, especially in the export intensity, compared to the main results.

From the results in Tables 3.4 to 3.6, we can see that the choice of TFP measures can have a significant impact on the estimation. The Levinsohn–Petrin methodology of calculating TFP is preferred over the other two for two reasons. The Olley–Pakes methodology uses total firm investment as a proxy variable, which is reported as zero in some firms, making the TFP incalculable without an ad-hoc data treatment. Moreover, the results obtained from using the Olley–Pakes TFP are quite different from the other two. On the other hand, the data for both the Levinsohn–Petrin TFP and value added per employee are almost complete. However, value added per employee is analogous to labour productivity, measuring just one of the factors of production. Comparing the results in Tables 3.4 and 3.6, we can see that not including the productivity of other production factors can greatly bias the estimation of the impact on exporting from productivity and its interaction.

### 3.5.5 Alternative lagged timing

The timing of impact response from productivity and importing is not uniform across firms. Production lead time, product lifecycle, and seasonal trends can alter the time to realise the gain from productivity and importing. Even though trading activities are generally persistent due to the need to recover the initial entry costs, I expect the estimates of the main variables—importing, productivity, and their interaction—to show a decreasing pattern over time. The decaying positive effects of past importing and productivity are due to the competition from other firms that catch up, which gives the learning a lower return with every passing year.

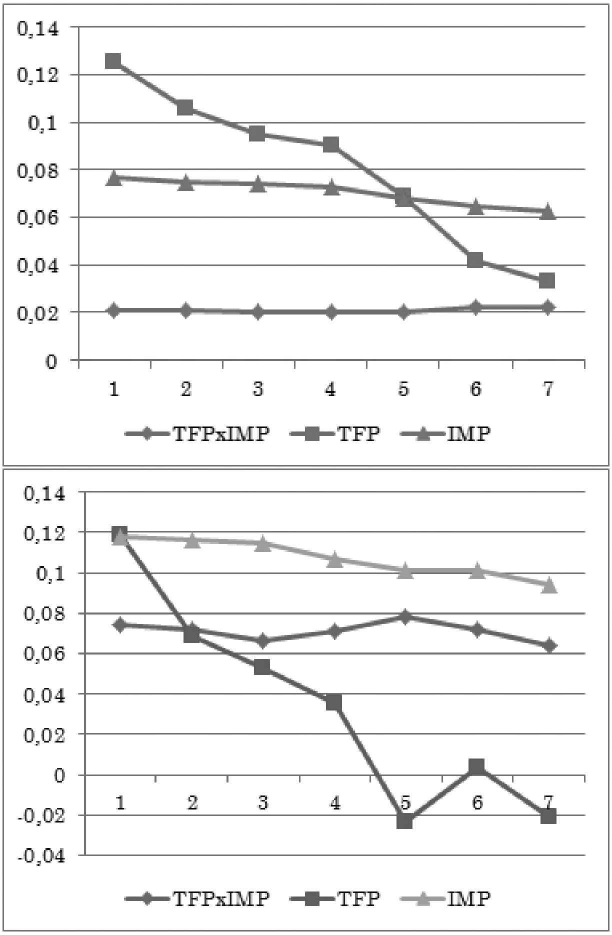
The estimated coefficients from seven consecutive lags (one to seven years) of the main variables are plotted below.[10] From Figure 3.2, we can observe a relatively stable pattern in the size of the interaction term in both export participation and intensity equations over time, within the range of 0.2 for the participation and 0.6–0.8 for the intensity. This suggests that the enhancing effect of importing and productivity on exporting has a stable effect on firms' export behaviour over time.

The decreasing pattern is observed for both TFP and import variables and for both export decisions. Note that the decrease in estimates of the import variable is minimal initially—i.e. from lags 1 to 3—probably due to its persistency, but such decrease is slightly more pronounced in later years. Furthermore, we can see a clearly decreasing pattern for the TFP variable over time. Comparing between the two variables, the change is much greater in the TFP variable while it is a relatively smaller change for the import variable. The possible explanation is that the benefit from learning does not diminish quickly over time. This is because institutions do not change rapidly so the knowledge of the market from some years ago can still be relevant for today. Whereas production technologies and machinery

[10] The reason for excluding lags 8 and 9 is that the number of observations drops sharply because not many firms survive for such a long period. This results in a big jump in the estimates, which is expected because the sample would only consist of the highly productive and successful firms that survive.

can change in a short term, using old machines can hamper the productivity greatly and hence the effect of TFP diminishes after a few years.

Figure 3.2: Estimated coefficient plots of the main variables from lag 1 to 7 years (Probit and OLS)




### 3.5.6 Alternative sample: Export starters

Export activities are persistent in the sense that firms usually continue their trading activities from the previous year in order to offset their initial entry

Table 3.7: Regressions with a restricted sample of export-starting firms

| | (14) | (15) | (16) |
|---|---|---|---|
| | Export propensity | Export intensity | |
| Variable | Probit | OLS | FE |
| *TFP × IMP* | 0.003*** | 0.132*** | −0.023 |
| | (0.000) | (0.020) | (0.020) |
| *TFP* | 0.012*** | 0.211*** | −0.041 |
| | (0.001) | (0.077) | (0.076) |
| *IMP* | 0.002*** | 0.094*** | 0.106*** |
| | (0.000) | (0.026) | (0.021) |
| Observations | 180,761 | 7,661 | 7,661 |
| $R^2$ | 0.392 | 0.305 | 0.028 |
| Firm–Country dyads | | | 2,860 |

**Note:** All regressions include unreported country- and firm-specific variables; year, industry, country dummies; and constants. *TFP*, *IMP* and the interaction term are in natural log and lagged one year. Standard errors clustered by country are displayed in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The probit $R^2$ in column 14 is the pseudo $R^2$.

costs with current profits. Excluding export incumbents from the analysis will isolate the effect of importing from this persistence of exporting. To achieve this, the sample is restricted to only contain firms that start to export. This is done by excluding firms with (i) no exporting throughout the study, (ii) any exports in the starting year of the data (1997), and (iii) no continuous exporting for another three years after the exporting starts. Because there is no way to indicate whether a firm was an exporter before 1997, the results will likely be biased downward due to an inclusion of export incumbents that do not export in 1997. The number of firms in this restricted sample is 2,023.

Table 3.7 reports the results. The $TFP \times IMP$ interaction variable is positive and significant for both the probit and OLS results, and with higher coefficient estimates than the main regression in Table 3.4, but it is insignificant for the FE result. This suggests that, for export starters, the enhancing effect matters more in both export decisions, especially for the participation. Compared to the regression with the full sample, the productivity variable shows a greater estimate size in both regressions, whereas the import variable shows slightly lower estimates in both export decisions.

## 3.6 Conclusions

There are two known facts: (i) exporters are a highly productive minority among all firms and (ii) the co-occurrence of importing and exporting is a regularity among traders, due to the complementarity of sunk entry costs between the two activities. Past productivity and importing are then expected to help determine firms' current exporting. For an external shock that raises an equal increase in productivity for all firms, it is hypothesised that firms with importing experience will be more likely to export, compared to firms with no such experience.

In this study, the central finding from the analysis of Swedish manufacturing firms is that there are significant interaction effects that enhance firms' exporting. Moreover, the positive effect of past importing and productivity is observed to be robust in explaining current exporting. Calculating the economic significance of productivity shows that the effect is not uniform; it depends on the intensity of past importing and suggests that higher importing implies learning and leads firms to export more.

I perform several robustness checks: alternative TFP measures, alternative time lags, and a restricted sample of export starters. The interaction effect is robust for alternative TFP measures and restricted samples. Tracing the interaction effect through time reveals a stable pattern for both export decisions. In a restricted sample of export starters, the interaction effect matters more for both export decisions, compared to the results using the full sample.

The implication of these findings is that a change in policy that results in an industry-wide shift of productivity will likely be more beneficial for firms with import experience. It allows firms to be more likely to start exporting and continue with the exporting in later periods. Also, importing directly helps firms to export more, but the effect decays over time. From the empirical evidence, this study supports a free-trade policy: Loosening import restrictions can help domestic firms to have more experiences that are necessary for exporting in later years.

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## 3.7 Appendix

Table 3.8: Descriptive statistics

| | Obs. | Mean | S.D. | Min. | Max. |
|---|---|---|---|---|---|
| *DEXP* | 7,186,536 | 0.053 | | 0 | 1 |
| *EXP* | 7,186,536 | 12.791 | 3.018 | 0.000 | 23.642 |
| *TFP* | 7,186,536 | 6.358 | 0.755 | −0.693 | 11.360 |
| $TFP_{OP}$ | 7,186,536 | 3.983 | 0.568 | −2.945 | 10.977 |
| *VA* | 7,186,536 | 9.247 | 1.935 | 0.000 | 17.267 |
| *IMP* | 7,186,536 | 14.665 | 3.302 | 0.000 | 24.055 |
| *GDP* | 7,186,536 | 9.410 | 2.395 | 3.873 | 16.396 |
| *Population* | 7,186,536 | 32.066 | 122.227 | 0.020 | 1,311.798 |
| *FirmSize* | 7,186,536 | 3.150 | 1.740 | 0.000 | 9.891 |
| *Uninational* | 7,186,536 | 0.222 | | 0 | 1 |
| *DomesticMNE* | 7,186,536 | 0.199 | | 0 | 1 |
| *ForeignMNE* | 7,186,536 | 0.161 | | 0 | 1 |

Table 3.9: Correlation table

| | *DEXP* | *TFP* | $TFP_{OP}$ | *VA* | *IMP* | *GDP* | *POP* | *FS* | *UNN* | *DMNE* |
|---|---|---|---|---|---|---|---|---|---|---|
| *TFP* | 0.172*** | | | | | | | | | |
| $TFP_{OP}$ | 0.034*** | 0.607*** | | | | | | | | |
| *VA* | 0.220*** | 0.785*** | 0.326*** | | | | | | | |
| *IMP* | 0.191*** | 0.483*** | 0.055*** | 0.642*** | | | | | | |
| *GDP* | 0.328*** | 0.008*** | 0.005*** | 0.001** | 0.004*** | | | | | |
| *POP* | 0.155*** | 0.002*** | 0.002*** | 0 | 0.001** | 0.750*** | | | | |
| *FS* | 0.212*** | 0.644*** | 0.180*** | 0.962*** | 0.621*** | −0.003*** | −0.001* | | | |
| *UNN* | −0.075*** | −0.081*** | 0.009*** | −0.096*** | −0.167*** | −0.001** | −0.001 | −0.087*** | | |
| *DMNE* | 0.101*** | 0.250*** | 0.085*** | 0.340*** | 0.240*** | −0.002*** | 0.000 | 0.345*** | −0.311*** | |
| *FMNE* | 0.100*** | 0.258*** | 0.024*** | 0.335*** | 0.352*** | 0.006*** | 0.003*** | 0.318*** | −0.279*** | −0.314*** |

