Fixed Costs per Shipment

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Abstract

Exporting firms do not only decide how much of their products they ship abroad but also at which frequency. Doing so, they face a trade-off between saving on fixed costs per shipments (by shipping large amounts infrequently) and saving on storage costs (by delivering just in time with small and frequent shipments). The firm's optimal choice defines a mapping from size and frequency of shipments to fixed costs per shipment. We use a unique dataset of Swiss cross-border trade on the transaction level to analyze the size and shape of the underlying fixed costs. The data suggest that for the average Swiss exporter the fixed costs per shipment are economically important: about one percent of the value of export or at a net present value of 7790 CHF. We document that the imputed fixed costs per shipment correlate negatively with language commonalities, trade agreements and geographic proximity.

Keywords: Trade costs, shipment, firm trade.

JEL Classifications: F10.

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1 Introduction

Fixed costs of exporting form a centerpiece of the broad literature following Melitz (2003). These costs divide the set of heterogeneous firms into highly productive exporters and less productive local sellers, generating rich trade patterns on the aggregate and the firm level alike.

Fixed costs of exporting are generally thought to decompose into the fixed costs of market entry and per-period fixed costs. These two components of trade costs are equivalent for trade flows in the static setup that is usually explored.[1]

In the present paper we introduce and analyze the concept of *fixed costs per shipment*. These fixed costs accrue by organizing the collection, insurance and delivery of goods on a per-shipment basis. Thus, they comprise the monetary equivalent of the time spent to view and bundle orders, fill in customs forms, organize trade credit, monitor and coordinate the transportation to the receiver. Exporting firms can, for any given quantity of yearly exports, save on fixed costs per shipment by shipping more at a time and paying storage costs at destination. Striking the optimal trade-off between these costs determines the frequency and the size of shipments as a function of standard parameters of demand, technology, and interest rates.

Our theory implies that expansions of trade volumes generally come along with a rise in the number of shipments and in the value per shipment. Economic conditions that tend to promote trade do generally increase the frequency and the size of shipments. We also show that these two observable variables – the frequency and the size of shipments – constitute sufficient statistics to quantify the fixed costs per shipment. With firm-level observations of these two variables one can thus infer the fixed costs per shipment.

In an empirical part, we use transaction-level data from Swiss exporters to quantify fixed costs per shipment according to our theory. The inferred fixed costs per shipment are economically important: on average, their net present value is about 7 790 CHF, which translates into a tariff-equivalent of 1.01 percent.

We further exploit the country variation of our data to estimate the impact of some determinants on the imputed fixed costs per shipment. Thus, a *common language* is associated with a 54% reduction, the existence of a *trade agreements* with a 41%

[1] More precisely, in steady state all relevant endogenous variables are unchanged as long as the sum of the net present value of both types of fixed costs is constant.

reduction and finally, the doubling of bilateral *distance* with a 7% increase in fixed costs per shipment. All of these effects are statistically significant independent of the inclusion of standard determinants of trade flows such as market size and per capita income. Finally, our data allow us to estimate whether the transportation mode correlates with fixed costs per shipment. Read with due caution, the analysis suggests that transportation per rail and per ship are associated with very high fixed costs per shipment compared to the fixed costs for transactions on the road.

Introducing fixed costs per shipment has a number of novel implications for trade theory. First, trade flows gains an additional margin through which they adjust: the traditional intensive margin (on the firm level) decomposes into frequency and the size of shipments. Our theory predicts that trade volumes generally expand along the two margins: the number of shipments and the value per shipment. An exception to this general rule occurs when fixed costs per shipment drop. In this case, the total trade volume and the number of shipments increases, while the value per shipment decreases.

Second, the concept of fixed costs per shipment smudges the border between fixed costs of exporting and variable costs of exporting. Thus, fixed costs per shipment are substitutable with variable storage costs: a firm can reduce one type of cost and increase the other by shipping goods more or less frequently. At the same time, fixed costs are roughly proportional to the value of shipments, which has important implications for empirical work measuring different components of trade costs. In particular, a firm that increases its yearly export volume also increases its shipment frequency. Thus, the fixed costs per shipment are roughly proportional to total export values in periodically reported trade data.[2] Being proportional to trade volumes, fixed costs per shipment are usually disregarded in studies measuring fixed costs of exports. For example, Das et al (2007) measure market entry costs and per-period fixed costs of exporting, while subsuming fixed costs of shipments under variable trade costs.[3] While the exact classification of fixed costs per shipment as part of fixed or variable costs may not appear be all that crucial, the empirical finding of zero per-period fixed costs has strong implications for theories of transition

[2] Also, common measures of variable trade costs like the cif/fob ratio incorporate the fixed costs per shipment. Prominent studies such as Baier and Bergstrand (2001) use the cif/fob ratio as a measure of variable transport costs.

