

A Theory on the Role of Wholesalers in International Trade*

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Abstract

This paper offers an explanation for the existence of wholesalers and other intermediaries in international trade, and analyses their effect in an economy with heterogeneous manufacturing firms. Exporting firms have to pay a fixed cost of establishing a distribution network in a foreign market. However, wholesalers possess a technology different to normal manufacturing firms: they can buy manufacturing goods domestically and sell in foreign markets, and they can handle more than one good. A wholesaler therefore faces an additional fixed cost which is convex and monotonically increasing in the number of goods it handles. The entry of wholesale firms leads to productivity sorting. The most productive firms export on their own by paying a fixed cost, but a range of firms with intermediate productivity levels export through international wholesalers. A higher fixed cost of exporting leads to (i) a higher share of the total value of exports and (ii) a higher share of exported product scope that is distributed by wholesalers. A higher fixed cost of exporting gives wholesalers a larger role, since these can spread the fixed cost across more than one good. The wholesale technology therefore exhibits economies of scope. Finally, a gravity model is developed where the ‘multilateral resistance variable’ is found to include the number of wholesalers of trading partners. Their presence lowers a country’s price index, as well as mitigates the positive effect that fixed trade costs have on price levels. An empirical analysis using Swedish firm-level data supports the main assumption and predictions of the model.

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1 Introduction

Consumers in modern economies buy few, if any, products directly from the original producer. Instead, a vast majority of goods are, to some extent, intermediated by retailers, wholesalers, international trading companies and other intermediaries. This phenomenon is likely even more important for internationally traded goods. Recent empirical research shows that intermediation is important also for how producers of goods enter foreign markets. For example, Blum, Claro, and Horstmann (2010) report that around 35% of imports into Chile are handled by wholesalers. Basker and Van (2008) document the role of Walmart as a catalyst for US imports from China and note that this large US retailer accounts for 15% of US imports from China. Feenstra and Hanson (2004) examine the role of Hong Kong in re-exporting goods from China during the period 1988-1998 and find that 53% of Chinese exports were shipped through Hong Kong as re-exports. The authors argue that intermediation was one of the more important factors for this. These ratios are even larger for some goods typically associated with China's rapid export growth in the 1990s, such as 77% for footwear and 83% for toys. Bernard, Jensen, Redding, and Schott (2010) find that exporting firms in the US exhibit substantial heterogeneity as regards export mode, i.e. whether firms manage their own exporting activities or export through intermediaries. Consequently, the common assumption in the literature on international trade—that firms are always responsible for their own exporting activities—does not provide a full picture of how firms enter foreign markets and why.¹ However, a growing theoretical literature is currently exploring the issue of intermediation in international trade. So far, this has mainly focused on the role of intermediaries in reducing contracting or matching frictions between buyers and sellers, as in Antràs and Costinot (2010a, b), Biglaiser (1993), Blum, Claro, and Horstmann (2009) or Rubinstein and Wolinsky (1987); or on their positions in networks in international trade, as in Rauch (1999, 2001), Rauch and Watson (2004) or Petropoulou (2007).²

This paper tells a rather different story about why intermediaries exist in international trade. The basic notion is that intermediaries assist producing firms in overcoming destination-specific barriers of entry. Here, intermediaries are wholesalers that are able to pool the fixed cost of exporting across more than one good.³ I utilise a standard model of international trade with firm heterogeneity, as in Melitz (2003), and introduce a sector

¹For further empirical evidence, see also Ahn, Khandelwal, and Wei (2010), Basker and Van (2010), Bernard, Grazi, and Tomasi (2010) and Rauch and Trindade (2002).

²Raff and Schmitt (2006, 2007, 2009) study issues relating to strategic interaction between wholesalers, retailers and producers.

³The term wholesalers will be used in the paper since the empirical analysis uses data for wholesale firms, but the theoretical model could just as well be applied to intermediaries in general.

of wholesalers. These do not produce goods themselves. Instead, they buy goods in their local market and export these goods to foreign markets. They only have to incur the fixed cost of establishing a distribution network in a foreign market once (regardless of how many goods they export). However, they face a fixed cost of their distribution network, which is convex and increasing in product scope (the range of goods that a wholesaler exports). For a producer, exporting through a wholesaler is therefore an alternative to setting up its own distribution channel. The main focus of the paper is on how aggregate trade flows and heterogeneous producers of goods respond to the possibility of exporting through wholesalers, as an alternative to managing their own distribution networks, and therefore wholesalers are assumed to be homogeneous.

The paper defines the general equilibrium of a model with wholesalers, which is characterised by free entry in all sectors. This generates a number of predictions about how exporting is conducted in the presence of intermediation. First, producers sort according to productivity in determining their mode of exporting. The most productive firms continue to manage their own exporting activities and incur the fixed cost associated with this as in the standard model. However, some firms that were almost productive enough to export on their own in a standard model now choose to do so, but through wholesalers instead. The least productive firms do not export through any of the two modes.⁴ Second, the size of the fixed cost of foreign market entry affects the choice of export mode. A higher fixed cost is associated with a larger importance of wholesalers: a larger share of aggregate exports is now intermediated rather than exported directly by the producing firms. Moreover, a larger number of firms choose to export through wholesalers rather than managing their own distribution systems when fixed costs of exporting are high. Finally, a larger fixed cost is associated with each wholesaler handling more goods (having a larger scope).

The core mechanism at work in the model is the following: Wholesalers manage to spread the fixed cost of exporting across more than one good. But, to cover the fixed cost, they need to charge a markup between the procurement price of the good and what it charges the final consumer in the foreign country. This markup that wholesalers charge causes productivity sorting in the choice of export mode: the most productive firms choose to incur their own fixed cost of exporting since their operating profit is large enough. However, some goods, which cannot be profitably exported by the producer itself, can be exported at a lower fixed cost (per good) by wholesalers, who export several goods but only have to make one investment in the fixed cost. This means that the wholesale technology exhibits *economies*

⁴The mechanisms which cause sorting are analogous to those in Helpman, Melitz, and Yeaple (2004). They model horizontal FDI as a mode of foreign market entry which, compared to exporting, is associated with a higher fixed cost but a lower variable cost.

of scope. When fixed costs increase, wholesalers become more important, since fewer firms can export on their own. Moreover, wholesalers have to expand and handle more goods to be able to cover the larger fixed cost. Wholesalers therefore help producers in overcoming destination-specific barriers to entry.

To reach the above conclusions, I have assumed free entry of manufacturing firms in order to restrict the model as little as possible. In the final theoretical section, however, I drop the free entry assumption and develop a multicountry gravity model under the assumptions in Chaney (2008) which does not allow for free entry in the manufacturing sector. The ‘multilateral resistance variable’ is found to include the number of wholesalers of trading partners, and their presence lowers a country’s price index as well as mitigates the positive effect that fixed trade costs have on the price level. Since the price level is indirectly a measure of welfare, wholesalers therefore contribute positively to welfare.

Swedish data is used to test the main assumption and predictions of the model. In this context, Sweden represents a small and highly open economy for which merchandise trade amounted to 63% of GDP in 2005 according to the World Bank, which can be compared to 21% for the United States in the same year. Specifically, I use Swedish firm-level data from 2005, which matches data from the Swedish customs office with production data on Swedish firms. The data structure enables a sector classification of firms according to main business activity, and also contains their trade flows by HS8 product code and destination. It can therefore be observed what goods are exported by firms listed as either ‘wholesalers’ or ‘manufacturers’ where the latter are treated as the producers of goods. The analysis supports the main assumption and the predictions of the model. Crucially, for the basic assumption about economies of scope, Swedish wholesalers export a larger scope of products (or HS8 product categories) than producers. A wholesaler exports about 54% more products per firm when destination-specific effects and firm size are accounted for, an empirical fact which supports the notion that there is a technological difference between wholesalers and producers. Moreover, wholesalers export, on average, substantially less in value (between 35 and 57% less) per firm within a product category than producers. Finally, wholesalers play a more important role in aggregate exports (both in terms of total value and in the number of HS8 product categories exported) from Sweden to countries characterised by larger fixed costs. Admittedly, no perfect measure of fixed costs exists so these are proxied by institutional variables, such as the difficulty to import, or the inverse of the residual from a gravity equation.

Two other papers in the literature also focus on the interaction between fixed costs and export mode in a setting of heterogeneous manufacturing firms, as in Melitz (2003).

Ahn, Khandelwal, and Wei (2010) assume that fixed costs are lower for producers if they export by using an intermediary than on their own but that they, in this case, have to pay an additional variable cost. Producers can pay one fixed cost to get access to all foreign markets through intermediaries, or they can pay a per-market fixed cost of direct exporting to enter certain markets without using an intermediary. The main difference to my paper is that I model the technology of intermediaries explicitly. This makes it possible to analyse a general equilibrium with free entry of firms in all sectors, and to use endogenous price levels, which is important in models building on monopolistic competition. Unlike in my model, Ahn, Khandelwal, and Wei (2010) predict a negative effect of the population size of a destination on the importance of intermediaries, which is supported by empirical evidence both in my and their empirical analysis. The dynamic behind their result comes from the assumption of exogenous price levels and that one fixed cost of intermediation gives access to all foreign markets, while direct exporting requires investing in per-market fixed costs. When the price level is fixed, an increase in the size of a destination generates a higher demand per firm which makes more producers productive enough to pay the fixed cost of direct exporting to that market and avoid the markup charged by intermediaries. In my model, however, all variables change endogenously. Moreover, changes in market size affect both intermediaries and producers in the same way, and therefore the choice of export mode does not change with a change in demand. Finally, they apply Chinese firm-level data to test their implications and use certain Chinese characters in the names of firms to identify intermediaries. Their empirical results are similar to those in my paper except that they find that intermediaries are fairly large compared to manufacturing firms, as measured by export volumes, destinations and product scope per firm, while I find intermediaries to be substantially smaller.⁵