*POP—Population*, *FS—FirmSize*, *UNN—Uninational*, *DMNE—DomesticMNE*, *FMNE—ForeignMNE*. The variables are in logarithmic form or as dummies. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 3.10: List of countries

| ISO | Country name | ISO | Country name |
|---|---|---|---|
| ABW | Aruba | DNK | Denmark |
| AFG | Afghanistan | DOM | Dominican Republic |
| AGO | Angola | DZA | Algeria |
| ALB | Albania | ECU | Ecuador |
| ANT | Netherlands Antilles | EGY | Egypt, Arab Rep. |
| ARE | United Arab Emirates | ERI | Eritrea |
| ARG | Argentina | ESP | Spain |
| ARM | Armenia | EST | Estonia |
| ATG | Antigua and Barbuda | ETH | Ethiopia |
| AUS | Australia | FIN | Finland |
| AUT | Austria | FJI | Fiji |
| AZE | Azerbaijan | FRA | France |
| BDI | Burundi | FRO | Faeroe Islands |
| BEL | Belgium | FSM | Micronesia, Fed. Sts. |
| BEN | Benin | GAB | Gabon |
| BFA | Burkina Faso | GBR | United Kingdom |
| BGD | Bangladesh | GEO | Georgia |
| BGR | Bulgaria | GHA | Ghana |
| BHR | Bahrain | GIN | Guinea |
| BHS | Bahamas, The | GMB | Gambia, The |
| BIH | Bosnia and Herzegovina | GNB | Guinea-Bissau |
| BLR | Belarus | GNQ | Equatorial Guinea |
| BLZ | Belize | GRC | Greece |
| BMU | Bermuda | GRD | Grenada |
| BOL | Bolivia | GRL | Greenland |
| BRA | Brazil | GTM | Guatemala |
| BRB | Barbados | GUY | Guyana |
| BRN | Brunei Darussalam | HKG | Hong Kong SAR, China |
| BTN | Bhutan | HND | Honduras |
| BWA | Botswana | HRV | Croatia |
| CAF | Central African Republic | HTI | Haiti |
| CAN | Canada | HUN | Hungary |
| CHE | Switzerland | IDN | Indonesia |
| CHL | Chile | IND | India |
| CHN | China | IRL | Ireland |
| CIV | Côte d'Ivoire | IRN | Iran, Islamic Rep. |
| CMR | Cameroon | IRQ | Iraq |
| COG | Congo, Rep. | ISL | Iceland |
| COL | Colombia | ISR | Israel |
| COM | Comoros | ITA | Italy |
| CPV | Cape Verde | JAM | Jamaica |
| CRI | Costa Rica | JOR | Jordan |
| CUB | Cuba | JPN | Japan |
| CYM | Cayman Islands | KAZ | Kazakhstan |

Table 3.10: (continued)

| ISO | Country name | ISO | Country name |
|---|---|---|---|
| CYP | Cyprus | KEN | Kenya |
| CZE | Czech Republic | KGZ | Kyrgyz Republic |
| DEU | Germany | KHM | Cambodia |
| DJI | Djibouti | KIR | Kiribati |
| DMA | Dominica | KNA | St. Kitts and Nevis |
| KOR | Korea, Rep. | PRY | Paraguay |
| KWT | Kuwait | PYF | French Polynesia |
| LAO | Lao PDR | QAT | Qatar |
| LBN | Lebanon | ROM | Romania |
| LBR | Liberia | RUS | Russian Federation |
| LBY | Libya | RWA | Rwanda |
| LCA | St. Lucia | SAU | Saudi Arabia |
| LKA | Sri Lanka | SDN | Sudan |
| LSO | Lesotho | SEN | Senegal |
| LTU | Lithuania | SGP | Singapore |
| LUX | Luxembourg | SLB | Solomon Islands |
| LVA | Latvia | SLE | Sierra Leone |
| MAC | Macao SAR, China | SLV | El Salvador |
| MAR | Morocco | SMR | San Marino |
| MDA | Moldova | SOM | Somalia |
| MDG | Madagascar | STP | São Tomé and Principe |
| MDV | Maldives | SUR | Suriname |
| MEX | Mexico | SVK | Slovak Republic |
| MHL | Marshall Islands | SVN | Slovenia |
| MKD | Macedonia, FYR | SWZ | Swaziland |
| MLI | Mali | SYC | Seychelles |
| MLT | Malta | SYR | Syrian Arab Republic |
| MMR | Myanmar | TCD | Chad |
| MNG | Mongolia | TGO | Togo |
| MNP | Northern Mariana Islands | THA | Thailand |
| MOZ | Mozambique | TJK | Tajikistan |
| MRT | Mauritania | TKM | Turkmenistan |
| MUS | Mauritius | TON | Tonga |
| MWI | Malawi | TTO | Trinidad and Tobago |
| MYS | Malaysia | TUN | Tunisia |
| NAM | Namibia | TUR | Turkey |
| NCL | New Caledonia | TWN | Taiwan |
| NER | Niger | TZA | Tanzania |
| NGA | Nigeria | UGA | Uganda |
| NIC | Nicaragua | UKR | Ukraine |
| NLD | Netherlands, The | URY | Uruguay |
| NOR | Norway | USA | United States, The |
| NPL | Nepal | UZB | Uzbekistan |
| NZL | New Zealand | VCT | St. Vincent and the Grenadines |
| OMN | Oman | VEN | Venezuela, RB |

Table 3.10: (continued)

| ISO | Country name | ISO | Country name |
|---|---|---|---|
| PAK | Pakistan | VNM | Vietnam |
| PAN | Panama | VUT | Vanuatu |
| PER | Peru | WSM | Samoa |
| PHL | Philippines | YEM | Yemen, Rep. |
| PLW | Palau | YUG | Yugoslavia |
| PNG | Papua New Guinea | ZAF | South Africa |
| POL | Poland | ZAR | Congo, Dem. Rep. |
| PRK | Korea, Dem. Rep. | ZMB | Zambia |
| PRT | Portugal | ZWE | Zimbabwe |

### 3.7.1 Estimation of the interaction effects

The pioneering work of Rajan and Zingales (1998) on financial dependence of growth is perhaps one of the first applied empirical studies in economics to focus mainly on an interaction term to explain a macroeconomic phenomenon. Their variable of interest is the interaction between industry dependence on external finance and a country's financial development.

For demonstration and convenience, we can suppose $X_1$ to be the import variable in this chapter, while $X_2$ is the productivity and $Y$ is firms' total exports. We can rewrite the model in equation (3.2), disregarding other independent variables, simply as

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_1 X_2 + \varepsilon, \tag{3.3}$$

where $X_1 X_2$ is the interaction term of interest. One of the first problems is that $X_1 X_2$ will likely correlate with $X_1$ and $X_2$ by construction. Another problem will be the interpretation. A change in $\beta_3$ cannot separately be interpreted while holding other variables constant since a change in the interaction term implies a change inherent from either $X_1$ or $X_2$ or both. This means that a marginal effect of productivity $X_2$, for example, will be

$$\frac{\partial Y}{\partial X_2} = \beta_2 + \beta_3 X_1, \tag{3.4}$$

which means that the import variable, $X_1$, is also a component in explaining the effect of productivity on exporting.

In order to estimate, the best practice is to de-mean the main variables before interacting:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 (X_1 - \bar{X}_1)(X_2 - \bar{X}_2) + \varepsilon. \tag{3.5}$$

In this analysis, the centred mean will be calculated from all manufacturing firms. The resulting model fit will be exactly the same and the estimated coefficients $\beta_1$ and $\beta_2$ will be close to the model with no interaction term.

### 3.7.2 Total factor productivity calculation

One important variable for this paper is firms' productivity. Empirically, it is estimated from the production function of the firm. This is assumed to be a Cobb–Douglas function,

$$y_t = \beta_0 + \beta_1 b_t + \beta_2 w_t + \beta_3 k_t + \beta_4 m_t + \beta_5 \omega_t + \eta_t, \tag{3.6}$$

where the lowercase letter denotes the logarithmic values, $y_t$ is the output measured by value added, $b_t$ and $w_t$ are blue- (unskilled) and white- (skilled) collar workers, $k_t$ denotes the capital, $m_t$ is intermediate inputs, and error terms are denoted by $\omega_t$ and $\eta_t$.

There are two problems in estimating the above equation. First, the productivity shocks, $\omega_t$ which is a state variable, are not observed and can impact inputs. For example, firms with high productivity may choose to use more inputs based on their productivity level and vice versa. This leads to the simultaneity problem, in which a serial correlation in $\omega_t$ will be correlated with inputs at time $t$. Second, the endogenous exit decisions can create a self-selection problem. As pointed out by Olley and Pakes (1996), a profit function is increasing in $k_t$ and allows firms to operate with the lower realised productivity threshold. Thus $\underline{\omega}_t(k_t)$ is a decreasing function in $k_t$. Employing the OLS estimator for equation (3.6) will lead to downward biases in the estimated parameters.

The estimation methodology by Levinsohn and Petrin (2003) extends the work by Olley and Pakes (1996) and uses an intermediate input as a proxy variable. The two-stage estimation is explained in detail for implementation in Stata software in Petrin et al. (2004). In this paper, I calculate each firm's input use by subtracting total sales from its value added.[11]

To allow for heterogeneity between industries, I estimate the TFP separately according to each industry by the 2-digit NACE code. However, all variables used in the estimation of the production function (and TFP consequently) are deflated using a single producer price index from Statistics Sweden instead of a PPI by industry due to unavailability. So, there could be some measurement error bias resulting from a punishment on low-valued industries of using the same index to deflate them as for high-valued industries.