[3] More precisely, Das et al (2007) implicitly subsume all trade costs that accrue proportional to trade volumes under market-specific production costs (see equation (4) in Das et al (2007) and the relevant discussion in footnote 6). These costs include the fixed costs per shipment, which are therefore not part of the estimatesd per-period fixed costs.

dynamics of trade. Indeed, Chaney (2005) emphasizes that the presence of per-period fixed costs has strong implications for transition dynamics of trade flows. Also, the absence of per-period fixed costs would be fatal for recent studies such as Segura-Cayuela and Vilarrubia (2008) or Irarrazabal and Opromolla (2009).[4] To the extent that fixed costs per shipment take on the role to per period fixed costs, they can reestablish the *raison d'être* for the studies mentioned. We therefore suggest that transition dynamics be analyzed within an adapted setup where the shipment frequency – or, equivalently, the length of a period – is endogenous.

By endogenizing the time between either two shipments for a given firm and export market, we raise the question about the adequate definition of exporter-status. Specifically, a firm that ships products twice a year will report zero exports at least every second quarter. Based on quarterly data, this firm will experience exits and re-entries, while it will be always considered to be a exporter based on a definition using yearly data. That distinction is central for the correct procedure to measure fixed costs of (re-) entry to export markets.[5]

Finally, when the cost of re-entry into an export market is a function of the length of the period of absence from that market, such dynamics should affect the optimal strategies of firms. One may thus ask how the shipment frequency evolves when learning reduces fixed costs per shipment similar to the framework of Segura-Cayuela and Vilarrubia (2008).[6] Our paper provides a framework to address such questions.

About a decade ago, the continuous rise of trade volumes and a secular decline of tariffs and measured transport costs suggested that trade costs had lost their prominent role. Baier and Bergstrand (2001) drew renewed attention to trade barriers by highlighting their role as a determinant of the rise in global trade volumes. Shortly after, Anderson and van Wincoop (2004) put forward that trade costs are still substantial in absolute size and in terms of economic impact. Recognizing the importance of trade cost Jacks, Meissner and Novy (2008) and Novy (2011) offer

[4] Segura-Cayuela and Vilarrubia (2008) study learning about an ex-ante "unknown per-period cost of presence in the foreign market," while Irarrazabal and Opromolla (2009) rely on the concept of per-period fixed costs to study exporters dynamics. Ruhl (2008), on the other hand, studies responses of trade to transitory or permanent terms of trade shocks, relying on the assumption that fixed costs are paid up front.

[5] Das et al (2007) find that firms "tend to continue exporting when their current net profits are negative, thus avoiding the costs of reestablishing themselves in foreign markets when conditions improve."

[6] On the one hand, a reduction of fixed costs per shipment should increase the shipment frequency; on the other hand, forward-looking firms may want to ship frequently right after market entry in an attempt to accelerate the learning process.

a novel way of estimating the combined magnitude of all macroeconomic frictions that impede international trade.

Our paper is not the first to study economies of scale in transaction technologies. Burnstein and Melitz (2011) explore the role of sunk costs, concluding that macroeconomic dynamics "can vary greatly over time depending on those modeling ingredients." Analyzing the liberalization of transportation services and the indirect effect through enhanced trade in goods, Deardorff (2001) explicitly models the transportation sector including fixed costs per shipment. More closely related to our paper, Alessandria et al (2010) and Alessandria, Kaboski and Midrigan (2011) analyze optimal inventory management of importers under stochastic demand with fixed costs of importing and transportation delays. In line with our finding that larger export volumes come along with higher shipment frequency, the authors report that "[f]irms with high demand deplete more of their current inventory holdings and import more readily." The calibration of their model indicates that fixed costs per shipment amount "to approximately 3.6 percent of the average value of an import shipment," which is higher than our estimates.[7] While the calibration in Alessandria et al (2010) aim to match the lumpiness of monthly U.S. trade, and the inventory holdings of Chilean importing plants, our estimation exercise exclusive relies on one coherent datasource, with very detailed information on the shipment level.