Felbermayr and Jung (2009) also model intermediaries, but the driver here is not economies of scope, but rather a hold-up problem due to contracting frictions as in Antràs and Helpman (2004). This leads to a bargaining process over the profits between the intermediary and the producer. This setup causes the most productive firms to export on their own to avoid sharing their profits with the intermediary and their model therefore generates productivity sorting. They do not, however, model intermediaries explicitly. Blum, Claro, and Horstmann (2009) explore the role played by intermediaries in alleviating matching frictions between buyers and sellers in spatially segmented markets and the matching patterns be-

⁵Bernard, Jensen, Redding, and Schott (2010) and Bernard, Grazi, and Tomasi (2010) also find pure wholesale firms to be substantially smaller than producers exporting on their own. One reason for this pattern in Chinese data could be that, prior to 2005 but not after, exporting from China required a license. Moreover, wholesalers are more exactly identified in Swedish data since all firms which report wholesale as its main activity are classified as such.

tween exporters and importers. Finally, Tang and Zhang (2011) explore the effect of trade intermediation in a setting with quality differentiation.⁶

Importantly, Bernard, Jensen, Redding, and Schott (2010) find evidence for ‘mixed’ firms (plants that engage in both manufacturing and wholesale activities). The authors have information on the main business activity of each plant and among these categories are ‘wholesale’ and ‘retail’. Firms which consist of plants engaging in both production and wholesale (or retail) are labelled as ‘mixed’ (this means that they have at least one plant which engages in wholesale and one plant which does not). Firms in this category are found to be larger, both in terms of turnover and number of employees, but also in terms of export and import volumes. Two points are important to make here since my model is more strict in the sense that it models firms which only engage in either production or wholesale.

First, the phenomenon of ‘mixed’ firms is to some extent a feature of how microdata is structured by statistical authorities, and the fact that larger firms are more likely to divide their businesses formally into different plants. All manufacturing firms engage in logistics of some kind. But a small firm with ten employees will not register its logistics unit as a plant in itself (it might be that only one employee handles all of the firm’s shipping, for example) since this activity is simply too small in size to constitute a plant or establishment. A large firm with several hundreds of employees, however, will probably employ a larger number of people working only with logistics and is more likely to have this activity in a separate building, perhaps even in an own subsidiary company if the parent firm is large enough. In the latter case, the firm will be ‘mixed’ since it has separate plants running both production and shipping. But, ultimately, the difference is driven by size and we know that larger firms also tend to engage in more exporting and importing. This phenomenon is reinforced since a ‘mixed’ firm, by definition, has to consist of more than one plant and multiplant firms are typically larger and more active in foreign trade than single plant firms. Second, if it is a widespread phenomenon that large firms indeed run their own wholesale distribution system and benefit from the same technology as wholesalers, the empirical results would not support the predictions I find. Finally, it is possible to see the model that I propose in this paper as one that analyses the extreme cases of ‘pure’ wholesalers and producers in order to highlight the effect of economies of scope in the wholesale technology.

Section 2 develops the model by introducing a wholesale industry into the model in Melitz (2003) and derives the main results. These predictions are also incorporated into a general gravity model with firm heterogeneity, as in Chaney (2008), to find the effect of

⁶Krauthaim (2009) also develops a model with firm heterogeneity where fixed costs play a role. Here, “Export-Supporting FDI” enables firms to transfer tasks related to distribution to a foreign affiliate in the export destination.

wholesalers on welfare. Section 3 describes the Swedish data and provides the empirical analysis. Section 4 concludes.

2 The Model

The basic model builds on the structure in Melitz (2003) but with an additional ‘agricultural’ sector characterised by constant returns to scale.

2.1 Basics

The model depicts two economies (‘Home’ and ‘Foreign’, the latter denoted by superscript ‘ F ’) with a primary production factor labour, L , which is used in all sectors. Ignoring the wholesale sector for the moment, there are two main sectors in the economy. First, the agricultural sector is a Walrasian, homogeneous-good sector with costless trade. Second, the manufacturing sector is characterized by increasing returns, Dixit-Stiglitz monopolistic competition and iceberg trade costs. Manufacturers face constant marginal production costs and three types of fixed costs. The fixed cost, F_E , is the standard Dixit-Stiglitz cost of developing a new variety. The other two fixed costs involved reflect the one-time expense of introducing a new variety into a market: \tilde{F}_D if it is the domestic market and \tilde{F}_X for the foreign market.

There is heterogeneity with respect to firms’ productivity levels, φ . Each Dixit-Stiglitz firm/variety is therefore associated with a particular labour output coefficient denoted by φ_i for firm i . After sinking F_E units of labour in the product innovation process, the firm is randomly assigned φ_i from the cumulative distribution function $G(\varphi)$.

The analysis exclusively focuses on steady-state equilibria and intertemporal considerations are ignored; the present value of firms is kept finite by assuming that firms face a constant Poisson hazard rate δ of forced exit.

Consumers in each country have two-tier utility functions with the upper tier (Cobb-Douglas) determining the consumer’s division of expenditure among the sectors and the second tier (CES) dictating the consumer’s preferences over the various differentiated varieties within the manufacturing sector.

All individuals in Home have the utility function

$$U = C_M^\mu C_A^{1-\mu} \tag{1}$$

where $\mu \in (0, 1)$, and C_A is the consumption of the homogeneous good. Manufactures enter

the utility function through the index C_M , defined by

$$C_M = \left[\int_0^N c_i^{(\sigma-1)/\sigma} di \right]^{\sigma/(\sigma-1)} \quad (2)$$

where N is the mass of varieties consumed, c_i the amount of variety i consumed and $\sigma > 1$ the elasticity of substitution between varieties.

Each consumer spends a share μ of his income on manufactures, and demand for a variety i is therefore

$$x_i = A p_i^{-\sigma}, \quad (3)$$

where

$$A \equiv \frac{\mu L}{P^{1-\sigma}}, \quad (4)$$

p_i is the consumer price of variety i , L is the population size and $P \equiv \left(\int_{i \in \Omega} p_i^{1-\sigma} di \right)^{\frac{1}{1-\sigma}}$ the price index of manufacturing goods available in the Home country. The set of available varieties is denoted by Ω .

The unit factor requirement of the homogeneous good is one unit of labour. This good is freely traded and since it is chosen as the numeraire

$$p_A = w = 1 \quad (5)$$

where w is the nominal wage of workers.

In an economy without wholesalers, shipping the manufactured good involves a frictional trade cost of the ‘iceberg’ form: for one unit of a good from Home to arrive in the Foreign country, $\tau > 1$ units must be shipped. It is assumed that trade costs are equal in both directions. Profit maximisation by a manufacturing firm i located in Home exporting to the Foreign country leads to the following consumer price in Foreign of firm i ’s good:

$$p_i^F = \frac{\sigma}{\sigma-1} \tau \varphi_i^{-1}. \quad (6)$$

Entrepreneurs entering the manufacturing sector draw their marginal productivity, φ , from the probability distribution $G(\varphi)$ after having sunk F_E units of labour to develop a new variety. Having learned their productivity, firms decide on entry in the domestic and foreign market, respectively. Doing so is associated with fixed market entry costs; firms pay

\tilde{F}_D to enter the domestic market and \tilde{F}_X to enter the foreign market. Firms will therefore enter a market as long as the operating profit in this market is sufficiently large to cover market entry cost associated with the market. Because of the constant mark-up pricing, it is easily shown that operating profits equal revenues divided by σ . The critical cut-off levels of productivity needed in order to enter the domestic and foreign markets (for the operating profit to be as large as the discounted fixed cost of entry) are given by:

$$\varphi_D^{\sigma-1} A = F_D \quad (7)$$

$$\varphi_X'^{\sigma-1} \tau^{1-\sigma} A^F = F_X \quad (8)$$

where $F_D \equiv \delta(\sigma-1)^{1-\sigma} \sigma^\sigma \tilde{F}_D$ and $F_X \equiv \delta(\sigma-1)^{1-\sigma} \sigma^\sigma \tilde{F}_X$. A and A^F indicate “per-firm demand” of the Home market and the Foreign market, respectively. Accounting also for free entry, which means that $E(\pi) = F_E$, yields that $A = A^F$. The reason for using the notation φ_X' is that the export cut-off will be different when wholesalers are introduced. Equations (7) and (8) yield the standard result from Melitz (2003) which can be summarised as follows (provided that $\frac{1}{\tau^{1-\sigma}} \frac{F_X}{F_D} > 1$):

Proposition 1 *In a world without wholesalers, only firms with a marginal productivity above φ_X' choose to export, firms with a productivity between φ_D and φ_X' serve the domestic market and firms with a marginal productivity below φ_D exit immediately.*

2.2 Introducing wholesalers

The third sector, which is the novel feature of the model, is the wholesale sector (variables relating to this sector are denoted by superscript “ W ”). Wholesale firms are indexed by j and are homogeneous. The wholesale technology gives a wholesaler firm j the ability to source a range of goods and ship these to the Foreign country. The mass of goods each wholesaler ships (equal to the mass of manufacturing firms the wholesaler is buying goods from) is denoted by m_j^W . The sector is characterised by free entry. A wholesaler faces the same cost as manufacturing firms to establish a retail channel in the foreign country, F_X , but has the technology to export several goods. Operations are assumed to become more costly the more goods a firm handles, so it also faces a per-period fixed cost that is monotonically and convexly increasing in the range of goods it handles. Its total fixed cost of foreign

market entry is therefore:

$$F_{Xj}^W = F_X + \frac{(m_j^W)^\gamma}{\gamma} \quad (9)$$

where $\gamma > 1$ and m_j^W is the mass of domestic manufacturing goods the wholesale firm j is handling. Since manufacturing firms are atomistic and therefore has a mass equal to zero, if a wholesale firm were to only export one single good, its scope measure m_j^W would be zero and $\lim_{m_j^W \rightarrow 0} F_{Xj}^W = F_X$. Therefore, a wholesale firm which only exports one good has the same fixed cost of exporting as a manufacturer. Moreover, the functional form in (9) is chosen both for technical and intuitive reasons. The technical reason is that some convexity needs to be included in this function to put an upper bound on the scope of wholesalers. If it was not present (i.e. if $\gamma = 0$), the economies of scope would be infinite and only one wholesaler would exist and would export all goods. The intuitive reason is that it is more costly to maintain an international distribution system the more different goods are in nature. If m_j^W is low, the wholesaler is more specialised in a more narrow range of products, for example sport cars of different kinds. However, as m_j^W increases, the products necessarily become more different; in the specific example the whole firm also starts to export other types of cars and other types of motor vehicles etc., and the level of specialisation decreases and the cost per product increases. The wider the scope, the more costly each product is to export.