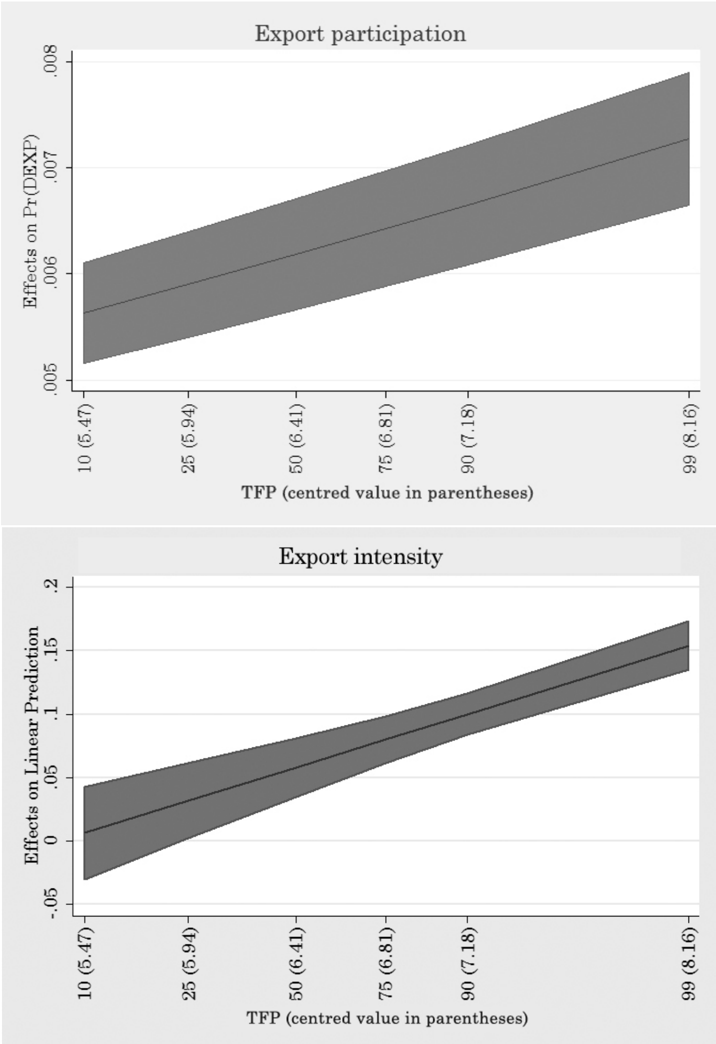
[11] Alternatively, one could subtract total sales from gross profit plus wage, I construct intermediate input with this approach as well but the two results do not differ significantly.

Table 3.11: Full-information maximum likelihood Heckman results

| Variable | (18)<br>Export participation<br>*DEXP* | (19)<br>Export intensity<br>*EXP* |
|---|---|---|
| $TFP \times IMP$ | 0.020*** | 0.079*** |
| | (0.003) | (0.007) |
| $TFP$ | 0.088*** | 0.167*** |
| | (0.004) | (0.020) |
| $IMP$ | 0.079*** | 0.154*** |
| | (0.003) | (0.010) |
| $GDP$ | 0.226*** | 0.509*** |
| | (0.029) | (0.115) |
| *Population* | 0.031 | 0.818* |
| | (0.234) | (0.476) |
| *FirmSize* | 0.247*** | 0.568*** |
| | (0.005) | (0.027) |
| *Uninational* | −0.062*** | −0.076*** |
| | (0.013) | (0.024) |
| *DomesticMNE* | 0.267*** | 0.366*** |
| | (0.013) | (0.033) |
| *ForeignMNE* | 0.235*** | 0.399*** |
| | (0.010) | (0.030) |
| *HumanCapital* | 0.671*** | |
| | (0.049) | |
| Fisher's $\rho$ | 0.264*** | |
| | (0.034) | |
| $\ln \sigma$ | 0.944*** | |
| | (0.020) | |
| Observations | 3,842,783 | 311,419 |
| Log-likelihood | −1,304,262 | |

**Note:** The number in the table is the raw coefficient. All regressions include unreported year, industry, and country dummies and constants. *TFP*, *IMP* and the interaction term are in natural log and lagged one year. *GDP*, *Population* and *FirmSize* are in natural log. *HumanCapital* is lagged one year. Standard errors clustered by country are displayed in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Figure 3.3: The marginal effects of past importing on current exporting



# Chapter 4

# The Interdependence of Innovation, Productivity, and Exports

## 4.1 Introduction

Recent work in international trade considers exporting as a self-selection process in which highly productive firms choose to pay upfront fixed costs to enter foreign markets (Bernard and Jensen, 1999; Bernard and Wagner, 1997; Delgado et al., 2002; Melitz, 2003). However, when it comes to explaining the source of firms' productivity heterogeneity, early theoretical models of exporting often treat it as exogenous. Studies that focus on endogenising productivity at the firm level are still rare.

Where does a firm's productivity come from? Several explanations attribute a gain in productivity to the firm's innovation-related activities, the argument being that a firm decides to invest in R&D and related activities to improve their operations. The result of a successful investment in these activities is likely to increase productivity and firm performance. Ederington and McCalman's (2008) theoretical dynamic model introduces the difference in adoption rates of new technologies (or innovation) as the primary source of productivity heterogeneity through a "rather lengthy diffusion process." To explain productivity growth, the endogenous growth model (Aghion and Howitt, 1992; Romer, 1990) and the knowledge production framework (Griliches, 2000) attribute productivity gain to the firm's capital accumulation and technological change (or innovation). Empirically, innovation microstudies find that R&D investments and innovation activities that lead to innovation output are the main source of firms' productivity heterogeneity (Hall and Mairesse, 2006).

An association between innovative firms and their export behaviour can be clearly seen from a simple breakdown of manufacturing firms included in this study. Approximately 90% of innovative firms are exporters, compared to about 72% for noninnovative firms. In this chapter, I take a closer look at this relationship and investigate the role that innovation plays in driving firms' exporting through productivity enhancement.

A complicating factor is that exports can also raise incentives for firms to innovate or invest in productivity-enhancing activities. Lileeva and Trefler (2010) argue that there is a complementarity in both exporting and investing, especially for low levels of initial productivity, where it is more profitable to both export and invest in productivity-enhancing activities than to do so separately. The interdependence of innovation, productivity, and exporting as a joint decision has been recently studied and modelled by Aw et al. (2008, 2011) among others. However, most studies test the relationship of innovation and firms' performance using R&D investments as a proxy for innovation output. Although related, R&D investment is still considered an input to innovation, so it is important to distinguish innovation into input from R&D and output as a successful result of such input. This study attempts to remedy this.

Furthermore, the evidence of an effect of exporting on innovation and productivity is still mixed. Liu and Buck (2007) find supporting evidence of international spillovers on firm performance in Chinese high-tech industries. Salomon and Shaver (2005) also find evidence of a positive effect of exporting on innovation in Spanish manufacturing firms. On the other hand, Aw et al. (2011) find that firms' exporting has virtually no effect on the probability to invest in R&D among Taiwanese firms. For the effect of past exporting on productivity, the surveys by Wagner (2007, 2012) give a comprehensive picture and offer some explanations for the differing results of various microlevel studies across countries. The idea is that exporting firms gain knowledge from having a presence at the destination markets and later this international network results in a spillover on firms' innovation and helps improve their performance.

The aim of this study is to examine the relationship between firms' investment in R&D, innovation output, productivity, and export performance. The hypothesis is that innovation output leads to a gain in productivity, which positively affects the firm's export performance in turn. Also, exports offer firms incentives to innovate and increase their productivity.

The empirical evidence in this study comes from a modified version of the structural model by Crépon et al. (1998) and Lööf and Heshmati (2006).

Table 4.1: Breakdown of firms by year

| | | Innovative firms | | Noninnovative firms | | Total |
|---|---|---|---|---|---|---|
| Year | | Firms | %* | Firms | %* | Firms |
| 2004 | Exporters | 426 | 91.03 | 413 | 71.95 | 839 |
| | Nonexporters | 42 | 8.97 | 161 | 28.05 | 203 |
| 2006 | Exporters | 401 | 89.91 | 434 | 72.82 | 835 |
| | Nonexporters | 45 | 10.09 | 162 | 27.18 | 207 |

**Note:** * Percentage of the total number of innovative and noninnovative firms in that year. This only includes firms that appear in the two waves of CIS surveys (2002–2004 and 2004–2006) within the manufacturing sector, NACE codes 15–36. The total number of firms is 1,042 after the data-cleansing procedure (details are explained in the Data section). Firms are categorised as innovative when they invest in innovation activities (input) and have a positive fraction of innovative products as part of their total sales (output).

The advantage of this structural framework is that it provides an intermediate step between innovation input and productivity and disentangles the effect of innovation into the input and output separately. Therefore, I can quantitatively measure the outcome of innovation investments in order to assess its impact on productivity, instead of proxying it with R&D investments, which is merely a measure of innovation input.

For the analysis, I employ two waves of Sweden's Community Innovation Survey (CIS) and complement them with firm-level export and registry data. By endogenising firms' productivity in an empirical setting, we can expand our understanding of the process that underlies how a firm enters export markets. Moreover, the findings can contribute to the discussion of innovation policy and its role in promoting firms' exports.

The chapter is organised as follows. Section 4.2 provides a discussion of relevant conceptual frameworks. In section 4.3, I discuss the empirical strategy and econometric issues. This is followed by the data and descriptive statistics. The results and discussion are in section 4.5, and the last section concludes.

## 4.2 Conceptual framework

### 4.2.1 Productivity–export

Not all firms are able to export. Eaton et al. (2004) find that among French manufacturing firms, exporters are a minority that tends to be more productive and larger than nonexporters. The main export barriers are the entry costs, be they variable, with a standard distance-varying iceberg assumption (Bernard et al., 2003), or fixed (Melitz, 2003; Roberts and Tybout, 1997).

The variable costs are assumed to consist mainly of the transportation and tariffs, which vary with the amount of export shipment and the distance to the destination. The fixed costs are the initial costs each firm invests to obtain a permit, establish the distribution network, and various other transaction costs. During the latter half of the twentieth century, the variable costs have seen a decline due to advances in technology and trade liberalisation. This implies the growing importance of informal trade barriers which constitute the upfront fixed costs.