Other studies have addressed fixed costs of exporting. Das et al (2007) structurally estimate fixed costs of entry to export markets and report a range of average entry costs range between $344,000 and $430,000 U.S. dollars. At the same time, the authors find that annual fixed costs of exporting are close to zero (see also Roberts and Tybout (1997)). Hummels and Skiba (2004) provide strong evidence against iceberg type of transportation costs. Anderson and Yotov (2010) analyze the proportions of trade costs paid by sellers and buyers, showing that the *incidence* of trade costs has important implications for the home bias, the disproportionate predicted share of local trade and the gains from trade. Recently, Harrigan (2010) investigates the choice of transportation mode (air versus ground) on trade patterns. The present paper adds to this literature by imputing one specific one component of trade costs, namely fixed costs per shipment, from trade transaction observables.[8]

Yet another strand of the literature addresses export transactions and transporta-

[7]The reason for this discrepancy is that in Alessandria et al (2010) storage cost is assumed to as high as 30 percent per year. The substitutability between both costs then requires a correspondingly high fixed costs per shipment to justify a given frequency of shipments.

[8]Békés et al (2012) consider a reduced form model of fixed costs per shipment to study transaction frequencies using a gravity framework.

tion technology directly. Thus, Eaton et al. (2008) document that the frequency of shipment is an important margin of aggregate trade volumes. Hornok and Koren (2011) model heterogeneous preferences for the arrival time of consumer goods. In their setup, fixed costs per shipment increase prices and reduce shipment frequency; the latter effect is showing up in firm-level export data from the US and Spain. Other papers like Békés and Muraközy (2011) and Kleinert and Spies (2011) analyze the endogenous choice of transportation technologies. The former study investigates the trade-off between variable and sunk cost trade technologies and explains observed characteristics of temporary trade. The latter study analyzes the endogenous adoption of an advanced transportation technology by a transport industry. More closely related to our paper, Békés et al (2012) explore a Baumol-Tobin model to investigate the role of fixed costs per shipment as a determinant of size and frequency of shipments. Using French firm level data, the authors show that export volumes expand and contract along the frequency margin, very similar to traditional margins. We add to this literature by encapsulating fixed costs in a standard trade model à la Melitz (2003). Doing so, we are able to identify the impact of standard parameters such as market size, distance and elasticities on determinants of the frequency and size of shipments within the state-of-the-art modelling framework. Moreover, we are able to derive an expression for fixed costs per shipment as a function of basic modeling parameters and variables, which allows us to impute fixed costs from the transaction-level export data using standard observables.

Finally, the current paper relates to Armenter and Koren (2010), who analyze trade patterns when firms randomly fire their shipments to export markets. While impressively matching many patterns of trade data, the authors disregard the endogeneity of frequency and size of shipments by imposing constant size of transactions. By focussing exactly on the trade-off between frequency and size of shipments, the present paper's approach is diametrically opposed to the one pursued by Armenter and Koren (2010).

The remainder of the paper is structured as follows. Section 2 presents the theoretical model. Section 3 describes the Swiss trade date, which we use to test our theory in Section 4. Finally, Section 5 concludes.

2 The Model

We develop a framework that incorporates the frequency of exports as an endogenous choice variable of firms in a standard Melitz-type model of heterogeneous firms. Doing so, we focus on an static setup, i.e. we assume that population sizes, technologies and trade barriers, and consequently output and trade flows are constant.

2.1 Setup

Preferences Consider a world with J countries, indexed by $j = 1, 2, ..., J$. Every country produces and consumes a continuum of products. Country j's flow utility function is

$$u_j = \left(\int_{B_j} q_{jk}^{1-1/\sigma} \, dk \right)^{\sigma/(\sigma-1)} \qquad \sigma > 1 \tag{1}$$

where q_{jk} is its consumption of variety k and B_j is the set of varieties sold in country j. The parameter σ is the elasticity of substitution across products.[9]

Consumers derive utility (1) at each point in time and aim to consume goods continuously. This demand effect tends to smoothen the stream of delivered goods.