I assume that a wholesaler gets the exclusive right to sell the manufacturing good in the foreign market (thereby excluding the possibility that more than one wholesaler sell the same manufacturing good). Since the wholesaler faces a CES demand abroad, its demand function towards manufacturing firms when procuring their products is also characterised by a CES structure. This causes manufacturing firms to charge the same price to wholesalers as they do to consumers. And since the manufacturer imposes a CES markup over its marginal cost and the wholesaler does the same, the final consumer price in the foreign economy for a good sold by a wholesaler is characterised by a “double marginalisation”; the CES markup of $\frac{\sigma}{\sigma-1}$ is imposed twice.

$$p_{ij}^W = \left(\frac{\sigma}{\sigma-1} \right)^2 \tau \varphi_i^{-1} \quad (10)$$

where p_{ij}^W is the price charged by wholesaler j selling manufacturing firm i 's good in the foreign market.

Proposition 2 *A wholesaler imposes a double marginalisation over the initial marginal cost of the producer.*

Proof. The marginal cost of wholesaler j consists of two parts. First, it pays an iceberg trade cost, τ , and, second, it pays the procurement price of the domestic manufacturing good (from manufacturer i). Since a monopolistically competitive manufacturer does not necessarily charge the same price to final consumers and wholesaler firms, the price manufacturer i charges wholesaler j is for now denoted by $p_{ij,P}$. The wholesaler's marginal cost, MC_{ij}^W of procuring manufacturer i 's good is then equal to

$$MC_{ij}^W = \tau p_{ij,P}.$$

The wholesaler faces the demand $A^F (p_{ij}^W)^{-\sigma}$ in the foreign economy where p_{ij}^W is the price that wholesaler firm j charges for manufacturing firm i 's good in Foreign. Faced with a CES type of demand, it will charge a constant markup over its marginal cost:

$$\begin{aligned} p_{ij}^W &= \frac{\sigma}{\sigma - 1} MC_{ij}^W \\ &= \frac{\sigma}{\sigma - 1} \tau p_{ij,P}. \end{aligned}$$

The demand for good i sold by wholesaler j in Foreign, x_{ij} , will be equal to $A^F \left(\frac{\sigma}{\sigma - 1} \tau p_{ij,P} \right)^{-\sigma}$ and wholesaler j 's cost function is therefore:

$$C_{ij}^W (p_{ij,P}, x_i) = \tau p_{ij,P} x_{ij}$$

Applying Shephard's lemma to find wholesaler j 's demand function for good i (i.e. the demand function that manufacturer i faces from wholesaler j), yields:

$$D_{ij}^W (p_{ij,P}) = \frac{\partial C_{ij}^W (p_{ij,P})}{\partial p_{ij,P}} = \tau x_{ij} = \tau^{1-\sigma} A^F \left(\frac{\sigma}{\sigma - 1} p_{ij,P} \right)^{-\sigma}.$$

This result has two important implications. First, the producer firm faces the exact same demand elasticity from wholesaler firms as that from domestic consumers, and will therefore charge the same price to wholesalers as it does to domestic consumers (a constant markup over its marginal cost), $p_{ij,P} = p_i$. Second, it can be seen that the wholesaler will charge the following price in the foreign economy (foreign consumers have CES demand and the wholesaler will charge a standard CES markup over its marginal cost):

$$p_{ij}^W = \left(\frac{\sigma}{\sigma - 1} \right)^2 \tau \varphi_i^{-1}. \quad (11)$$

The term $\left(\frac{\sigma}{\sigma-1}\right)^2$ decreases in the elasticity of substitution which means that the degree of double marginalisation is smaller in sectors where varieties are more substitutable. ■

Proposition 3 *The double marginalisation is higher in less competitive sectors, i.e. in sectors characterised by low elasticities of substitution.*

Proof. See proof to Proposition 2.

Since manufacturers can choose their export mode (i.e. by establishing their own distribution system or exporting through a wholesaler), their choices are determined by what mode yields the highest profits from exporting. The expected operating profits (discounted by the forced exit rate δ) of a manufacturing firm i that exports through wholesaler j will be

$$\frac{1}{\delta} (p_{ij,P} \tau x_{ij} (p_{ij}^W) - \varphi_i^{-1} \tau x_{ij} (p_{ij}^W)) = \frac{1}{\delta} \tau^{1-\sigma} \varphi_i^{\sigma-1} A^F \left(\frac{\sigma-1}{\sigma}\right)^{2\sigma} \frac{1}{\sigma-1} \quad (12)$$

where $x_{ij} (p_{ij}^W)$ indicates foreign sales of good i at price p_{ij}^W , i.e. the price set by the wholesaler. The expected discounted operating profits of a manufacturing firm exporting on its own would be

$$\frac{1}{\delta} (\tau p_i x_i (\tau p_i) - \varphi_i^{-1} \tau x_i (\tau p_i)) - \tilde{F}_X = \frac{1}{\delta} \tau^{1-\sigma} \varphi_i^{\sigma-1} A^F \left(\frac{\sigma-1}{\sigma}\right)^{\sigma} \frac{1}{\sigma-1} - \tilde{F}_X. \quad (13)$$

Comparing the profits for a manufacturing firm choosing between the two export modes yields the following condition, using (12) and (13), for the firm to choose to export on its own:

$$\varphi_i^{\sigma-1} > \frac{F_X}{\tau^{1-\sigma} A^F} \frac{1}{\left(1 - \left(\frac{\sigma-1}{\sigma}\right)^{\sigma}\right)}. \quad (14)$$

This means that more productive firms will want to export on their own rather than through a wholesaler. This is due to the fact that they are productive enough to take the fixed cost of exporting themselves and avoid the markup incurred on them by the wholesaler. Note also that (14) defines the new export cut-off

$$\varphi_X^{\sigma-1} = \frac{1}{\left(1 - \left(\frac{\sigma-1}{\sigma}\right)^{\sigma}\right)} \frac{F_X}{\tau^{1-\sigma} A^F} > \frac{F_X}{\tau^{1-\sigma} A^F} = (\varphi'_X)^{\sigma-1}.$$

The inequality sign demonstrates that, with wholesalers present, some producers that previously exported on their own now decide to use wholesalers instead. Therefore the

export cut-off is higher with wholesalers in the model than without. This phenomenon is illustrated in figure 1. The lines π_X and π_W show the operating profits of manufacturing firm exporting on its own and exporting through a wholesaler, respectively, as functions of their productivity levels. The line π_W starts from zero since a manufacturing firm does not have to pay any fixed costs when exporting through a wholesaler. However, exporting directly requires paying a fixed cost F_X . The slope of π_W is lower than that of π_X due to the additional markup charged by the wholesaler. A manufacturer with productivity higher than φ_X will always have higher operating profits from exporting on its own ($\pi_X > \pi_W \forall \varphi > \varphi_X$).

Supposing that wholesalers only find it profitable to buy goods with a productivity higher than φ_W means that firms with productivity levels between φ_W and φ_X will prefer to export through a wholesaler rather than on their own. Also, the export cut-off in an economy without wholesalers, φ'_X , will always lie to the left of φ_X , which can be seen in the graph. Note also that since wholesaler prices are higher, they also export smaller volumes per good. The reason that their prices are higher is due to (i) their additional markup and (ii) the fact that they export goods produced by less productive firms.

Finally, equation (14) shows that the degree of competition (the elasticity of substitution across varieties) in a sector affects the productivity cutoff for direct exporting since it determines the impact of the double marginalisation imposed by wholesalers. Less competition (i.e. a smaller σ) means that the cutoff for direct exporting is lower since the wholesaler's additional margin is higher which makes it relatively more expensive to use.

Proposition 4 *The model generates productivity sorting as regards choice of export mode. The most productive firms, $\varphi > \varphi_X$, export their products on their own, firms with intermediate productivity levels, $\varphi \in [\varphi_W, \varphi_X)$, export through wholesalers and the least productive firms, $\varphi \in [\varphi_D, \varphi_W)$, do not export. That $\varphi_D < \varphi_W$ has, however, to be assumed.*

Proposition 5 *Export sales per good are lower for wholesalers than for producers exporting on their own.*

Proposition 6 *Sectors characterised by less competition (low elasticity of substitution) have a lower export cutoff due to the stronger effect of the double marginalisation imposed by wholesalers.*

Proof. See appendix A.1.

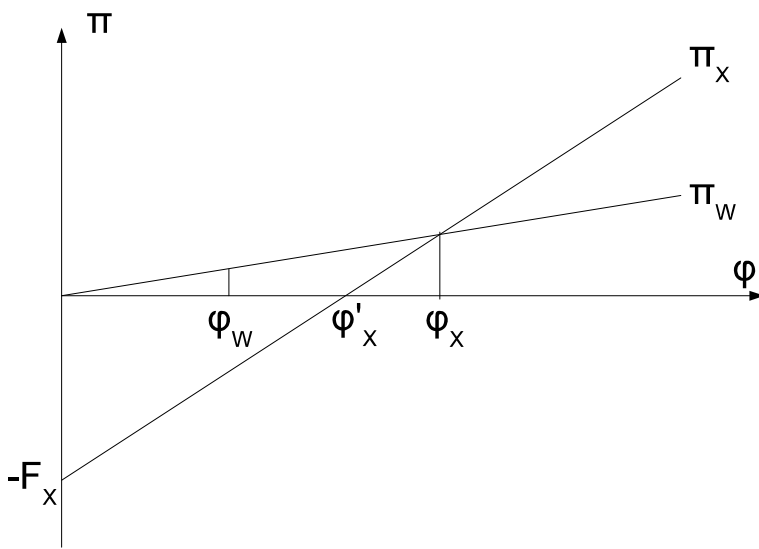


Figure 1: Relative profits for different export modes. π_X indicates the operating profit of a producer which exports on its own and π_W indicates the operating profit of a producer exporting through a wholesaler.