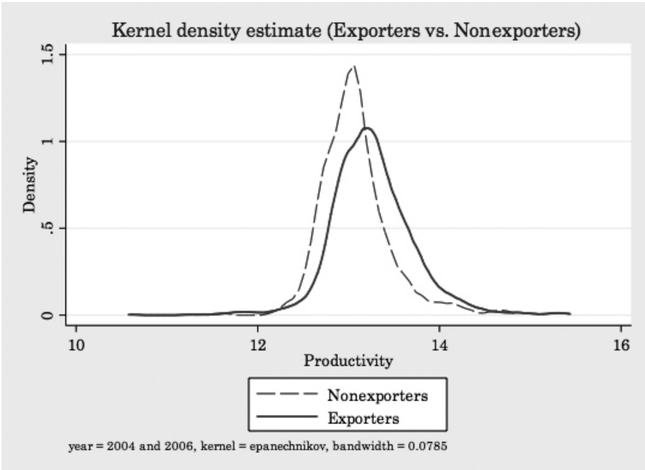
Ample empirical evidence connects exporters with higher productivity compared to nonexporters. Wagner's (2007) survey concludes that, among 54 studies covering 34 countries, "exporters are found to be more productive than nonexporters, and the more productive firms self-select into export markets, while exporting does not necessarily improve productivity."

To illustrate the same phenomenon with this study's data, Figure 4.1 exhibits the distribution of productivity among Swedish exporters and nonexporters in 2004 and 2006. The thick solid line represents the productivity of exporters. At the upper end of productivity distribution (or at the right on the horizontal axis), the thick line is above the dashed line which means that there is a greater concentration of productivity among exporters compared to nonexporters. This is because only those firms at the upper end of the productivity distribution can afford to enter the foreign markets. According to early heterogeneous-firm trade models, the initial productivity of each firm and the productivity distribution are exogenously determined (Melitz, 2003) or depend only on the variation of the firms' efficiency (Bernard et al., 2003). The theories developed thereafter have largely neglected the source of productivity difference, which thus remained a "black box" until recently.

There are attempts in the trade literature to formally model firms' exports by assuming endogenous productivity.[1] Ederington and McCalman (2008) develop a dynamic model with endogenous firm-level productivity

[1] Another line of research on endogenous firm productivity considers within-firm reallocation as a source of productivity growth, the argument being that there is substantial heterogeneity across products serving between domestic and export markets within multiproduct firms. Various frameworks attempt to account for the distribution of exports across products and countries within these firms. I do not discuss this literature in detail since the focus of this study is on R&D and innovation. For a review on some models along this line, see Redding (2011).

Figure 4.1: Kernel distribution of productivity between exporters vs. nonexporters, 2004 and 2006




using adoption of new technology to explain heterogeneity in firms' productivity. In this model, the difference across firms is the timing of adoption due to the high cost, albeit marginally decreasing, of early technology adoption.

Segerstrom and Stepanok (2011) propose a quality-ladders endogenous-growth model without Melitz-type assumptions that firms invest in R&D to introduce new varieties of products. Instead, they distinguish two types of R&D technologies: inventing higher quality existing products and learning how to export. The latter involves an investment in terms of a stochastic fixed market entry cost. Compared to Melitz (2003), the productivity threshold does not exist in this setting and there is an overlap between exporters' and nonexporters' productivity distribution. The difference between this quality-ladders model and the model by Ederington and McCalman (2008) is that each product requires different levels of R&D. It is, therefore, more difficult to invest in R&D and learn how to export highly advanced and complex products. Restated, it is the difference in product quality versus the difference in timing of technology adoption.

Other recent theoretical papers have also introduced R&D and innovation to provide a structural link with firms' decision to export. In this strand of literature, firms make a joint decision to export and investment in R&D, in which this investment raises firms' productivity and affects positively on exporting while participation in the export market also raises the return to R&D investments. The evolution of firms' productivity is characterised as a stochastic process. Starting from the exogenous productivity in Olley and Pakes (1996), there are extensions to allow the evolution of productivity endogenously with R&D (Doraszelski and Jaumandreu, 2013), product and process innovations (Peters et al., 2013), and exporting (Aw et al., 2011; Maican et al., 2013). Using this framework, Aw et al. (2007, 2008, 2011) confirm the significant role of R&D investments in the evolution of productivity dynamics and exports among Taiwanese firms.

### 4.2.2 Innovation–productivity

Research activities have long been associated with the improvement of firms' performance. The typical explanation of the mechanism is that R&D in general leads to a creation of a new set of instructions (knowledge) in order to develop new products and services or improve the efficiency of work operations within the firm. This development and improved efficiency then result in a gain in productivity.

Although the study of the innovation effect on productivity is mostly empirical (Cohen, 1995; Griliches, 2000; Hall and Mairesse, 2006), it is the endogenous-growth theory that explicitly provides a theoretical foundation linking economic output and innovation (Aghion et al., 1998; Howitt, 2000; Romer, 1990). Romer (1990) provides at least two distinct reasons explaining why innovation leads to higher productivity: (i) Technological change, or product innovation, provides the incentive for continued capital and knowledge accumulation, which in turn leads to an increase in productivity, and (ii) the new set of instructions for workers, or process innovation, requires some fixed costs but later on such instructions can be used over and over again, which eventually leads to an economy of scale, lower cost of production, and again an increase in productivity.

On a firm level, Klette and Kortum (2004) develop further the parsimonious model of innovation to link firms' heterogeneity, R&D, and productivity based on several stylised facts from empirical studies on the subject. The model describes the innovation process of an individual firm, the heterogeneity of research intensity, firm entry, and size distribution, and solves for aggregate innovation in general equilibrium. In this model, the heterogeneity of productivity is derived from a variation in the size of innovation steps. The implication of the model then predicts that R&D intensity is positively correlated with persistent differences in productivity across firms. Accordingly, the empirical evidence is growing, using a knowledge-production-function framework in microlevel studies of innovation, showing that innovation indeed leads to higher productivity within firms in various countries (Hall and Mairesse, 2006).

Furthermore, the knowledge-production-function framework argues that innovation itself should be treated as a process with input and output parts (Hall and Mairesse, 2006). The empirical evidence suggests that innovation input increases innovation output and eventually it is innovation output (not input) that increases productivity (Crépon et al., 1998). So I also base my analysis in this study on the distinction between innovation input and output, which is considered vital for empirical innovation studies.

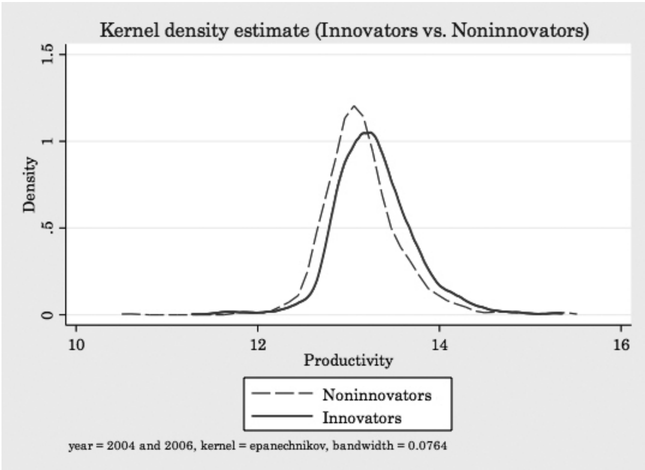
Innovation input has traditionally been measured as R&D investment (Griliches, 1998), but more recent innovation surveys have added more categories, such as investment in training of employees (OECD & Statistical Office of the European Communities, Luxembourg, 2005). Such addition of more categories to innovation input is important, since, for instance, it is shown that R&D investment is only about one quarter of the total innovation input (expenditure) in Dutch firms (Brouwer and Kleinknecht, 1997).

Innovation output has traditionally been measured in terms of patents or even productivity (Klette and Kortum, 2004), while recent innovation surveys, following Schumpeter (1961), have provided more direct measures of innovation output, grouped in several types: product, process, marketing, and organisational innovation (OECD & Statistical Office of the European Communities, Luxembourg, 2005). In particular for the product innovation, an attractive measure has been available—i.e., the amount of firms' sales due to innovative products—which is argued to have fewer weaknesses compared to classic measures (Kleinknecht et al., 2002).

Using this quantitative measure of innovation output—i.e., sales due to innovative products—we can also see in Figure 4.2 that among all firms, innovative firms are those that appear more concentrated at the upper end of the productivity distribution.

From the discussion above, innovation seems to be associated with high productivity, which in turns is related to high export performance. To test the hypothesis, the next section presents an outline of the empirical strategy.

Figure 4.2: Kernel distribution of productivity between innovative vs. noninnovative firms, 2004 and 2006




# 4.3 Empirical strategy

## 4.3.1 Models of innovation and productivity

Most studies test the relationship of innovation and firms' performance using R&D investments as a proxy for innovation. Although related, R&D investments are merely a part of innovation input. This input is the total innovation investment which, according to the Oslo manual, consists of six innovation investment categories: intramural R&D, extramural R&D, machinery acquisition, other external knowledge gathering, training, and market introduction of innovation (OECD & Statistical Office of the European Communities, Luxembourg, 2005). To assess the impact of innovation on firms' performance, the focus must be placed on the outcome of the knowledge production, which is the output of these innovation activities. Therefore, it is crucial to distinguish innovation into input, consisting of R&D and other related investments, and output, as a successful result of such input. The innovation output can be measured accordingly as the fraction of total turnover due to innovative products.[2]

[2]Innovation output is further divided into new to the firm and new to the market. In this study, the focus is on the former and not necessarily the latter.

The empirical setting that allows for the distinction above can be traced back to Pakes and Griliches (1984), who introduce a knowledge-production function that can be formulated in a three-equation structure:[3]

$$k = \beta_{0,1} + \sum_m \beta_{m,1} x_{m,1} + \varepsilon_1 \tag{4.1}$$

$$i = \beta_{0,2} + \beta_k k + \sum_l \beta_{l,2} x_{l,2} + \varepsilon_2 \tag{4.2}$$

$$p = \beta_{0,3} + \beta_i i + \sum_j \beta_{j,3} x_{j,3} + \varepsilon_3, \tag{4.3}$$

where $k$ denotes knowledge increment (or innovation input intensity as measured by logged total innovation investment per employee), $i$ denotes number of patents as an indication of innovation output (or, alternatively, logged innovative sales per employee), $p$ denotes productivity (logged total factor productivity—TFP), $\beta_i$ are parameters to estimate, $x$'s are vectors of independent variables associated with each equation and $\varepsilon_i$ are the disturbance terms, assumed to be independent in all three equations.

The above setup disentangles the relationship between innovation input and productivity by providing an intermediate step, that is the innovation output. However, this set of equations suffer from an important econometric issue. Because the firms that enter the estimation are not randomly drawn from the whole population, the selectivity issue can arise and result in biased estimates. Moreover, because the innovation input is endogeneous in the innovation equation and the innovation output is endogeneous in the productivity equation, this can also lead to a simultaneity bias.