Let Y_j be the income of country j, which equals its expenditure level. Then country j's demand for variety k is

$$q_{jk} = p_{jk}^{-\sigma} \frac{Y_j}{P_j^{1-\sigma}} \tag{2}$$

where p_{jk} is the price of variety k in country j and P_j is the country's ideal price index.

Transport Costs Firms located in country i can enter country j's market at the cost of F_{ij} local labor units. We will analyze a static setup so that, just as in Melitz (2003), the cost of market entry may consist of a pure up-front cost or the net present value of per-period fixed costs (or a combination of both).

Each shipment of varieties from country i to country j is subject to fixed costs $f_{ij} > 0$ and marginal transport costs τ_{ij}. We follow the notational convention that τ_{ij} units of a variety must leave the exporting country's port for one unit of the

[9] By condition $\sigma > 0$, standard consumption smoothing motives imply that consumers consume a continuous flow of consumption bundles. The exact quantities of each good will vary periodically along with consumer prices, which, in turn, reflect storage and trade costs.

variety to arrive in county j. This "iceberg-type" transport costs thus satisfies $\tau_{ij} \geq 1$. Fix and marginal trade costs are constant and accrue at the date of the shipment.

Production Firms are heterogeneous and characterized by their draw of marginal unit labor requirements a. The cumulative distribution function $G(a)$ with support $[\underline{a}, \bar{a}]$ describes the distribution of firms, where $0 \leq \underline{a} < \bar{a}$. A firm with draw a located in country i can produce the quantity q_k of its unique variety k out of labor l_k according to the technology

$$q_k = l_k / a$$

2.2 Equilibrium Pricing

Mill Prices Consider a firm located in country i with a productivity draw $1/a$, hence facing the marginal production costs aw_i. Maximizing profits, this firm sets the mill-price of its variety to

$$\tilde{p}(a) = \frac{\sigma}{\sigma - 1} aw_i \tag{3}$$

where w_i is the prevailing wage in country i. Given that this firm exports to country j the consumer price in country j is a composite of mill-price and all accruing variable costs. The typical iceberg transport costs due to losses in the process of shipping constitutes the standard component of the variable cost.

Storage Costs We assume that there are storage costs for those varieties that are consumed some time t' after they are actually shipped to a destination country. In particular, we focus on the costs up-front of financing, i.e. those that accrue due to interest payments that arise between shipment and consumption.[10] Setting r for the world interest rate, the gross interest after $t' \geq 0$ periods is $e^{rt'}$. Consequently, the consumer price in country j at time t' after the shipment is[11]

$$p_{ij}(a) = \tau_{ij} e^{rt'} \frac{\sigma}{\sigma - 1} aw_i \tag{4}$$

[10] This assumption is consistent with a competitive market for storing with zero storage costs.

[11] Notice that with a competitive market for storing it is irrelevant for the equilibrium consumption quantities, whether the buyer or the seller pays the storage bill. In both cases, storage costs are ultimately payed by the consumer and reduce consumption quantities by the same rate.

Operating profits are the difference between the flow of revenues ($p_{ij}q_{ji}(a)$) and total cost times units delivered. To compute the latter product, we multiply the units leaving the factory gate ($\tau_{ij}q_{ji}(a)$) with costs. The costs are the sum of unit production costs a and unit storage costs $(e^{rt'}-1)a$. With local demand (2), the flow of operating profits from sales in country j at date $t+t'$ is thus

$$\pi_{ij}(t_1+t') = \left(p_{ij} - \tau_{ij}e^{rt'}aw_i\right) q_{ji}(a) = \sigma^{-\sigma}\left[\frac{\tau_j e^{rt'}}{\sigma-1}\frac{aw_i}{P_j}\right]^{1-\sigma} Y_j. \qquad (5)$$

where t_1 is the date of shipment and $q_{ji}(a)$ is the quantity consumed in country j of the variety produced by a firm located in country i with productivity $1/a$.

Profits Firms do not only decide upon their pricing policy, thereby determining the export volume. In addition, they manage the timing of their shipments. This latter problem is non-standard and requires a word of explanation.