Wholesale firms are homogeneous and I assume that the atomistic manufacturing firms that use wholesalers for the distribution of their goods are randomly matched with wholesaler firms (see figure 2). This ensures that wholesaler firms in equilibrium will, on average, have identical baskets of goods that they export. They will therefore have the same number of products and also the same distribution of productivity among the goods in their baskets.⁷ The scope of goods that wholesaler firms then handle will be equal to the mass of manufacturing firms that use wholesalers for exporting (i.e. those with a level of productivity between φ_W and φ_X). The mass of manufacturers in this range is $M^M \frac{G(\varphi_X) - G(\varphi_W)}{1 - G(\varphi_D)}$ where M^M is the mass of manufacturing firms in total. The scope per wholesaler is then equal to this expression divided by the number of wholesale firms, n^W :

$$m_j^W = \frac{M^M}{n^W} \frac{G(\varphi_X) - G(\varphi_W)}{1 - G(\varphi_D)}. \quad (15)$$

The total fixed cost of a wholesaler, as specified in equation (9) can therefore be written:

$$\begin{aligned} F_{Xj}^W &= F_X + \frac{(m_j^W)^\gamma}{\gamma} \\ &= F_X + \frac{1}{\gamma} \left(\frac{M^M}{n^W} \frac{G(\varphi_X) - G(\varphi_W)}{1 - G(\varphi_D)} \right)^\gamma \end{aligned} \quad (16)$$

where φ_W is the marginal productivity of the least productive manufacturing firm that exports through wholesalers.

A wholesaler takes as given the number of other wholesale firms and the mass of domestic manufacturing firms and its pricing mechanism is, as described in equation (10): a constant markup over the marginal cost. Therefore the number of wholesale firms and the range of goods they consume can be determined by two conditions. First, the free entry condition states that the profits of wholesale firms should be zero. Second, an optimal scope condition by wholesalers, i.e. that the marginal increase in operating profits for a wholesaler firm to expand its set of goods distributed (its scope) must equal the resulting marginal increase in fixed costs, specifies the scope of each wholesale firm.

⁷Wholesalers control more than one good and are therefore no longer atomistic like the manufacturing firms. This could potentially have implications for how they affect prices, but it is assumed here that parameters are such that these baskets of atomistic products are still small enough not to have an effect on the aggregate price level. In a sense, a wholesaler could be labelled ‘moleculistic’, i.e. larger than an ‘atomistic’ firm but still small enough not to have an effect on the aggregate price level. In this context, it can also be noted that in the seminal contributions by, for example, Dixit and Stiglitz (1977) and Krugman (1979, 1980), the distribution of differentiated varieties are discrete and not continuous such as in the more recent trade literature. With a discrete and finite set of varieties, all manufacturing firms are theoretically able to affect the aggregate price index so it has to be assumed that they do not.

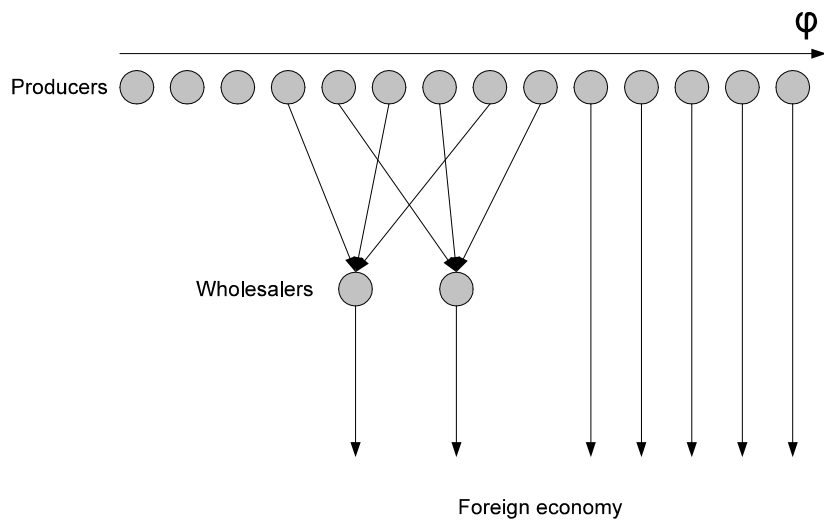


Figure 2: Productivity sorting and export mode.

$$F_X + \frac{(m_j^W)^\gamma}{\gamma} = m_j^W \tilde{\pi}_j^W \quad (\text{Zero profit condition}) \quad (17)$$

$$\frac{\partial}{\partial m_j^W} \left(F_X + \frac{(m_j^W)^\gamma}{\gamma} \right) = \frac{\partial}{\partial m_j^W} (m_j^W \tilde{\pi}_j^W) \quad (\text{Optimal scope}). \quad (18)$$

These two conditions jointly determine the mass of manufacturing firms exporting through each wholesaler, m_j^W , and the weighted average of operating profit per good handled

$$m_j^W = F_X^{\frac{1}{\gamma}} \left(\frac{\gamma}{\gamma-1} \right)^{\frac{1}{\gamma}} \quad (19)$$

$$\tilde{\pi}_j^W = F_X^{\frac{\gamma-1}{\gamma}} \left(\frac{\gamma}{\gamma-1} \right)^{\frac{\gamma-1}{\gamma}}. \quad (20)$$

The fixed cost of exporting, F_X , is the key variable in understanding how the size of wholesaler firms is determined. A larger fixed cost of exporting forces wholesale firms to expand their scope so that the fixed cost is spread across more goods. It also makes the operating profit per good handled to be larger in equilibrium. The parameter determining how difficult it is for wholesalers to handle more goods, γ , also plays an important role. The elasticity of the optimal scope with respect to the fixed cost in equation (19) is $\frac{1}{\gamma}$ which decreases in γ ; the more difficult it is to handle many goods, the less responsive is the scope of wholesalers to fixed costs.

Proposition 7 *The optimal scope of wholesalers increases in the size of the fixed cost of exporting.*

Proposition 8 *The elasticity of the optimal scope of wholesalers with respect to the fixed cost of exporting is lower when it is more difficult for wholesalers to expand their scope (when γ is high).*

To close the equilibrium, I note that the operating profit of wholesaler j selling good i is:

$$\pi_{ij}^W = p_{ij}^W x_{ij} - p_{ij,P} \tau x_{ij} = A^F \tau^{1-\sigma} \varphi_i^{\sigma-1} \left(\frac{\sigma}{\sigma-1} \right)^{1-2\sigma} \frac{1}{\sigma-1}.$$

Therefore, the total operating profit of wholesale firm j is

$$m_j^W \tilde{\pi}_j^W(\varphi_W, \varphi_X) = m_j^W \frac{1}{G(\varphi_X) - G(\varphi_W)} \tau^{1-\sigma} A^F \left(\frac{\sigma}{\sigma-1} \right)^{1-2\sigma} \frac{1}{\sigma-1} \int_{\varphi_W}^{\varphi_X} \varphi^{\sigma-1} dG(\varphi) \quad (21)$$

where $\tilde{\pi}_j^W(\varphi_W, \varphi_X)$ is the average operating profit per good handled given the range of productivity in the basket.

Combining (20), and (21) gives:

$$\frac{1}{G(\varphi_X) - G(\varphi_W)} \tau^{1-\sigma} A^F \left(\frac{\sigma}{\sigma-1} \right)^{1-2\sigma} \frac{1}{\sigma-1} \int_{\varphi_W}^{\varphi_X} \varphi^{\sigma-1} dG(\varphi) = F_X^{\frac{\gamma-1}{\gamma}} \left(\frac{\gamma}{\gamma-1} \right)^{\frac{\gamma-1}{\gamma}} \quad (22)$$

where φ_W is the equilibrium level of the lowest productivity needed for a manufacturing firm to use a wholesaler firm to export.⁸ The export cut-off, φ_X , is determined according to (8) by τ , F_X and A^F . The variable and fixed trade costs are exogenous but A^F is endogenous. Since the left side of (22) is monotonically increasing in φ_W , equation (22) yields an implicit solution for φ_W as a function of A^F .

Using the equilibrium value for φ_W , it is also possible to find a solution for the number of wholesale firms by combining (15) and (19):

$$\frac{M^M}{n^W} \left(\frac{G(\varphi_X) - G(\varphi_W)}{1 - G(\varphi_D)} \right) = F_X^{\frac{1}{\gamma}} \left(\frac{\gamma}{\gamma-1} \right)^{\frac{1}{\gamma}}. \quad (23)$$

Finally, the free entry condition for manufacturing firms says that, in expectation, the expected total profit of entrepreneur must equal the fixed entry cost:

$$\begin{aligned} \int_{\varphi_D}^{\infty} (\varphi^{\sigma-1} A - F_D) dG(\varphi) + \int_{\varphi_W}^{\varphi_X} \left(\varphi^{\sigma-1} \tau^{1-\sigma} A^F \left(\frac{\sigma-1}{\sigma} \right)^{\sigma} \right) dG(\varphi) \\ + \int_{\varphi_X}^{\infty} (\varphi^{\sigma-1} \tau^{1-\sigma} A^F - F_X) dG(\varphi) = F_E. \end{aligned} \quad (24)$$

The set of equations (4), (7), (14), (22), (23) and (24) yield implicit solutions for the productivity cut-offs φ_D , φ_W , φ_X and the mass of wholesale and manufacturing firms, n^W , M^M . The ‘per-firm demand’ A in Home and A^F in Foreign are determined by the mass

⁸There is nothing in the model that ensures that $\varphi_W > \varphi_D$ (that manufacturers exporting through wholesalers need to be more productive than manufacturers producing for the domestic market). This has to be assumed but this restriction is similar to the assumption in the literature that $\varphi_X > \varphi_D$ (that exporters are more productive than nonexporters). In any case, this does not matter for the final results.

of firms, number of wholesalers together with the productivity cutoff levels through the expression for the price levels. This set of equations therefore defines a general equilibrium in the sense that there is free entry in all sectors, and that price levels and market demand are endogenous.