The seminal work of (Crépon et al., 1998, CDM hereafter) highlights these selectivity and simultaneity issues and solves the selectivity bias by introducing a selection equation in addition to the three-equation approach above and assuming the disturbance terms to be correlated across all four equations. Using an asymptotic least squares estimator, they provide a consistent estimate that corrects for both the selectivity and simultaneity biases.

Lööf and Heshmati (2006) use a structural model that differs slightly from the CDM model. Instead of assuming all disturbances to be correlated,

[3] In its simplest form, the formulation in Pakes and Griliches (1984) can also be written as $\dot{k} = \Sigma r + u_1$, $p = \dot{k} + u_2$, and $a = \Sigma r + u_3$, where $\dot{k}$ is knowledge increment, $r$ is expenditure in different research activities, $p$ is patent as inventive output, and $u_i$ are uncorrelated error terms.

they separate the four equations into two parts—the selection equations (using the Heckman selection estimator) and the innovation-performance equations (using three-stage least squares; 3SLS).

The setup can be formulated as:

$$g^* = \beta_{0,1} + \sum_n \beta_{n,1} x_{n,1} + \varepsilon_1 \tag{4.4}$$

$$k^* = \beta_{0,2} + \sum_m \beta_{m,2} x_{m,2} + \varepsilon_2 \tag{4.5}$$

$$i = \beta_{0,3} + \beta_k k + \beta_{IMR} IMR + \sum_l \beta_{l,3} x_{l,3} + \varepsilon_3 \tag{4.6}$$

$$p = \beta_{0,4} + \beta_i i + \sum_j \beta_{j,4} x_{j,4} + \varepsilon_4, \tag{4.7}$$

where the selectivity part contains $g*$ denoting innovation input propensity (a latent variable with value 1 if total innovation investment is positive) and $k*$ denoting innovation input intensity (logged total innovation investment per employee) which corresponds to the observed innovation input propensity—i.e., $g = 1$—and the last two equations consist of the innovation output and productivity, denoted $i$ and $p$. In this case, the disturbances from equations (4.4) and (4.5) are correlated, as are equations (4.6) and (4.7). The two parts are linked by *IMR*—the inverted Mills' ratio from the selection equations in the previous step.

### 4.3.2 The structural model of innovation, productivity, and exports

As in Lööf and Heshmati's (2006) setup, this study relies on the two-part structural model with an added export equation:

$$g^* = \beta_{0,1} + \sum_n \beta_{n,1} x_{n,1} + \varepsilon_1 \tag{4.8}$$

$$k^* = \beta_{0,2} + \sum_m \beta_{m,2} x_{m,2} + \varepsilon_2 \tag{4.9}$$

$$i = \beta_{0,3} + \beta_k k + \beta_e e + \beta_{IMR} IMR + \sum_l \beta_{l,3} x_{l,3} + \varepsilon_3 \tag{4.10}$$

$$p = \beta_{0,4} + \beta_i i + \beta_e e + \sum_j \beta_{j,4} x_{j,4} + \varepsilon_4 \tag{4.11}$$

$$e = \beta_{0,5} + \beta_p p + \sum_h \beta_{h,5} x_{h,5} + \varepsilon_5, \tag{4.12}$$

where $e$ denotes export intensity (logged total exporting per employee). The first part, equations (4.8) and (4.9), is estimated with the full-information Heckman selection estimator. The second part, equations (4.10) to (4.12), is estimated with the 3SLS estimator.

Equation (4.8) examines the decision of the firm to invest in innovation input. The dependent variable is an indicator that takes a value of 1 if a firm invests and 0 otherwise. On the right-hand side, $x_n$ is a vector of the independent variables. These include firm-specific variables that indicate the firm's capacity and resources to invest in innovation: *FirmSize* (measured as the log number of employees),[4] *PhysicalCapital* (log total costs of building, machinery, and inventories), *HumanCapital* (the fraction of highly educated employees), and ownership-structure variables (categorical variables indicating a firm as being nonaffiliated, part of a uninational corporate group, domestic MNE, or foreign MNE). This categorical variable for ownership structure is registered data obtained from Statistics Sweden. I prefer using this categorical variable rather than the dichotomous variable in CIS data (indicating whether a firm belongs to a group or not). This type of substitution is arguably useful for improving the quality of an empirical analysis in CIS data (Mairesse and Mohnen, 2010). The nonaffiliated firms are the reference group.

Equation (4.9) considers the amount of innovation investment, measured as total investment per employee in six categories according to the Oslo manual. Similar to the previous equation, $x_m$ is a vector of explanatory variables, which contain the same set of variables as $x_n$ with an exclusion of *FirmSize* to make the estimation identified.

Equation (4.10) explains the innovation output of the firm, measured as total sales of innovative products per employee. This equation is sometimes called the "innovation production function." The predicted value of innovation input, $k$, from the previous equation is used as the main regressor. The *IMR* variable is the inverted Mills ratio, used to correct for selection bias (Heckman, 1979). Also it contains the same set of explanatory variables, denoted as $x_l$, as in equation (4.9) but with a two-year lag.

In equation (4.11), productivity $p$ is explained mainly by innovation output. Instead of using labour productivity as in previous studies, I use the inputs to estimate each firms' production function and obtain TFP,

[4] Unfortunately, the data does not allow me to construct the market-share variable, which is common in studies of this kind (e.g., Crépon et al., 1998).

which is captured in a residual. The methodology of estimating the TFP follows Levinsohn and Petrin (2003).[5] The explanatory variables in both equations (4.11) and (4.12), denoted $x_j$ and $x_h$, are the same as in equation (4.9) for innovation input intensity but with a two-year lag.[6]

Furthermore, the interdependence of exporting, innovation and productivity is also incorporated within this framework. Because an improved access to international market is found in many studies to also encourage firms to invest more in innovation in order to raise future productivity (see for example Baldwin and Gu, 2004; Lileeva and Trefler, 2010). For evidence on productivity, the metastudy on exporting's positive effect on firms' productivity, or the so-called learning-by-exporting hypothesis, Martins and Yang (2009) among 30 studies find that international access is an important factor for firms' performance, and even more so in developing countries.[7] Hence, in this study, export intensity, $e$, is included in both equations (4.10) and (4.11), in order to capture the effect of exporting on both innovation output and productivity.

Finally, the export equation examines the self-selection hypothesis predicting firms' productivity to drive firms' exports. In order to test for this, TFP is included as a regressor in equation (4.12). I also include a dummy indicating previous export experience[8] in order to account for any previous learning from an international market access because exporting is often observed to be a persistent behaviour over time.

In summary, the setup for these three equations allows for an investigation of both how innovation and productivity affect exporting and, at the same time, how exporting raises the incentive to innovate and how it affects firms' productivity.

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[5]The dependent variable can be either firms' value added or revenue. I choose firms' value added. The independent variables include total number of blue- and white-collar workers, total capital, and material costs are used as proxies. Aw et al. (2011) estimate TFP from R&D and exports, but this dataset does not allow this methodology due to insufficient R&D observations.

[6]The variable *FirmSize* is reintroduced again in both productivity and export equations because size is a good predictor of firms' performance and neither equation contains the *IMR* term, which may be collinear with size.

[7]In contrast, Wagner's (2007) related survey shows that the evidence of this learning-by-exporting is rather mixed. Productivity positively affects firms' exporting but exporting does not necessarily lead to increased productivity.

[8]With the availability of firm registry data before the beginning of the data, up to 1997, I can trace back whether the firm was an exporter or not.

### 4.3.3 Estimation steps

This section motivates and briefly summarises the choice of estimators used for the two steps involved in estimating equations (4.8)–(4.12).

**Step 1: Innovation input equations** In equation (4.9), the dependent variable is the innovation input, measured as total investment costs in innovation-related activities. A problem arises if firms report this as zero because the function is in the logarithmic form, rendering zeros undefined. There is evidence that these missing values are not random and there is a potential selection bias in the CIS data (Mairesse and Mohnen, 2010). To deal with the selectivity, many studies use the Heckman selection estimator, a generalised Tobit estimator (Heckman, 1979), implying a selection process, equation (4.8) that determines firms' investment in innovation.

The general practice for consistent results from a Heckman estimator is that there should be an exclusion variable that determines the selection but not the outcome.[9] For this study, I decide to use *FirmSize* because one stylised fact in innovation studies is that R&D intensity is independent of firm size (Klette and Kortum, 2004).

**Step 2: Innovation output, productivity, and export equations** In this step, I estimate all three equations for the innovation output, productivity and export performance jointly using the 3SLS.[10] As previously mentioned, this is similar to Lööf and Heshmati (2006) with the exception of an additional equation for exporting. They demonstrate a simultaneity issue because the innovation input is endogeneous in the output equation (4.10), and innovation output is endogeneous in the productivity equation (4.11). In order to consistently estimate both parts, it requires a set of instruments that is uncorrelated to the error term but correlated with the endogeneous variable. The predicted value of the innovation input intensity is used in the innovation output equation. Instead of having a full correlation of all error terms, there is a correlation of the error terms within each part and the two parts are linked by the inverted Mills' ratio in this two-step approach (Lööf

[9]There are two approaches for Heckman-selection estimation. Both equations can be jointly estimated with maximum likelihood or the estimation is performed in two steps with probit for the first step and OLS for the second. I prefer the maximum likelihood approach because the standard errors of the second step in the two-step approach are incorrect (Verbeek, 2008).

[10]An alternative estimator is the two-stage least squares (2SLS), but 3SLS has an efficiency advantage over 2SLS by taking into account the correlations of the error terms between equations (Greene, 2012).

and Heshmati, 2006). The inclusion of this inverted Mills' ratio is justified by the need to correct for the selectivity bias from the reduced nonrandom sample of only innovative firms.[11]

The regressors in all three equations are lagged two years to reduce the simultaneity problems. Lastly, in order to correct for the bias induced by an inclusion of the predicted regressor from the previous step, the standard errors are bootstrapped.

Because this structural framework involves more than one round of selection—that is, the selection into innovation and then selection into exporting—the number of observations is reduced from 1,042 to only 291. The data variation might also be partially lost. As an alternative, I also model equations (4.10)–(4.12) as the seemingly unrelated regression (SUR) model while taking away the innovation input equation, equations (4.8) and (4.9). I prefer the multistep structure because all five equations are estimated and better provide the structural links. I discuss more details of the SUR model after the main results.