By the definition of consumers' flow utility (1), a continuous flow of the traded varieties are consumed in the export markets. Under positive storage cost, exporting firms suffer losses if they don't ship at the exact day of consumption. In absence of fixed costs per shipment, a firm would therefore send a flow of shipments to the destination countries so that its products arrive precisely at the date of consumption.[12] In presence of fixed costs per shipment, however, such a strategy is infinitely costly, since at each infinitesimal date a discrete cost would arise. Consequently, shipments are discrete.

In our static setup output Y_j, prices P_j and trade costs are constant and we can compute present value of total operating profits of a firm located in country i, which accrue between a shipment at date t_1 and the following shipment at date $t_1+\Delta$. These profits are[13]

$$\Pi_{ij}(t_1,\Delta) = \int_0^{\Delta} e^{-rt'}\pi_{ij}(t_1+t')\,dt' = \sigma^{-\sigma}\left[\frac{\tau_{ij}}{\sigma-1}\frac{aw_i}{P_j}\right]^{1-\sigma} Y_j\frac{1-e^{-r\sigma\Delta}}{r\sigma}. \qquad (6)$$

It will prove useful to normalize the reference span of time - a year - to unity. This means that the interval Δ is expressed as a fraction of years. Consequently, the inverse of Δ (i.e. Δ^{-1}) is the number of shipments per year between two countries.

[12] Notice that this statement is true even in the presence of per-period trade cost.

[13] One arrives at the same expression when assuming that a competitive spediteur buys the quantity $Q_j = \tau_j \int_0^{\Delta t} x_j(t)dt$ for the mill price (3).

There are two requirements for a firm to be an exporter. First, the net present value of profits from all shipments must cover market entry costs. And second, the sum of its operating profits between two consecutive shipments must exceed the fixed costs per shipment f_{ij}. Formalizing the latter requirement, a firm with productivity draw a exports to country j if and only if inequality

$$\sigma^{-\sigma}\left[\frac{\tau_j}{\sigma-1}\frac{aw_i}{P_j}\right]^{1-\sigma} Y_j \frac{1-e^{-r\sigma\Delta}}{r\sigma} \geq f_{ij} \tag{7}$$

holds. The expression on the left is increasing in the term Δ. Conditional on having paid market entry costs, those firms located in country i whose productivity satisfy (7) will generate positive operating profits from exporting to country j – at potentially very long intervals Δ between two shipments. In the limit, the firm whose productivity $1/a$ satisfies (7) with equality would only make a single shipment to the specific destination and then retreat from the market.[14]

2.3 Equilibrium Shipments

An exporting firm faces a trade-off between paying more fixed costs by shipping at higher frequencies and paying more storage costs by shipping more goods at the time.[15] A firm's optimal strategy then determines the frequency of shipments and the value per shipment.

The Frequency of Shipments We now turn to the optimal frequency of shipments. Since Y_j, P_j and r are constant, so will be the intervals Δ between either two shipments. Setting

$$\gamma_{ij}(a) = e^{-r\Delta_{ij}(a)} \qquad \text{and} \qquad A_{ij}(a) = \sigma^{-\sigma}\left[\frac{\tau_{ij}aw_i}{(\sigma-1)P_j}\right]^{1-\sigma} Y_j \tag{8}$$

the expression for gross profits per shipment (6) simplifies to $A_{ij}(1-\gamma^\sigma)/r\sigma$. For a firm of productivity $1/a$ located in country i and selling into market j the present

[14]Such a firm, however, would make zero operating profits and be unable to cover the market entry costs F_{ij}. Therefore, (7) holds with strict inequality for all exporters and there is a positive minimal frequency of exports (implying $\Delta_{ij}(a) < \infty$ and $\bar{\gamma}_{ij}(a) > 0$).

[15]In this sense, our model is thus reminiscent of the Baumol-Tobin model.

value of all operating profits net of per-shipment costs is thus

$$NPV_{ij} = \sum_{k \geq 0} \gamma_{ij}^{k} \left\{ \frac{A_{ij}}{r\sigma}(1 - \gamma_{ij}^{\sigma}) - f_{ij} \right\} = \frac{1}{1 - \gamma_{ij}} \left\{ \frac{A_{ij}}{r\sigma}(1 - \gamma_{ij}^{\sigma}) - f_{ij} \right\} \tag{9}$$

where we have suppressed the dependence on a.