2.3 Imposing the Pareto distribution

To find exact expressions for the importance of wholesalers in the economy, the exact distribution of productivity, $G(\varphi)$ has to be specified. I therefore impose the scale-free Pareto distribution, which has been found to correspond reasonably well with observed distributions of firm productivity, see Axtell (2001) or Luttmer (2007). Now

$$G(\varphi) = 1 - \varphi^{-k},$$

where $\varphi \in [1, \infty)$. For solutions to exist it is also required that $\beta \equiv \frac{k}{\sigma-1} > 1$.

To calculate the relative export volumes that occur by firms exporting on their own versus through wholesalers, it can be noted that the export volume of a good through the two export modes is:

$$V_{i,X}(\varphi_i) = p_i x_i = \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} \tau^{1-\sigma} \varphi_i^{\sigma-1} A^F \quad (\text{direct exporting}) \quad (25)$$

$$V_{j,W}(\varphi_i) = p_{ij}^W x_{ij}^W = \left(\frac{\sigma}{\sigma-1}\right)^{2(1-\sigma)} \tau^{1-\sigma} \varphi_i^{\sigma-1} A^F \quad (\text{wholesale}). \quad (26)$$

The ratio of total export volumes will therefore be

$$\frac{V_W}{V_X} = \frac{\int_{\varphi_W}^{\varphi_X} V_W(\varphi) dG(\varphi)}{\int_{\varphi_X}^{\infty} V_X(\varphi) dG(\varphi)} = \left(\frac{\sigma-1}{\sigma}\right)^{\sigma-1} \left(\left(\frac{\varphi_X}{\varphi_W}\right)^{k-(\sigma-1)} - 1 \right), \quad (27)$$

which is an explicit function of the relative productivity cut-off levels φ_X and φ_W .

The relative mass of firms exporting on their own versus through wholesalers can be written

$$\frac{\int_{\varphi_W}^{\varphi_X} dG(\varphi)}{\int_{\varphi_X}^{\infty} dG(\varphi)} = \left(\frac{\varphi_X}{\varphi_W}\right)^k - 1 \quad (28)$$

which is also an explicit function of the relative productivity cut-offs.

To see what affects the relative importance of wholesalers in both total value, equation (27), and scope, equation (28), it is necessary to understand what affects the relative

productivity cut-off, $\frac{\varphi_X}{\varphi_W}$. An explicit solution for φ_W cannot be found but by evaluating equation (22), the following nonlinear relationship can be found:

$$\frac{\left(\frac{\varphi_X}{\varphi_W}\right)^k - 1}{\left(\frac{\varphi_X}{\varphi_W}\right)^{k-(\sigma-1)} - 1} = \lambda_1 F_X^{\frac{1}{\gamma}} \quad (29)$$

where λ_1 is a constant of parameters.⁹ The expression shows that the relative productivity cut-off increases in the fixed cost of exporting.

First, a higher fixed cost causes the relative productivity cut-off to *increase*. This, therefore, causes: (i) more firms to export through wholesalers (which is equivalent to more varieties or products being exported through wholesalers) and (ii) the relative export volume that is managed by wholesalers to increase. This result originates in the central dynamic provided by the model: the wholesale industry pools the export fixed costs across goods and therefore reduces the fixed cost per good, a feature which is more important when fixed costs are large. We saw previously that a higher fixed cost causes wholesale firms to expand the set of goods that they handle. By doing so, the fixed cost per good decreases. Second, neither the variable trade cost, τ , or per firm demand, A^F , play any role for the choice of export mode. This is due to the fact that for the operating profit, these variables affect wholesalers and direct exporters in identical ways.¹⁰ The wholesale technology therefore exhibits an increasing returns to scale property with regard to product scope. An increase in the product scope lowers the fixed cost *per good*, making wholesalers more important as fixed costs increase.

The net effect of the elasticity of substitution, however, is unclear. As we saw in Proposition 6, more competition (higher σ) causes firms at the margin between choosing direct or wholesale exporting to opt for exporting through wholesalers. This should make σ increase the role played by wholesalers. However, a higher σ also makes price differences more impor-

⁹ $\lambda_1 \equiv \frac{k}{k-(\sigma-1)} \left(\frac{\gamma-1}{\gamma}\right)^{\frac{\gamma-1}{\gamma}} \frac{1}{\left(1-\left(\frac{\sigma-1}{\sigma}\right)^\sigma\right)} \frac{1}{\sigma} \left(\frac{\sigma-1}{\sigma}\right)^{2(\sigma-1)}$.

¹⁰ Distance appears to significantly affect the importance of intermediaries in activities relating to foreign trade in many empirical studies. Indeed, the empirical analysis in this paper shows that wholesalers are more important in distant markets. While contrary to the results of this paper, a range of explanations can be argued to give this pattern. An obvious one is that the fixed cost of entering a foreign market increases with distance, since cultural barriers, supervision costs etc. are larger in markets far away than in those close to the home country of a firm. This would be in line with the theoretical predictions presented here.

Market size per firm, A^F , should not be confused with country size, L . In all theoretical models with a homogenous sector and free entry in the differentiated sector, e.g. Helpman, Melitz, and Yeaple (2004), the market size per firm, $A = \frac{\mu L}{P^{1-\sigma}}$, is in fact the same across countries regardless of population size (since the price level is lower in larger economies). Regardless of assumptions, the entry of firms (which lowers prices) always counterbalances an increase in country size and the net effect depends on assumptions.

tant for revenues and profitability. When the elasticity of substitution is high, the additional markup imposed by wholesalers becomes more important for how much is actually sold and this has a negative effect on the aggregate role played by wholesalers in exporting.

The conclusions above can be summarised in the following two propositions.

Proposition 9 *A higher fixed cost is associated with (i) a higher share of total exports being shipped by wholesalers and (ii) a larger number of firms exporting through wholesalers relative to exporting on their own. This is due to the fact that wholesalers spread the fixed cost of exporting across more goods.*

Proof. The following is a proof that

$$\frac{\partial}{\partial x} \left(\frac{\left(\frac{\varphi_X}{\varphi_W}\right)^k - 1}{\left(\frac{\varphi_X}{\varphi_W}\right)^{k-(\sigma-1)} - 1} \right) > 0 \quad \text{if } \frac{\varphi_X}{\varphi_W} > 1 \text{ and } k > \sigma - 1 > 0.$$

First, the condition for the derivative to be positive can be simplified to

$$\left(\frac{\varphi_X}{\varphi_W}\right)^k (\sigma - 1 - kx^{\sigma-1-k}) + k - (\sigma - 1) > 0.$$

Now, consider the factors of the first term. $\left(\frac{\varphi_X}{\varphi_W}\right)^k$ is minimised when $\frac{\varphi_X}{\varphi_W} = 1$ and $\sigma - 1 - k \left(\frac{\varphi_X}{\varphi_W}\right)^{\sigma-1-k}$ is minimised when $\frac{\varphi_X}{\varphi_W} = 1$ (recall that $\frac{\varphi_X}{\varphi_W} > 1$ and $k > \sigma - 1$). When $\frac{\varphi_X}{\varphi_W} = 1$, the expression on the left hand side is equal to 0. However, as $\frac{\varphi_X}{\varphi_W}$ increases, both $\left(\frac{\varphi_X}{\varphi_W}\right)^k$ and $\sigma - 1 - k \left(\frac{\varphi_X}{\varphi_W}\right)^{\sigma-1-k}$ increase, meaning that the whole expression on the left hand side will increase. Therefore, the condition holds since $\frac{\varphi_X}{\varphi_W}$ has to be *strictly* greater than 1. ■

Proposition 10 *The net effect of the elasticity of substitution on the aggregate importance of wholesalers in exporting is unclear.*

Proof. See appendix A.2.

Finally, if this model was expanded to a multicountry setting, the ratio of the productivity cut-offs, $\frac{\varphi_X^J}{\varphi_W^J}$, to each export destination J would depend on country J 's fixed cost

of entry. Since such costs differ across countries, many manufacturing firms would export directly to some countries but through a wholesaler to other countries. In this case, the equilibrium would contain firms that use both export modes at the same time but not, however, both export modes to the same country. This is the focus of the following section.

2.4 Gravity and Welfare

The model outlined above gives predictions for when wholesale firms are important for aggregate trade flows (both in terms of value of export flows but also in terms of product scope). It also gives predictions for what firms select into which of the two export modes available. The advantage with the setup used so far is that it assumes free entry in both the manufacturing and wholesale industries and therefore generates a general equilibrium model. However, in this section, I make an important modification of the assumptions for two reasons. First, I wish to attain analytically solvable expressions for welfare, which in this model is measured by the price index. Second, I want to compare my model to a version of the model by Melitz (2003) that has become relatively standard in the literature, namely that of Chaney (2008). He estimates the effect of firm heterogeneity on the gravity model and modifies the ‘multilateral resistance’ variable proposed by Anderson and van Wincoop (2003).