## 4.4 Data

The main data for the analysis comes from the Swedish CIS. The CIS is a pan-European cross-sectional survey that consists of microlevel national data on various aspects of firms' innovation-related activities. This self-reported survey is conducted by the participating countries and the highly consistent questions and methodology among the countries are advantageous for cross-country comparisons. The survey is currently repeated every two years. For an overview of a growing group of empirical studies employing CIS-data see Hall and Mairesse (2006).

For this study, the dataset contains two waves:[12] The CIS4 survey covers 2002–2004, and the CIS2006 survey covers 2004–2006. The surveys are conducted by Statistics Sweden, with a response rate close to 70% in both the manufacturing and business-service sectors.

[11] Innovative firms are defined as the firms which have positive innovation input (total investment in innovation activities) and positive innovation output (innovative sales).

[12] Although it is ideal to include three waves to test the recursive relationships from productivity and exporting back to innovation input, my attempt to merge the three waves do not yield a dataset with enough observations. The variation in many of the variables is small enough that most of the estimates do not have significant results.

The advantage of combining the two waves of CIS surveys is the ability to capture a causal relationship between variables of interest and remove simultaneity bias. So, in this case, the past values of innovation input can be used to explain innovation output at the current period, instead of proxying it with the current values. The disadvantage is that the resulting dataset excludes firms that only participate in one of the two waves and thus reduces the observations for the analysis by roughly 40%.[13]

I complement the CIS data by including the annual firms' registry and export dataset by matching the encoded unique firm identification number. This is preferable to relying on the reported data from the survey, which can suffer from a "questionable quality" (Lööf and Heshmati, 2006).

I restrict my analysis to the manufacturing sector to focus on firms that export what they actually produce. This is because many exporting firms within the services sector are intermediate trading firms that distribute the products from other domestic firms. So the cost structure is very different from that of manufacturing firms. The final sample includes 1,042 firms in total (see the overall breakdown in Table 4.1 and by industry in Table 4.8). The descriptive statistics for all variables in this study are presented in Table 4.2 for the year 2004, which is the year used for most of the variables in the actual estimation. Table 4.9 in the appendix lists the correlation of all variables; the generally low correlation among variables seems to pose no multicollinearity problem for the analysis.

## 4.5 Results and discussion

First, I present the Heckman results from the first step, followed by several variants of the second step. I only show the result from the Heckman estimator because it does not differ greatly in terms of sign, significance, or size from the standard probit and OLS regressions. In contrast, the choice of estimator and the inclusion of variables pose a significant difference in the second step.

[13]The total number of firms that participate in CIS4 is 1,802 and 1,764 for CIS2006. The total number of firms in this study is 1,042. This means an exclusion rate of 42% for CIS4 and 41% for CIS2006. However, if we take into account a data cleansing procedure to exclude firms with missing observations for the main variables, the exclusion rate is lower. See the number of firms by industry for 2004 (CIS4) in Table 4.8 in the appendix.

Table 4.2: Descriptive statistics for the year 2004

| | Innovative Sample ($N = 446$) | | | | Noninnovative Sample ($N = 596$) | | | |
|---|---|---|---|---|---|---|---|---|
| Variable | Mean | Std. Dev. | Minimum | Maximum | Mean | Std. Dev. | Minimum | Maximum |
| Dependent variables | | | | | | | | |
| *InnovationInput* | 114.40 | 234.96 | 0.10 | 2,944.44 | — | — | — | — |
| *InnovationOutput* | 466.05 | 683.04 | 0.30 | 6,209.81 | — | — | — | — |
| *TFP* | 391.70 | 328.98 | 31.99 | 4,141.55 | 308.10 | 256.51 | 64.38 | 3,613.57 |
| *ExportIntensity* | 945.99 | 1,263.99 | 0.00 | 14,183.32 | 591.38 | 900.55 | 0.00 | 5,958.07 |
| *ExportExperience* | 0.88 | | 0 | 1 | 0.69 | | 0 | 1 |
| Independent variables | | | | | | | | |
| *FirmSize* | 312.75 | 1,328.03 | 5 | 18,141 | 98.05 | 282.40 | 1.00 | 4,831.00 |
| *PhysicalCapital* | 344.72 | 476.97 | 5.38 | 3,739.94 | 475.39 | 3,072.28 | 0.30 | 72,578.18 |
| *HumanCapital* | 0.12 | 0.13 | 0 | 0.75 | 0.06 | 0.11 | 0 | 0.73 |
| *Uninational* | 0.21 | | 0 | 1 | 0.30 | | 0 | 1 |
| *DomesticMNE* | 0.31 | | 0 | 1 | 0.18 | | 0 | 1 |
| *ForeignMNE* | 0.28 | | 0 | 1 | 0.19 | | 0 | 1 |

The unit for all financial variables is million SEK.

### 4.5.1 Step 1: Innovation input

Table 4.3 reports the joint estimation of the innovation-input equations—equations (4.8) and (4.9). Column (1) is the selection equation corresponding to equation (4.8). The dependent variable is innovation input propensity, measured as a dummy with value one if the total investments in innovation activities is positive. Column (2) is the outcome equation corresponding to equation (4.9). The dependent variable is innovation-input intensity, measured as log total investments in innovation activities per employee. All variables are observed at year 2004.

Table 4.3 shows that firm size is highly significant for determining firms' decision to invest in innovation activities. While holding other variables constant, doubling the firm size is associated with a 8.6% increase in the probability of investing in innovation. Also shown, physical capital and human capital have a positive and significant influence on both the decision and the intensity of innovation input. The results correspond to a 4.6% increase for a doubling of physical capital and a 64.1% increased chance for a doubling in the share of skilled workers. This is in line with previous studies using CIS data (Crépon et al., 1998; Lööf and Heshmati, 2006). Ownership structure variables are insignificant, suggesting that it makes no difference if firms belong to a uninational corporate group, a Swedish or a foreign multinational firm when it comes to the decision to invest in innovation.

In terms of the intensity of innovation investments, almost all of the firms' characteristics except a Swedish uninational corporate affiliation are positive and significant. The results show that doubling the physical capital or the share of highly educated workers corresponds to roughly a quarter and a quadruple increase in innovation input, respectively. Being affiliated with multinationals also increases the investments by more than 30%.

The likelihood ratio (LR) test of independence of the two equations reported at the bottom of the table indicates that the null hypothesis of independence between the error terms is rejected. This means that a selection bias is present and justifies the use of the Heckman selection estimator.

### 4.5.2 Step 2: Innovation output, productivity, and exporting

In this step, I present first the three equations, which are estimated separately using the OLS estimator. This approach takes into account neither the

Table 4.3: Step 1: Innovation input determinants. Estimator: Full-information maximum likelihood Heckman estimator.

| Variable | (1) *InnovationInput Propensity* | (2) *InnovationInput Intensity* |
|---|---|---|
| *FirmSize* | $0.086^{***}$ | |
| (log) | (0.016) | |
| *PhysicalCapital* | $0.043^{***}$ | $0.242^{***}$ |
| (log) | (0.012) | (0.054) |
| *HumanCapital* | $0.641^{***}$ | $4.376^{***}$ |
| | (0.163) | (0.529) |
| *Uninational* | −0.017 | 0.269 |
| | (0.042) | (0.194) |
| *DomesticMNE* | 0.073 | $0.370^{**}$ |
| | (0.049) | (0.169) |
| *ForeignMNE* | 0.008 | $0.339^{*}$ |
| | (0.052) | (0.175) |
| Fisher's $\rho$ | $0.353^{***}$ | |
| | (0.078) | |
| $\ln \sigma$ | $0.383^{***}$ | |
| | (0.041) | |
| Observations | 1,042 | 632 |
| $\chi^2$ | 246.4 | 246.4 |
| $\Pr > F$ | 0.000 | 0.000 |
| Log-likelihood | −1,732 | −1,732 |

**Note:** The reported numbers are the marginal effects which indicate the elasticities of each variable. Unreported industry dummies and constants are included. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; LR test of independency: $\chi^2(1) = 18.33$ with $p = 0.000$.

selectivity nor the simultaneity issue. Hence, the innovation output equation, column (3), includes neither the predicted value of innovation input nor the inverted Mills' ratio from the first step, and the error terms of all three equations are independent (Table 4.4).

Using this basic single-equation technique, I can thereafter compare the results with the structural model that corrects for both the selectivity and the simultaneity issues. This allows me to compare the change in results and potential misinterpretations from the single-equation estimations.

Regarding the innovation input equation in column (3), innovation input and export intensity are positive and highly significant. Interestingly, the elasticity for exporting is quantitatively greater than the innovation input predicted from the first step. Doubling the export value is associated with an increase in innovation output by 9.1% compared to 5.4% in the case of the innovation input. Other firm characteristics are insignificant except human capital.

Turning to the productivity equation in column (4), innovation output is also positive and significant, as expected. The elasticity size of 0.045

Table 4.4: Step 2: Innovation Output. Estimator: Ordinary least squares excluding inverted Mills' ratio

| Variable | (3) *InnovationOutput* | (4) *TFP* | (5) *ExportIntensity* |
|---|---|---|---|
| *InnovationInput* | $0.054^{***}$ | | |
| (predicted)(lag)(log) | (0.015) | | |
| *InnovationOutput* | | $0.045^{**}$ | |
| (lag)(log) | | (0.018) | |
| *TFP* | | | $0.759^{***}$ |
| (lag)(log) | | | (0.243) |
| *ExportIntensity* | $0.091^{***}$ | 0.011 | |
| (lag)(log) | (0.030) | (0.013) | |
| *ExportExperience* | | | $2.404^{***}$ |
| | | | (0.456) |
| *FirmSize* | | $0.234^{***}$ | −0.062 |
| (lag)(log) | | (0.017) | (0.084) |
| *PhysicalCapital* | 0.079 | −0.016 | $0.277^{***}$ |
| (lag)(log) | (0.054) | (0.020) | (0.073) |
| *HumanCapital* | $1.015^{*}$ | 0.446 | 1.441 |
| (lag) | (0.539) | (0.293) | (1.108) |
| *Uninational* | −0.175 | 0.044 | 0.264 |
| | (0.200) | (0.061) | (0.275) |
| *DomesticMNE* | −0.141 | $0.150^{**}$ | $1.459^{***}$ |
| | (0.178) | (0.070) | (0.263) |
| *ForeignMNE* | −0.056 | $0.177^{**}$ | $1.640^{***}$ |
| | (0.197) | (0.077) | (0.273) |
| Observations | 418 | 435 | 815 |
| $R^2$ | 0.193 | 0.566 | 0.404 |

**Note:** Industry dummies and constants are included but not reported. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

is roughly similar to the 0.054 in a study by Lööf and Heshmati (2006). Furthermore, firms' inherent characteristics are found to be the main determinants of firms' productivity, where we can see a much bigger elasticity for firm size (0.234) and an affiliation to multinationals (0.150 and 0.177 for domestic and foreign MNE, respectively). Here, I also see no support for the learning-by-exporting hypothesis because previous export performance does not have a significant impact on TFP. Whereas, in the export equation in column (5), TFP shows a strong impact on export performance, as well as most of the firms' characteristics. Finally, previous export experience, dummy indicating whether a firm has engaged in exporting before, does help firms to continue exporting in the current period.