Taking derivatives of (9) with respect to Δ determines the profit-maximizing frequency of exports

$$(\sigma - 1)\,\gamma_{ij}^{\sigma} - \sigma\gamma_{ij}^{\sigma-1} + 1 - r\sigma f_{ij}/A_{ij} = 0 \tag{10}$$

It is straightforward to check that the expression on the left hand side of (10) is decreasing in γ_{ij} as long as $\gamma_{ij} \in (0, 1)$. Moreover, at $\gamma_{ij} = 1$ the expression on the left is negative, while it is positive for $\bar{\gamma}_{ij} = 0$ (since $A_{ij} > r\sigma f_{ij}$, which holds by (9)). Hence, there is a unique $\gamma_{ij}(a) \in (0, 1)$ solving (10). We label the solution of (10) $\bar{\gamma}_{ij}$.

Given uniqueness of the optimal frequency of shipment, we turn to comparative statics. Notice that the expression on the left hand side of (10) is decreasing in γ_{ij}. Therefore, every parameter change that increases f_{ij}/A_{ij} must be compensated by a decrease in γ_{ij} or equivalently, by an decrease in the frequency $1/\Delta_{ij} = -r/\ln(\bar{\gamma}_{ij})$. Using expression (8) we can summarize these observations in the following proposition.

Proposition 1 *The export frequency of a firm located in country i exporting to country j $(1/\Delta_{ij})$ increases with firm productivity $(1/a)$ export market size and price level (Y_j and P_j) and demand elasticity (σ), but it decreases with local wage (w_i), iceberg trade costs (τ_{ij}) and fixed costs of trade (f_{ij}).*

Proof: The statement remaining to be shown concerns σ. Taking derivatives of LHS, the expression on the left of (10), with respect to σ yields

$$\begin{aligned} \frac{d}{d\sigma}LHS &= \left[\bar{\gamma}_{ij}^{\sigma} - \bar{\gamma}_{ij}^{\sigma-1} - rf_{ij}/A_{ij}\right] + \ln(\bar{\gamma}_{ij})\left[(\sigma-1)\,\bar{\gamma}_{ij}^{\sigma} - \sigma\bar{\gamma}_{ij}^{\sigma-1}\right] \\ &= \left[1 - \bar{\gamma}_{ij}^{\sigma}\right]/\sigma - \ln(\bar{\gamma}_{ij})\left[\sigma\bar{\gamma}_{ij}^{\sigma-1} - (\sigma-1)\,\bar{\gamma}_{ij}^{\sigma}\right] > 0 \end{aligned}$$

where the inequality holds by $\bar{\gamma}_{ij} \in (0, 1)$. Since LHS is decreasing in $\bar{\gamma}_{ij}$, the implicit function theorem implies that $\bar{\gamma}_{ij}$ and therefore $1/\Delta_{ij}$ is increasing in σ. ■

The proposition shows that all factors that traditionally promote trade (productivity and size of export market) increase the frequency of shipment. At the same time, factors that tend to hinder trade (trade costs and toughness of competition in export markets) decrease the frequency.

An interesting and novel aspect concerns the substitution elasticity σ, higher levels of which tend to increase the frequency of shipments. The intuition of this result is the following. A lower frequency of shipments implies that the lag between delivery and consumption increases, which raises the average consumer prices via the channel of higher storage costs. But consumers reduce demand more strongly in reaction to such price increases when their demand elasticity σ is high. Consequently, the negative impact of storage costs on firm profits is more pronounced at higher elasticities and therefore optimizing firms react stronger to storage costs and chose to ship their varieties at higher frequencies.

Finally, Proposition 1 allows us to make a statement about the qualitative difference between fixed costs per shipment and the traditional types of fixed costs. Specifically, applying the envelope theorem to (9), the derivative of NPV_{ij} w.r.t. f_{ij} can be shown to equal $-1/(1-\gamma_{ij})$. Recall that in the static Melitz (2003) framework, trade flows and firm profits are unaffected whether fixed costs are paid up-front or period-by period. As long as the net present value is unchanged, the equilibrium outcome is the same. This equivalence translates partially to the concept to fixed costs per shipment. The translation is partial since γ_{ij} changes with firm productivity $1/a$. In particular, Proposition 1 implies that γ_{ij} is increasing in $1/a$ so that higher productivity firms, with higher export volumes, pay also more fixed costs per shipment (in terms of net present value). This observation shows that the total value of fixed costs per shipment, being neither independent of trade volumes nor perfectly proportional to trade volumes, are effectively a hybrid form of fixed costs per period and marginal trade costs.