This section therefore imposes the same assumptions for the manufacturing sector as Chaney (2008). Most importantly, free entry in the manufacturing sector, as in (24), is restricted.¹¹ Instead, there is a constant number of ‘potential entrants’ in country i , M_i^M , which is proportional to the size of that economy:

$$M_i^M = w_i L_i. \tag{30}$$

This means that the expected profit of firms is no longer zero. Instead, profits are collected into a global fund in which workers own shares according to their income. For comparability, I also assume that the productivity in the homogenous (agricultural) sector differs across countries which generates wage differences across countries. I denote the wage level in country i by w_i . The dividend per share in the global fund is equal to π and is the same across countries. Therefore, the output level in country i is equal to

$$Y_i = (1 + \pi) w_i L_i. \tag{31}$$

¹¹The reason for not choosing this restriction of entry already from the start is that the model generates all the results until this point while allowing for free entry which is the most preferable setup for a general equilibrium model.

The dividend, π , can therefore be written

$$\pi = \frac{\sum_i w_i L_i \left(\int_{\varphi_D^i}^{\infty} \pi_D^i(\varphi) dG(\varphi) + \sum_{j \neq i} \left(\int_{\varphi_X^{ij}}^{\infty} \pi_X^{ij}(\varphi) dG(\varphi) + \int_{\varphi_W^{ij}}^{\varphi_X^{ij}} \pi_W^{ij}(\varphi) dG(\varphi) \right) \right)}{\sum_j w_j L_j} \quad (32)$$

where $\pi_W^{ij}(\varphi)$ indicates the profits of a manufacturing firm with productivity φ from exporting through a wholesaler from country i to country j and $\pi_X^{ij}(\varphi)$ indicates the same but for direct exporting instead. The remaining assumptions are as before and wholesalers are assumed to be present in all countries. This provides the equilibrium conditions for all endogenous variables: $\varphi_D^i, \varphi_X^{ij}, \varphi_W^{ij}, Y^i, n_i^W, P_i \forall i, j$ and π . The variable n_i^W denotes the number of wholesale firms in country i .

Since nominal wages (measured in terms of the numeraire) are determined exogenously by each country's level of productivity in the homogenous sector, the relevant measure of welfare is the price index in the manufacturing sector weighted by the consumption share of manufacturing goods in the utility function: $P_i^{-\mu}$. It turns out that the model generates an expression for the price level of manufacturing goods which is very similar to that found by Chaney (2008):

$$P_i = \lambda_2 Y_i^{\frac{1}{k} - \frac{1}{\sigma-1}} \theta_i$$

where

$$\theta_i^{-k} \equiv \frac{\sum_j \frac{Y_j}{Y_W} w_j^{-k} \tau_{ji}^{-k} (\rho^{ij} F_{ji})^{1-\beta}}{1 - \frac{\sigma\gamma}{\mu(\gamma-1)} \sum_{j \neq i} \frac{n_j^W}{Y_i} F_{ji}} \quad (33)$$

and where ρ^{ij} takes the value 1 if $i \neq j$ and 0 otherwise.¹²

Two components of this result are especially important. First, the presence of wholesalers in other countries, $n_j^W > 0$, lowers the price level in the Home country (country i above) which increases competition there and also raises welfare. Second, an increase in the fixed cost in a model without wholesalers increases the price level. However, when wholesalers are present, the positive effect of an increase in the fixed cost of entry from country j into country i is lower due to the presence of $n_j^W F_{ji}$ in the denominator. Wholesalers therefore mitigate the effect of fixed costs on price levels.

Finally, the variable described in equation (33) is this model's version of the so called 'multilateral resistance' term highlighted by Anderson and van Wincoop (2003), an ag-

¹² $\rho \equiv \frac{1}{1 - \left(\frac{\sigma-1}{\sigma}\right)^\sigma}$ and $\lambda_2 \equiv \left(\frac{\sigma}{\sigma-1}\right)^{\frac{1}{\beta}} \mu^{\frac{1}{k} - \frac{1}{\sigma-1}} \left(\frac{\beta-1}{\beta}\right)^{\frac{1}{k}} Y_W^{-\frac{1}{k}} (1 + \pi)^{\frac{1}{k}}$.

gregate index of the remoteness of country i . Chaney (2008) calculates the multilateral resistance variable with his assumptions and finds:

$$\theta_i^{-k} \equiv \sum_j \frac{Y_j}{\bar{Y}^W} w_j^{-k} \tau_{ji}^{-k} F_{ji}^{1-\beta}. \quad (34)$$

A comparison of equations (33) and (34) shows that the expressions are virtually identical except for the entry of ρ in the numerator and the effect of wholesale firms in the denominator. Since $n_j^W > 0$, it is therefore the case that the presence of wholesale firms lowers the price index in all countries and increases both welfare and competition as compared to the standard model in Chaney (2008). This effect is especially strong in bilateral relationships characterised by high fixed costs of entry. Moreover, it can be seen that the presence of wholesale firms (higher n_j^W) mitigates the effect of a higher fixed cost on the price level.

Proposition 11 *The presence of wholesalers in the economies of trading partners lowers a country's price index and increases welfare and competition in this country. Moreover, the presence of wholesalers mitigates the effect of an increase in the fixed cost on the price index.*

3 Empirical evidence

3.1 Data

The data on trade is based on Swedish firm data from 2005 (the most recent year for which such data is available) which includes all active firms in Sweden. A firm in this dataset is classified according to its main activity, and the analysis will utilise firms that are listed as 'wholesalers' and firms active in any of the manufacturing sectors. Only exporting firms are used and in 2005 there were 7,281 wholesaler firms exporting and 8,798 manufacturing firms.¹³ The trade data is from Swedish Customs and records all trade flows per firm, product code (according to the Combined Nomenclature, CN, up to 8 digits) and destination country. For 2005, there are in total 469,437 transactions reported over 8,283 CN8 categories and 194 destination countries.

¹³Firms with no employees are excluded.

TABLE 1

Descriptive statistics (only exporting firms included)					
	Wholesalers	Manufacturers		Wholesalers	Manufacturers
Number of firms	7 281	8 798			
Total exports (1000 SEK)			Capital intensity (%)		
Mean	14 973	76 065	Mean	21	24
10th perc.	7	9	10th perc.	0.6	1.0
Median	237	622	Median	4	11
90th perc.	16 454	65 547	90th perc.	40	47
Product scope (CN8)			Labour intensity $\left(\frac{\text{employees}}{\text{MSEK output}}\right)$		
Mean	11	8	Mean	1.3	0.8
10th perc.	1	1	10th perc.	0.5	0.3
Median	3	3	Median	1.0	0.7
90th perc.	22	18	90th perc.	2.0	1.4
Export destinations			Turnover (1000 SEK)		
Mean	4.2	7.5	Mean	26 500	160 000
10th perc.	1	1	10th perc.	969	2 235
Median	2	2	Median	5 721	16 600
90th perc.	11	22	90th perc.	42 000	185 000

Due to the extreme detail of the CN8 classification, I use the number of CN8 categories exported by a firm as a proxy for the number of products exported by a firm. A CN8 category can therefore be seen as a manufacturing variety (or a product, the two are equivalent in the model) in the analysis. CN4 categories (Combined Nomenclature at the four-digit aggregation level) will be used as a control for a more aggregated sector classification. Any reference in the following text to 'sectors' therefore refer to CN4 aggregates.

The average number of CN8 product categories that a firm exported was 11 for wholesalers and 8 for manufacturers. However, manufacturers were much larger and accounted for 86% of aggregate export volumes (measured in Swedish currency).

As for market size (GDP) and the institutional variables used, all data comes from the World Bank's World Development Indicators (WDI) and Doing Business databases. Distance measures are from Centre d'Etudes Prospectives et d'Informations Internationales (CEPII).

Table 1 reports descriptive statistics for exporting wholesalers and manufacturers.

3.2 Main assumption and predictions

This section will assess empirically the main assumption on which the model builds and also the four main hypotheses that it gives. The underlying assumption of the model is that the wholesale technology is characterised by economies of scope, while that of manufacturers is not. This is a somewhat stylised assumption used in order to focus on the dynamics linked to a case in which wholesalers have *more* economies of scope compared to manufacturers (that wholesalers have a comparative advantage in generating economies of scope in exporting). We already know from a vast literature that manufactures often sell more than one product and that firms doing so are often very important. However, one way to see whether the assumption of this paper makes sense is to look at whether wholesalers on average sell more products than manufacturers, generally and when controlling for different characteristics of these firms such as sector, export destinations and productivity. This is done first in the empirical section.

The main empirical predictions of the model are:

1. *Export sales per good are lower for wholesalers than for producers exporting on their own (Proposition 5).*
2. *A larger share of aggregate export volumes is handled by wholesalers to countries with high fixed costs of entry (Proposition 9).*
3. *A larger share of the number of exported goods is handled by wholesalers to countries with high fixed costs of entry (Proposition 9).*
4. *Producers sort according to productivity when choosing export mode (Proposition 4).*

The first prediction originates from the fact that goods sold abroad through wholesalers are produced in a less productive way than other export goods and the fact that wholesalers charge an additional markup. The following two predictions, however, are both related to the core mechanism highlighted in the theoretical section: when fixed costs increase, the

ability of wholesalers to generate economies of scope by spreading the fixed cost of entry across more goods becomes more valuable. Variation in both variables listed is therefore driven by the variation in fixed costs. Measures of fixed costs of entry are always imperfect but a reasonable proxy would be measures of institutional quality which relate to trade and these are used in the analysis.

Finally, one important prediction remains which I cannot test with the data currently at hand: that manufacturing firms sort according to productivity as regards export mode (Result 4). Due to the fact that intermediated exporting, as opposed to direct exporting, entails a lower fixed cost but a higher variable cost, it follows that, in a framework as in Melitz (2003), the most productive firms will choose to export on their own while firms with intermediate productivity will choose to export through a wholesaler. Since I cannot observe sales by manufacturers to wholesalers inside Sweden, I do not test the prediction of productivity sorting and export mode. However, early evidence by, for example, Abel (2010) and McCann (2010), builds on a dataset provided by the World Bank which includes a sample of firms from several different developing countries. Interestingly, this data includes mode of export, and both authors find robust evidence that the firms which choose direct exporting are more productive than those which choose indirect exporting.