As discussed in the previous section, the results from using OLS in this basic model specification suffer from both the selectivity and the simultaneity problems. So Table 4.5 displays the main results from estimating the structural model with 3SLS, as I outlined earlier in the empirical section, to correct for both issues.

After correcting for both selectivity and simultaneity issues, the positive

Table 4.5: Step 2: Innovation Output. Estimator: Three-stage least squares including inverted Mills' ratio

| Variable | (6) *InnovationOutput* | (7) *TFP* | (8) *ExportIntensity* |
|---|---|---|---|
| *InnovationInput* | 0.374 | | |
| (predicted)(lag)(log) | (0.729) | | |
| *InnovationOutput* | | $0.038^{*}$ | |
| (lag)(log) | | (0.022) | |
| *TFP* | | | $0.696^{*}$ |
| (lag)(log) | | | (0.367) |
| *ExportIntensity* | $0.162^{***}$ | $0.031^{*}$ | |
| (lag)(log) | (0.049) | (0.018) | |
| *ExportExperience* | | | $1.873^{*}$ |
| | | | (0.991) |
| *FirmSize* | | $0.235^{***}$ | −0.103 |
| (lag)(log) | | (0.019) | (0.125) |
| *PhysicalCapital* | −0.130 | −0.019 | 0.164 |
| (lag)(log) | (0.269) | (0.027) | (0.101) |
| *HumanCapital* | −1.323 | 0.186 | 0.059 |
| (lag) | (3.345) | (0.350) | (1.338) |
| *Uninational* | $-0.641^{**}$ | 0.023 | −0.056 |
| | (0.316) | (0.087) | (0.471) |
| *DomesticMNE* | $-0.751^{**}$ | 0.125 | $1.493^{***}$ |
| | (0.335) | (0.091) | (0.333) |
| *ForeignMNE* | $-0.785^{**}$ | 0.093 | $1.476^{***}$ |
| | (0.353) | (0.107) | (0.380) |
| *IMR* | −0.991 | | |
| | (0.697) | | |
| Observations | 291 | 291 | 291 |
| $R^2$ | 0.246 | 0.624 | 0.449 |
| Log-likelihood | −1,030 | −1,030 | −1,030 |

**Note:** Industry dummies and constants are included but not reported. Bootstrapped standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

impact of innovation input is insignificant, whereas exporting still retains the significance of its impact on innovation output with the elasticity of 0.16 or a 16% increase in the share of innovative sales per employee for a doubling of the export value. Corporate group affiliation, however, exhibits a significant and negative effect on innovation output, which is unexpected. One possible explanation is that belonging to a corporate or multinational firm involves a bureaucratic inefficiency that reduces firms' innovation output, especially when the company ownership is controlled from outside the country (the negative elasticity is greatest for foreign multinationals).

TFP is positively related to innovation output at the 10% significance level. The coefficient in this study, 0.04, is lower than the result for labour productivity reported in Crépon et al. (1998) and Lööf and Heshmati (2006), which is in the range of 0.07–0.1. The discrepancy could come from the different productivity measure. This study uses a TFP that is a residual from an estimation of firms' production function and captures the productivity of both factors of production: capital and labour. Unlike previous results, the hypothesis of learning-by-exporting is supported as there is a significant association between export intensity and TFP. Last, among firm characteristics, only firm size is positively significant in explaining TFP.

In the export equation, column (8), the productivity is positive and significant at the 10% level, which is weakened compared to OLS results in Table 4.4. In terms of the magnitude of impact, doubling productivity is associated with an increase in the intensity of exporting by approximately 70%. Not surprisingly, the positive result is a regularity that is found in many studies and confirms the self-selection hypothesis. Export experience also helps firms to continue their engagement in the export market. In contrast to the innovation output equation, the affiliation variables are positive and significant. The explanation is intuitive, multinationals obviously have an international connection, which can help firms to engage in exporting.

Comparing the results before (Table 4.4) and after (Table 4.5) correcting for econometric issues, the size of the elasticity from using 3SLS is generally greater in most variables in all three equations.[14] Moreover, restricting the error terms to be correlated across all three equations reduces the valid observations down around half so a variation in the dataset might not be adequately captured during the estimation. It would be interesting to repeat the same model structure on a larger dataset.

### 4.5.3 Alternative model specifications: Selectivity vs. simultaneity

As a robustness check, two alternative model specifications are displayed in columns (9) and (10) of Table 4.6. The first specification corrects for selectivity, but not simultaneity. Therefore, the estimator in use is OLS with the predicted value of innovation input from the first step and the inverted Mills' ratio. Because the error terms are not correlated with the productivity and export equations, the estimated results for the last two equations are the same as in Table 4.4. The second specification corrects for simultaneity but not selectivity. The estimator is thus 3SLS, but without the inverted Mills' ratio in the innovation-output equation.

The difference in the estimates from the basic to the main results in

[14]The downward bias for OLS results without selectivity and simultaneity correction is also reported in Lööf and Heshmati (2006).

Table 4.6: Step 2: Two alternative model specifications

| Variable | (9) *Innovation Output* | (10) *Innovation Output* | (11) Difference | (12) |
|---|---|---|---|---|
| *InnovationInput* (predicted)(lag)(log) | 0.543 (0.674) | −0.184 (0.722) | 0.489 | 0.558 |
| *ExportIntensity* (lag)(log) | 0.097*** (0.030) | 0.167*** (0.044) | 0.006 | −0.005 |
| *PhysicalCapital* (lag)(log) | −0.154 (0.239) | 0.137 (0.222) | −0.233 | −0.267 |
| *HumanCapital* (lag) | −1.094 (2.917) | 1.482 (2.868) | −2.109 | −2.805 |
| *Uninational* | −0.310 (0.229) | −0.504* (0.277) | −0.135 | −0.137 |
| *DomesticMNE* | −0.385 (0.252) | −0.423* (0.219) | −0.244 | 0.328 |
| *ForeignMNE* | −0.327 (0.281) | −0.472** (0.233) | 0.271 | 0.313 |
| *IMR* | −0.753 (0.510) | | | |
| Observations | 418 | 291 | | |
| $R^2$ | 0.169 | 0.238 | | |
| Log-likelihood | | −1,032 | | |

**Note:** The OLS results in column (9) correct for the selectivity (by including inverted Mills' ratio), but not the simultaneity issue (where the error term is independent of other equations). The 3SLS results in column (10) correct for the simultaneity (by restricting the error terms), but not the selectivity issue (by excluding the inverted Mills' ratio). The numbers in columns (11) and (12) are the difference of coefficient values compared to results in columns (3) and (6), respectively. Industry dummies and constants are included but not reported. Bootstrapped standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The results for the productivity and export equations are exactly the same or have negligible differences compared to the basic and main results; they are not reported, but can be supplied upon request.

column (3) in Table 4.4 and column (6) in Table 4.5 is listed in columns (11) and (12). This means that column (11) shows the bias from selectivity and column (12) the bias from simultaneity issue. Judging from this table, the conclusion is that the selectivity issue does not bias the results as much as the simultaneity issue.

### 4.5.4 Alternative specification: Seemingly unrelated regression

The full structural framework in the main results involves the selection of firms into both innovation investments and exporting. Thus, it reduces the observations down remarkably from 1,042 to a mere 291, or around 70%. This double selection process can wipe out some of the variation in the data. As an alternative, I estimate the last three equations of innovation, productivity, and exports as a SUR model. The error terms are contemporaneously correlated across all equations and the model is estimated using maximum likelihood. Another option is to estimate the model using feasible generalised least squares using a two-step approach. The first step is ordinary least squares and the modified variance matrix is used for the generalised least square estimation in the second step. The standard errors of this two-step approach is asymptotically equivalent to SUR in large samples.

The SUR methodology allows for the interdependence between innovation, productivity, and exports to be captured since all error terms are assumed to be correlated. Econometrically, this model can deal with both simultaneity and endogeneity issues, in which the dependent variable of one equation is endogeneous in another. Using ordinary least squares instead will result in inconsistent estimates. Besides, if the correlation between the error terms does not exist, then the estimation of SUR reduces down to ordinary least squares anyway. In this study, however, I prefer the multistep approach to this SUR model because it also addresses the selection process of firms' innovation-investment decision.

The results are displayed in Table 4.7. The covariance between the error terms of TFP and export intensity equations is significant, which justifies the use of the SUR model for productivity and export equations at the least. Concerning the sign of estimates, most variables do not differ from the main results. Human capital turns positive and significant at 10% in the innovation-output equation. Several main variables of interest show an increased significance level, except export intensity in column 14. In this result, innovation output has a positive and highly significant impact on innovation input, which is in contrast to the main results, possibly due to the exclusion of selection in the innovation input. Regarding the size of the estimates, the productivity equation (column 15) shows a similar size as the main results, whereas the other equations show a greater difference in size, with generally smaller magnitude in the innovation-output equation (column 11) and greater estimated size in the export-intensity equation (column 13).