The Value per Shipment We turn now to the value of a single shipment. By integrating demand (2) over time, using prices (4) and expression (8) we can compute the total value of a shipment from country i to country j [16]

$$x_{ij} = \frac{A_{ij}}{r}\left(1 - \bar{\gamma}_{ij}^{\sigma}\right) \tag{11}$$

[16] See Appendix.

To analyze how x_{ij} varies with the model's parameters, we take implicit derivatives of (10) to get

$$\frac{d\bar{\gamma}_{ij}}{dA_{ij}} = \frac{rf_{ij}}{A_{ij}^2} \frac{1}{(\sigma-1)\,\bar{\gamma}_{ij}^{\sigma-2}\left(1-\bar{\gamma}_{ij}\right)}$$

We can use this expression together with (11) to compute[17]

$$\frac{d}{dA_{ij}} \ln\left(x_{ij}\right) = \frac{1}{A_{ij}} \frac{\sigma - 1 + \bar{\gamma}_{ij}^{\sigma} - \sigma\bar{\gamma}_{ij}}{(\sigma-1)\left(1-\bar{\gamma}_{ij}\right)\left(1-\bar{\gamma}_{ij}^{\sigma}\right)} \tag{12}$$

It is easy to check that the expression in the numerator is positive for $\bar{\gamma}_{ij} \in (0,1)$ so that x_{ij} is increasing in A_{ij}. Finally, since by Proposition 1 any increase in f_{ij} decreases $\bar{\gamma}_{ij}$, otherwise leaving x_{ij} from (11) unchanged, the value of shipment is increasing in the fixed costs of trade. We can formulate the corresponding results for the value of each shipment.

Proposition 2 *The value per shipment of a firm located in country i exporting to country j (x_{ij}) increases with productivity ($1/a$), export market size and price level (Y_j and P_j) and fixed costs per shipment (f_{ij}), but it decreases with local wages (w_i) and iceberg trade costs (τ_{ij}).*

Proposition 2 shows, parallel to Proposition 1, that all factors that promote trade (productivity and size of export market) increase the value per shipment. Here again, whenever trade volumes increase – e.g. via an increase in foreign demand – they do so along the value margin. The proposition also shows that the value per shipment tend to decrease in the toughness of competition of an export market and in iceberg trade costs. Thus, the mentioned parameters that generally promote (curb) trade do increase (reduce) the size of shipment.

Taking the two propositions together, firms tend to increase and reduce trade volumes in parallel along two margins – frequency and size of shipment.

One exception in this general statement concerns fixed costs per shipment. Indeed, a rise in the fixed costs per shipment does *increase* the per-shipment value. This result in not surprising: when fixed costs are high, firms tend to avoid the accruing costs by compensating, at the margin, with higher inventories. This result contrasts the impact of fixed costs per shipment on frequency.

Notice finally that Proposition 2 is silent on the impact of the demand elasticity σ on the value per shipment. It may seem that an increase of this elasticity, by increasing

[17] See Appendix.

the frequency, should reduce the volume per shipment. This effect, however, may be overturned by an overall increase in export volume, in the case that the exporter's products are very cheap relative to the export market's general price level. In fact, it can be shown that the impact of σ on x_{ij} depends on the exporters relative price in the export market.

2.4 Export Flows

Entry to Export Markets Firms incur fixed costs of entry to an export market whenever costs fall short of the present value of exporting to the relevant market. We can combine equations (9) and (10) to compute NPV_{ij} the present value of exporting, which must exceed the market entry cost:[18]

$$NPV_{ij} = \frac{A_{ij}}{r}\bar{\gamma}_{ij}^{\sigma-1} \geq F_{ij} \tag{13}$$

In combination with (8) and (10), condition (13) fixes the minimal productivity $1/\tilde{a}_{ij}$ of exporters from country i to country j. We define $\tilde{a}_{ij}$ as the maximal exporter production cost and set $\tilde{\gamma}_{ij} = \bar{\gamma}_{ij}(\tilde{a})$ for the corresponding exporter frequency, for which (13) holds with equality. Thus, substituting with (10) A_{ij} in (13) renders

$$(\sigma - 1)\,\tilde{\gamma}_{ij} + \tilde{\gamma}_{ij}^{1-\sigma} - \sigma = \sigma f_{ij}/F_{ij}$$

The derivative of the expression on the left with respect to $\bar{\gamma}_{ij}$ is $(\sigma - 1) + (1 - \sigma)\tilde{\gamma}_{ij}^{-\sigma} = (\sigma - 1)(1 - \tilde{\gamma}_{ij}^{-\sigma}) < 0$. Hence, $\tilde{\gamma}_{ij}$ is decreasing in f_{ij}/F_{ij}.