3.3 Economies of scope

As stated, the underlying assumption of the paper is that the wholesale technology is characterised by economies of scope: wholesale firms are able to distribute more than one product internationally. We know, however, that many manufacturers in reality distribute more than one good but the theoretical section is set up such that the effect of a difference between wholesalers and manufacturers is seen in its simplest form. One way to test this assumption in the data, however, would be to see whether wholesalers, on average, export more products controlling for firm size, destination and sector effects. I do this by running the following OLS regression:

$$Scope_{isc} = \alpha + \beta W_i + \gamma size_i + f_s + f_c + \varepsilon_{ijl} \quad (35)$$

where $Scope_{isc}$ denotes the number of CN8 product codes exported by firm i to country c in sector s . W_i takes the value 1 if the product is sold by a wholesale firm and 0 if it is sold by a manufacturer. The variable $size_i$ denotes the logarithm of revenues of firm i and is included since it is well known that larger firms tend to produce and export a wider scope of products. To account for characteristics of specific product categories and specific markets, fixed effects are included for sectors, f_s , and destination countries, f_c . Otherwise, if wholesalers export within different categories than manufacturers, or serve different markets, the coefficient

might be biased. Finally, it is quite possible that the errors are correlated within countries. This would yield artificially low estimates of the standard errors given that the number of destinations is relatively low (194 countries are included) but the number of observations fairly high (there are 96,273 combinations of firms and destinations).¹⁴ The standard errors reported here are therefore clustered at the country level.

The coefficient β measures how much larger the product scope per country is for wholesalers compared to manufacturers. The assumption used in the paper would correspond to β being positive. Table 2 reports the results.

TABLE 2

	(1)	(2)	(3)
Dep. variable: Product scope per firm and destination (in logarithms)			
Wholesale dummy	0.144*** (0.0493)	0.0976* (0.0414)	0.443*** (0.0463)
Firms size (in logarithms)			0.216*** (0.0099)
Fixed effects			
Destination	NO	YES	YES
Observations	96 273	96 273	96 130
R^2	0.005	0.052	0.194

The dependent variable is the logarithmic value of the number of CN8 products exported by each firm. The explanatory variables are (i) a dummy for whether the firm is classified as a wholesaler according to Statistics Sweden and (ii) the logarithmic value of firms' revenues. Standard errors are clustered at the country level and reported in parentheses. All regressions include destination specific effects.

*** p<0.01, ** p<0.05, * p<0.1.

It can be seen that estimated difference in scope is positive and significant in all columns, which supports the main assumption used in the theoretical section. When the size of firms

¹⁴See Donald and Lang (2007) for a discussion on how the estimated standard errors from a standard OLS regression can be artificially low if the number of observations is very large but the number of groups (within which the error terms can be correlated) is low.

is not included, the difference is not too large and around 10%. But when I take into account that wholesalers are much smaller in size, on average, by including the logarithm of firms' revenues, the estimated difference is fairly large, around 0.43 (translating into a 56% difference). This is a fairly large number given that the average product scope of firms is around 10. I therefore conclude that there is an important difference in terms of scope between wholesalers and manufacturing firms.

3.4 Export sales per product

This part examines whether sales per good are lower for wholesalers than manufacturers. The theoretical motivation for this is that wholesalers handle goods that are produced with lower productivity than manufacturers and are therefore more expensive. Moreover, wholesalers need to charge an extra markup which exporting manufacturers do not.

As noted, manufacturers account for 86% of aggregate exports which gives an indication that this prediction holds. However, to account for effects that are specific for products and destination countries, a regression analysis using fixed effects for these variables is carried out.

The regression equation is:

$$x_{ipc} = \alpha + \beta W_i + \gamma size_i + f_p + f_c + \varepsilon_{ipc} \quad (36)$$

where x_{ipc} is the logarithm of the value of exports of product p by firm i to country c . The coefficient β therefore measures the difference in export levels *per good* between wholesalers and manufacturers. It is possible that the error terms are correlated within countries and the standard errors reported here are therefore clustered at the country level. It is, of course, possible, that the errors are correlated at the product level too but since the product categories are of such detail (there are 8,283 HS8 categories) this is most surely of less worry than any correlation at the country level. Indeed, the standard errors are substantially smaller when they are clustered at the product level instead of the country level. Table 3 lists the result of these regressions.

TABLE 3

	(1)	(2)	(3)	(4)	(5)
Dep. variable: Log(export value)					
Wholesale dummy	-0.687*** (0.0562)	-0.399*** (0.0403)	-0.770*** (0.0563)	-0.540*** (0.0475)	-0.543*** (0.0828)
Firm size (in logarithms)					-0.00186 (0.0276)
Fixed effects					
Product	NO	YES	NO	YES	YES
Destination	NO	NO	YES	YES	YES
Observations	469 437	469 437	469 437	469 437	468 710
R^2	0.013	0.236	0.033	0.464	0.465

The dependent variable is the logarithmic form of the value of exports of firms for each product and destination. The explanatory variables are (i) a dummy for whether the firm is classified as a wholesaler according to Statistics Sweden and (ii) the logarithmic value of firms' revenues. Standard errors are clustered at the country level and reported in parenthesis. All regressions include fixed effects as specified.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The regressions indicate that wholesalers, on average, sell between 33% and 54% less of a given product to a given country. The negative effect is significant at the 1% level for all four combinations of fixed effects. The results therefore suggest that the prediction holds: wholesalers sell less per good than producers. The change in magnitude of the estimated difference, when I include fixed effects, is of some magnitude (which means that there is some selection of firms, especially as regards product categories). This effect, however, is not large and the results are qualitatively similar. The effect of including the size of firms does not influence the outcome either.

3.5 Importance of wholesalers and fixed costs in destination countries

Regarding predictions 2 to 3, the explanatory variable is the fixed cost of entry in both cases. Therefore, these predictions will be examined in the same context in this section. The theory states that a higher fixed cost increases the importance of the wholesalers' ability of generating economies of scope. Wholesalers are able to spread the fixed cost across several products and are therefore better equipped to export to markets where the fixed cost is high. They therefore also control a larger share of export volumes and export scope to markets with higher fixed costs of entry.

I will use measures of institutions relating to international trade as proxy variables for fixed costs of foreign market entry. These variables have to fulfill two criteria: (i) they have to be a relevant proxy for fixed costs in international trade, and (ii) they have to be available for a large enough number of countries. This leads to the choice of the following measures from the World Bank: (i) the time required to start a business, (ii) the number of procedures needed to open a warehouse, (iii) the time required to open a warehouse, and (iv) the cost, time and number of documents needed to import.¹⁵ These variables are arguably reasonable proxies for the type of fixed costs present in the model.

To see the effect that fixed costs have on the importance of wholesalers, the following regressions are used:

$$\left(\frac{V_W}{V_W + V_X}\right)_{sc} = \beta_0 + \beta_1 Q_c + \beta_2 Y_c + \beta_3 dist_c + f_s + \varepsilon_i \quad (37)$$

$$\left(\frac{N_W}{N_W + N_X}\right)_{sc} = \beta_0 + \beta_1 Q_c + \beta_2 Y_c + \beta_3 dist_c + f_s + \varepsilon_i \quad (38)$$

where $\left(\frac{V_W}{V_W + V_X}\right)_{sc}$ denotes wholesalers' share of aggregate export volumes in sector s (a sector here is a CN4 category) to destination country c , $\left(\frac{N_W}{N_W + N_X}\right)_{sc}$ the share of CN8 products handled by wholesalers in sector s which are exported to country c , Q_c the institutional measure for country c (logarithmic values are used), Y_c the level of GDP of country c , $dist_c$ the distance from Sweden to country c and f_s a sector fixed effect. Both GDP and distance are in logarithms as well. Fixed effects are used here to control for technological differences in export mode across sectors. In this and the following section, only product and destination pairs where wholesalers are active are included in the analysis, since this is

¹⁵The first three variables (reported in Table 4a) are collected from the World Bank's World Development Indicators and the last three (Table 4b) are from the World Bank's Doing Business Survey. The last three variables were not available for 2005 so instead data from 2006 is used.

the situation on which the model focuses.

As regards the error terms, these are likely to be correlated both within countries as well as within sectors. I therefore apply the multiway clustering method as described in Cameron, Gelbach, and Miller (forthcoming) and cluster on both destination and sector.

TABLE 4a

	(1)	(2)	(3)	(4)	(5)	(6)
	Share of total exports handled			Share of scope handled		
Dep. variables:	by wholesalers			by wholesalers		
Time to start business	0.0203** (0.00993)			0.0191*** (0.00695)		
Procedures to open a warehouse		0.0396** (0.0173)			0.0273*** (0.00914)	
Time to open a warehouse			0.0212 (0.0137)			0.0157 (0.00969)
GDP	-0.0558*** (0.00495)	-0.0575*** (0.00506)	-0.0574*** (0.00491)	-0.0364*** (0.00325)	-0.0382*** (0.00348)	-0.0380*** (0.00343)
Distance	0.0477*** (0.0127)	0.0490*** (0.0127)	0.0498*** (0.0131)	0.0271*** (0.0101)	0.0288*** (0.0103)	0.0292*** (0.0107)
Fixed effects						
Sector (CN4)	YES	YES	YES	YES	YES	YES
Observations	21 779	21 779	21 779	21 779	21 779	21 779
R^2	0.50	0.50	0.50	0.51	0.50	0.50

The dependent variable is the relative importance of wholesalers relative to manufacturing firms in exporting, both in terms of total value of exports as well as product scope. The explanatory variables are the logarithmic values of institutional measures from the World Bank as well as GDP and distance. All regressions are run at the sector (CN4) and destination level. Standard errors in parentheses. These are clustered on both destination and sector (CN4) according to the multiway clustering method described in Cameron, Gelbach and Miller (forthcoming). All regressions include fixed effects at the CN4 sector level.