## 4.6 Conclusion

It is well known that exporters are productive firms. But the source of their productivity is not yet fully explained. This study aims to examine the interplay between innovation activities, productivity, and export performance

Table 4.7: Alternative model specification: Seemingly unrelated regression

| Variable | (14) *Innovation Output* | (15) *TFP* | (16) *Export Intensity* |
|---|---|---|---|
| *InnovationInput* | 0.054*** | | |
| (lag)(log) | (0.014) | | |
| *InnovationOutput* | | 0.062*** | |
| (lag)(log) | | (0.019) | |
| *TFP* | | | 1.496*** |
| (lag)(log) | | | (0.412) |
| *ExportIntensity* | 0.089* | 0.055*** | |
| (lag)(log) | (0.047) | (0.021) | |
| *ExportExperience* | | | 2.199*** |
| | | | (0.406) |
| *FirmSize* | | 0.223*** | −0.249** |
| (lag)(log) | | (0.018) | (0.118) |
| *PhysicalCapital* | 0.078 | −0.036* | 0.293*** |
| (lag)(log) | (0.053) | (0.019) | (0.074) |
| *HumanCapital* | 0.961* | 0.309 | 1.395 |
| (lag) | (0.528) | (0.286) | (1.114) |
| *Uninational* | −0.179 | 0.037 | 0.220 |
| | (0.195) | (0.061) | (0.267) |
| *DomesticMNE* | −0.128 | 0.083 | 1.406*** |
| | (0.181) | (0.075) | (0.259) |
| *ForeignMNE* | −0.055 | 0.092 | 1.574*** |
| | (0.204) | (0.081) | (0.269) |
| var($\varepsilon$) | 1.132*** | 0.165*** | 4.570*** |
| | (0.079) | (0.026) | (0.325) |
| cov($\varepsilon_{IO} \times \varepsilon_{TFP}$) | | −0.034 | |
| | | (0.035) | |
| cov($\varepsilon_{IO} \times \varepsilon_{EI}$) | | 0.031 | |
| | | (0.273) | |
| cov($\varepsilon_{EI} \times \varepsilon_{TFP}$) | | −0.378** | |
| | | (0.158) | |
| Observations | 849 | 849 | 849 |
| Log-pseudolikelihood | | −2,574.285 | |

**Note:** The row labelled var($\varepsilon$) indicates the variance of the error term in each equation, cov($\cdot$) indicates the covariance of error terms between equations (*IO*—*InnovationOutput*, *EI*—*ExportIntensity*). Industry dummies and constants are included but not reported. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

by incorporating innovation in a structural model framework.

There are two novelties in this study. First, I examine the black box concerning the source of productivity heterogeneity in exporting firms. Although we know that productive firms can become exporters later, this study answers the question of why those productive firms are productive in the first place. An addition of the export equation provides an interaction between innovation output, productivity, and exports for an investigation of several hypotheses, including joint decisions of exporting and self-selection. Second, by merging two waves of Swedish CIS data and tracing the participants' behaviour from 2004 to 2006, it becomes possible to (i) consider lagged values of innovation input to explain current innovation output and (ii) consider the innovation output to further explain current productivity and export performance. Such a structure can reduce the simultaneity bias from using cross-sectional data from one year.

The main findings are that exports are driven by firms' productivity, which is in turn positively related to past innovation output. This conclusion is robust regardless of the estimator in use. I also find a positive relationship between innovation input (R&D and other related investments) and innovation output (sales due to innovative products), but this is diminished when correcting for the selectivity and simultaneity issues. Furthermore, among the relationships between innovation output, productivity, and exports, I find the supporting evidence for the self-selection hypothesis for exporting and that exporting raises an incentive for innovation, but mixed results for the export–productivity relationship. Export intensity is statistically significant in explaining TFP in the case when both selectivity and simultaneity are corrected for (main results and SUR model), whereas it is not significant in the OLS results. This suggests that exporting also drives innovation and productivity, especially in innovative firms.

When the selection issue is corrected, the insignificant result between innovation input and output would suggest that there is an inefficiency in realising the results of investments. So one implication is that any policy aiming at promoting innovation should not place too much emphasis only on the amount of input; rather, it should take into account how these investments can bear an actual output. This innovation output must be the main focus because it will lead to an improvement in firms' productivity and export activity.

Besides the limited number of observations, another limitation of this study is the short period of observations. It would be ideal to construct a longer panel to test recent dynamic models of stochastic productivity (Aw et al., 2011; Maican et al., 2013) using a more direct measure of innovation; that is, its output rather than an input in the form of R&D investments.

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# 4.7 Appendix

Table 4.8: Average value of selected variables by industry, year 2004

| NACE | Industry | CIS | Dataset | *II* | *IO* | *TFP* | *EI* | *FS* | *PC* | *HC* |
|---|---|---|---|---|---|---|---|---|---|---|
| 15 | Food products | 128 | 80 | 25,571.50 | 132,238.13 | 260,620.33 | 376,706.76 | 201.03 | 321,735.85 | 0.049 |
| 16 | Tobacco products | 4 | 2 | 199,610.67 | 876,325.62 | 1,681,299.88 | 205,776.22 | 388.00 | 2,546,757.38 | 0.149 |
| 17 | Textiles | 56 | 30 | 30,521.42 | 126,270.95 | 246,476.98 | 723,130.53 | 74.23 | 308,095.66 | 0.041 |
| 18 | Wearing apparel | 27 | 17 | 8,782.97 | 178,477.76 | 229,120.29 | 764,493.92 | 36.41 | 104,059.81 | 0.049 |
| 19 | Leather | 11 | 7 | 13,829.24 | 86,635.26 | 296,846.91 | 524,331.91 | 73.14 | 122,652.47 | 0.043 |
| 20 | Wood | 128 | 64 | 51,317.49 | 60,680.66 | 264,286.60 | 978,799.93 | 85.00 | 504,144.52 | 0.036 |
| 21 | Pulp and paper | 81 | 51 | 59,508.41 | 190,662.18 | 471,664.30 | 1,252,557.52 | 269.14 | 2,268,538.34 | 0.101 |
| 22 | Publishing | 151 | 81 | 39,154.81 | 87,666.43 | 330,334.23 | 56,882.25 | 76.99 | 272,888.51 | 0.134 |
| 23 | Coke, refined petroleum | 9 | 5 | 29,188.60 | 266,928.08 | 500,104.27 | 2,953,502.01 | 167.00 | 440,315.09 | 0.132 |
| 24 | Chemicals | 91 | 52 | 195,584.70 | 276,216.70 | 531,323.23 | 1,571,976.18 | 350.23 | 595,576.65 | 0.179 |
| 25 | Rubber and plastics | 102 | 60 | 82,665.07 | 259,690.19 | 275,480.75 | 638,025.77 | 61.05 | 339,087.86 | 0.045 |
| 26 | Other mineral products | 78 | 49 | 15,983.30 | 192,113.94 | 308,993.91 | 329,478.38 | 126.94 | 418,321.90 | 0.05 |
| 27 | Basic metals | 72 | 41 | 35,337.27 | 128,108.54 | 434,791.47 | 1,696,300.90 | 312.37 | 429,801.78 | 0.062 |
| 28 | Fabricated metals | 167 | 82 | 33,734.47 | 89,468.33 | 273,265.68 | 351,911.27 | 73.15 | 370,935.87 | 0.039 |
| 29 | Machinery | 195 | 116 | 213,883.71 | 281,946.99 | 371,428.64 | 964,296.63 | 190.52 | 264,326.64 | 0.098 |
| 30 | Office machinery | 25 | 20 | 110,478.45 | 273,633.70 | 339,462.87 | 970,272.10 | 105.05 | 124,890.80 | 0.213 |
| 31 | Electrical machinery | 95 | 64 | 55,827.16 | 224,119.52 | 295,072.03 | 344,370.79 | 74.09 | 136,924.82 | 0.069 |
| 32 | Radio, television | 47 | 30 | 120,277.32 | 403,808.73 | 472,698.67 | 728,300.14 | 639.23 | 363,969.04 | 0.157 |
| 33 | Medical instruments | 88 | 54 | 138,825.52 | 379,945.57 | 424,163.41 | 1,059,542.90 | 143.72 | 192,748.70 | 0.215 |
| 34 | Motor vehicles | 100 | 55 | 60,559.68 | 429,379.39 | 427,933.36 | 660,139.98 | 682.49 | 263,485.72 | 0.086 |
| 35 | Other transport equipment | 54 | 36 | 75,927.31 | 176,532.57 | 332,319.18 | 649,849.96 | 282.78 | 255,926.21 | 0.065 |
| 36 | Furniture | 93 | 46 | 32,741.02 | 350,691.37 | 293,844.46 | 510,068.52 | 123.83 | 270,104.56 | 0.043 |
| | Total firms/Avg. value | 1,802 | 1,042 | 114,398.52 | 466,053.87 | 391,704.64 | 945,088.77 | 312.75 | 344,715.85 | 0.120 |

The third column refers to the number of firms that report in CIS survey. The fourth column refers to the number of firms in the dataset for analysis after the data-cleansing procedure. Other columns report the average value within the respective industry. The numbers in the last row are the average values of each variable for the whole sample of 1,042 firms. *II—InnovationInput*, *IO—InnovationOutput*, *TFP—TFP*, *EI—ExportIntensity*, *FS—FirmSize*, *PC—PhysicalCapital*, *HC—HumanCapital*.

Table 4.9: Correlation table

| | *II* | *IO* | *TFP* | *EI* | *EE* | *FS* | *PC* | *HC* | *UNN* | *DMNE* |
|---|---|---|---|---|---|---|---|---|---|---|
| *IO* | 0.204*** | | | | | | | | | |
| *TFP* | 0.140*** | 0.191*** | | | | | | | | |
| *EI* | 0.135*** | 0.286*** | 0.301*** | | | | | | | |
| *EE* | 0.043 | 0.019 | 0.064 | 0.113** | | | | | | |
| *FS* | 0.241*** | 0.228*** | 0.442*** | 0.188*** | 0.023 | | | | | |
| *PC* | 0.272*** | 0.049 | 0.278*** | 0.270*** | 0.066 | 0.098** | | | | |
| *HC* | 0.249*** | 0.235*** | 0.339*** | 0.181*** | 0.032 | 0.163*** | 0.009 | | | |
| *UNN* | −0.034 | −0.104** | −0.172*** | −0.206*** | −0.005 | −0.101** | −0.055 | −0.114** | | |
| *DMNE* | 0.082* | 0.061 | 0.135*** | 0.102** | 0.110** | 0.082* | 0.071* | 0.084* | −0.345*** | |
| *FMNE* | 0.000 | 0.098** | 0.228*** | 0.255*** | 0.027 | 0.109** | 0.046 | 0.125*** | −0.349*** | −0.384*** |

*II*—*InnovationInput*, *IO*—*InnovationOutput*, *TFP*—*TFP*, *EI*—*ExportIntensity*, *EE*—*ExportExperience*, *FS*—*FirmSize*, *PC*—*PhysicalCapital*, *HC*—*HumanCapital*, *UNN*—*Uninational*, *DMNE*—*DomesticMNE*, *FMNE*—*ForeignMNE*. The variables are in logarithmic form or a dummy. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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