*** p<0.01, ** p<0.05, * p<0.1.

TABLE 4b

	(1)	(2)	(3)	(4)	(5)	(6)
	Share of total exports handled			Share of scope handled		
Dep. variables:	by wholesalers			by wholesalers		
Documents to import	0.0791*** (0.0203)			0.0505*** (0.0153)		
Cost to import		0.0260 (0.0218)			0.0320** (0.0151)	
Time to import			0.0672*** (0.0138)			0.0463*** (0.00960)
GDP	0.0539*** (0.00502)	-0.0566*** (0.00525)	-0.0490*** (0.00461)	-0.0353*** (0.00342)	-0.0364*** (0.00364)	-0.0318*** (0.00315)
Distance	0.0343*** (0.0119)	0.0473*** (0.0136)	0.0303*** (0.0115)	0.0189*** (0.00948)	0.0255*** (0.0109)	0.0153* (0.00895)
Fixed effects						
Sector (CN4)	YES	YES	YES	YES	YES	YES
Observations	21 707	21 707	21 707	21 707	21 707	21 707
R^2	0.50	0.50	0.51	0.51	0.50	0.51

See Table 4a.

Tables 4a and 4b report the regression result for equations (37) and (38). All the measures of institutional qualities have positive signs in the regression and almost all are significant.¹⁶ If these variables are good proxies of the fixed cost of entering a specific market, then the regression results mean that wholesalers are more important, both in quantity and scope, for entering markets characterised by large fixed costs.

Distance appears to significantly affect the importance of wholesalers and with a positive sign. As argued before, this is not directly implied by the theoretical model but could still be in line with it. An obvious explanation is that distance not only affects the variable trade cost but also the fixed costs involved in exporting. The fixed cost of entering a foreign market may very well increase with distance since cultural barriers, supervision costs etc. are obviously larger in markets far away than those close to the home country of a firm.

¹⁶If the standard errors are not clustered, all coefficients are significant at the one percentage significance level, indicating that the errors are correlated within countries and sectors.

Regarding the effect of GDP, this is not captured in the theoretical model either. In any case, I do not claim that the theoretical model explains all aspects of intermediated trade, instead it focuses on one dynamic involved and this relates most strongly to fixed costs.

4 Conclusion

The paper presents a model that gives a rationale for the presence of wholesalers and intermediaries in international trade. Wholesalers possess a technology that allows them to use their international distribution network to handle more than one good (although the fixed cost increases in the number of goods they handle), while the producers of these goods (manufacturing firms) can only export their own good. In order to cover the fixed cost of exporting, wholesalers charge a markup between the price at which they procure the good and the final price that they charge in the foreign country. This markup causes manufacturing firms to export on their own as long as they are productive enough to cover the fixed cost of doing so. However, if they are not productive enough, they will instead try to sell their good to the foreign market through a wholesaler's distribution network. This process results in productivity sorting in the choice of export mode: the most productive firms export on their own while less productive firms export through wholesalers. The least productive firms do not export at all.

When aggregated, this generates new results for what affects the importance played by wholesalers in international trade, especially for the share of exports as well as the share of products that are shipped through wholesalers' networks. The fixed cost of exporting plays an important role: the higher the fixed cost of exporting, the more important are wholesalers. This is the case since wholesalers can spread the fixed cost over several goods, as opposed to manufacturing firms, which need to incur one fixed cost for their single good. As fixed costs become more important, firms shift to exporting through wholesalers (which expand the number of goods they handle) to benefit from the lower fixed costs per good exported. Wholesalers therefore assist those firms which are not productive enough to export on their own to do so.

This microeconomic foundation is also used to derive equilibrium price indices in a multicountry framework. It is found that the presence of wholesalers lowers price indices in countries with which they trade. Therefore, wholesalers increase welfare and competition in these countries. Finally, the presence of wholesalers mitigates the effect of fixed costs on price levels.

The empirical section supports the main assumption and predictions of the model. First,

Swedish wholesalers export a broader range (56%) of products than manufacturers. Second, wholesalers export smaller amounts of each product, even when the effect of which particular product it concerns or which country the good is exported to is controlled for. Finally, wholesalers are more important, both in quantity and scope, for markets characterised by high fixed costs. The empirical analysis therefore supports the notion that wholesalers play a larger role in exporting to countries characterised by larger fixed costs of entry.

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A Appendix

A.1 Proof to Proposition 6

I define

$$v \equiv \log \left(\left(\frac{\sigma - 1}{\sigma} \right)^\sigma \right) = \sigma \log \left(\frac{\sigma - 1}{\sigma} \right).$$

This means that:

$$\begin{aligned} v' &= \log \left(\frac{\sigma - 1}{\sigma} \right) + \frac{1}{\sigma - 1} \\ v'' &= -\frac{1}{\sigma(\sigma - 1)^2}. \end{aligned}$$

Therefore:

$$\begin{aligned} \lim_{\sigma \rightarrow 1^+} v &= -\infty \\ \lim_{\sigma \rightarrow \infty} v &= \lim_{\sigma \rightarrow \infty} v' = 0 \end{aligned}$$

where l'Hôpital's rule is used in the second equality. To find the sign of v' , I note that

$$v'' = -\frac{1}{\sigma(\sigma - 1)^2} < 0.$$

The limit values of v' are

$$\begin{aligned} \lim_{\sigma \rightarrow 1^+} v' &= \infty \\ \lim_{\sigma \rightarrow \infty} v' &= 0. \end{aligned}$$

Since we know that v' decreases in σ at all possible values of σ (because $v'' < 0$) and approaches zero when $\sigma \rightarrow \infty$, it must therefore always be strictly positive in the space $\sigma \in (1, \infty)$. Therefore, we know that v always increases in σ . Furthermore, we know that $\left(\frac{\sigma - 1}{\sigma} \right)^\sigma \in (0, 1)$ since $\lim_{\sigma \rightarrow 1^+} e^{v(\sigma)} = 0$, $\lim_{\sigma \rightarrow \infty} e^{v(\sigma)} = 1$ and $v' > 0 \quad \forall \sigma \in (1, \infty)$. ■

A.2 Proof to Proposition 10

Equation (29) can be rewritten as

$$u\left(\frac{\varphi_X}{\varphi_W}, \sigma\right) = \theta(\sigma) v(\sigma)$$

where

$$\begin{aligned} u\left(\frac{\varphi_X}{\varphi_W}, \sigma\right) &\equiv \frac{\left(\frac{\varphi_X}{\varphi_W}\right)^k - 1}{\left(\frac{\varphi_X}{\varphi_W}\right)^{k-(\sigma-1)} - 1} \\ v(\sigma) &\equiv \frac{1}{\sigma} \left(\frac{\sigma-1}{\sigma}\right)^{2(\sigma-1)} \\ \theta(\sigma) &\equiv \frac{1}{\left(1 - \left(\frac{\sigma-1}{\sigma}\right)^\sigma\right)} \frac{k}{k - (\sigma-1)} F_X^{\frac{1}{\gamma}}. \end{aligned}$$

Then, the total derivative of equation (29) can be formulated as

$$\begin{aligned} u \frac{\varphi_X}{\varphi_W} d\left(\frac{\varphi_X}{\varphi_W}\right) + u_\sigma d\sigma &= (\theta_\sigma v + \theta v_\sigma) d\sigma \\ \frac{d\left(\frac{\varphi_X}{\varphi_W}\right)}{d\sigma} &= \frac{\theta_\sigma v + \theta v_\sigma - u_\sigma}{u \frac{\varphi_X}{\varphi_W}}. \end{aligned} \tag{39}$$

We know that $u \frac{\varphi_X}{\varphi_W}$ is positive from the proof to Proposition 9. Then,

$$u_\sigma = \frac{\left(\frac{\varphi_X}{\varphi_W}\right)^k - 1}{\left(\left(\frac{\varphi_X}{\varphi_W}\right)^{k-(\sigma-1)} - 1\right)^2} \left(\frac{\varphi_X}{\varphi_W}\right)^{k-(\sigma-1)} \log\left(\frac{\varphi_X}{\varphi_W}\right) > 0$$

since $\frac{\varphi_X}{\varphi_W} > 1$ and $k > (\sigma - 1)$.

Turning to v_σ , evaluating the sign of the derivative of $\log v(\sigma)$ instead of $v(\sigma)$ is equiv-

alent since the logarithm is a monotonic transformation.

$$\begin{aligned}
\log v(\sigma) &= -\log \sigma + 2(\sigma - 1) \log \left(\frac{\sigma - 1}{\sigma} \right) \\
\frac{\partial}{\partial \sigma} \log v(\sigma) &= 2 \log \left(\frac{\sigma - 1}{\sigma} \right) + \frac{1}{\sigma} \\
\frac{\partial^2}{\partial \sigma^2} \log v(\sigma) &= \frac{\sigma + 1}{\sigma^2 (\sigma - 1)} \\
&= \frac{1}{\sigma^2} \left(\frac{\sigma + 1}{\sigma - 1} \right) > 0
\end{aligned}$$

since $\sigma > 1$. Since the second derivative is always positive, the first derivative will have its maximum when σ approaches infinity. The first derivative must therefore always be negative since $\lim_{\sigma \rightarrow 1^+} \frac{\partial}{\partial \sigma} \log v(\sigma) = -\infty$ and $\lim_{\sigma \rightarrow \infty} \frac{\partial}{\partial \sigma} \log v(\sigma) = 0$. Therefore, $\frac{\partial}{\partial \sigma} \log v(\sigma) < 0$ and also $\frac{\partial}{\partial \sigma} v(\sigma) < 0 \quad \forall \sigma \in (1, \infty)$.

However, we also know that $\theta_\sigma > 0$ since

$$\frac{\partial}{\partial \sigma} \left(\frac{1}{\left(1 - \left(\frac{\sigma-1}{\sigma}\right)^\sigma\right)} \right) > 0$$

from the proof to Proposition 6. This means that the net effect in the numerator in equation (39) is unclear since $\theta_\sigma > 0$ but v_σ and $-u_\sigma$ are negative. ■