Thus, at constant σ, F_{ij} and f_{ij} the value $\tilde{\gamma}_{ij}$ is constant so that (13) with equality shows that A_{ij} is constant. Using (8), we have thus[19]

$$\tilde{a}_{ij} = const \cdot \frac{P_j}{\tau_{ij} w_i} Y_j^{1/(\sigma-1)} \tag{14}$$

Equation (14) shows that the cutoff-productivity for exporters from country i to country j $(1/\tilde{a}_{ij})$ increases with variable trade costs τ_{ij} and the toughness of competition $1/P_j$ but decreases with the size of the export market Y_j.

To some extent, this finding confirms the standard results of the Melitz (2003) framework: firms endogenously select into export markets and only the firms that

[18] See Appendix.

[19] The constant depends on σ, F_{ij} and f_{ij}, of course.

can generate the highest profits export to the markets that are difficult to penetrate. Consequently, exporters tend to be the most productive and the corresponding markets the most profitable ones.

There are, however, differences to the standard Melitz setup, where all steady state variables are unchanged if the fixed costs of market entry F_{ij} is replaced by a per-period fixed cost f_{ij} with identical net present value. Treating f_{ij} as such, one may consider the extreme case $F_{ij} = C$ and $f_{ij} = 0$. In that case, there is a constant flow of shipments, i.e. $\Delta = 0$ and $\tilde{\gamma}_{ij} = 1$, so that

$$\tilde{A}_{ij} = rC$$

holds for the marginal exporter ($\tilde{A}_{ij} = A_{ij}(\tilde{a}_{ij})$). In case of the other extreme, where $F_{ij} = 0$ and $f_{ij} = C(1 - \tilde{\gamma}_{ij})$, setting NPV_{ij} from (9) to zero renders

$$\tilde{A}_{ij} \frac{1 - \tilde{\gamma}_{ij}^{\sigma}}{\sigma(1 - \tilde{\gamma}_{ij})} = rC$$

As $\tilde{\gamma}_{ij} < 1$, the fraction on the left is smaller than one. Consequently, the corresponding $\tilde{A}_{ij}$ must be larger ($\tilde{a}_{ij}$ must be smaller) in the second case than in the first of seemingly equivalent market entry costs. In the second case, the requirements for exporters are tougher.

While in standard models per-period fixed costs and market entry costs are exchangeable without affecting steady state variables, the case is different for fixed cost per shipment. Fixed costs per shipment constitute a higher impairment to trade than market entry cost of the same net present value. The reason is, once again, that in presence of fixed costs per shipments firms must incur additional, secondary costs by paying for storage.

Aggregate Trade Flows We will now take a brief look at aggregate yearly trade flows. Since the interval Δ_{ij} is expressed as a fraction of years, the yearly exports to country j of a firm with productivity $1/a$ located in country i are (compare (11))

$$\frac{x_{ij}}{\Delta_{ij}(a)} = A_{ij}(a) \frac{1 - \bar{\gamma}_{ij}^{\sigma}(a)}{r\Delta_{ij}(a)}$$

where we have expressed the dependence of $\bar{\gamma}_{ij}$ and Δ_{ij} on a explicitly. Notice that the term $(1 - \bar{\gamma}_{ij}^{\sigma}(a))/(r\Delta_{ij}(a))$ is decreasing in $r\Delta_{ij}(a)$, while $\Delta_{ij}(a)$ shrinks in productivity a. Consequently, firm exports increases with firm productivity by more than in the traditional Melitz (2003) framework. Specifically, at constant frequency of export (constant $(1-\bar{\gamma}_{ij}^{\sigma}(a))/(r\Delta_{ij}(a))$), firm productivity affects the export volumes by the factor $a^{1-\sigma}$ (compare (8)). In addition to this standard result, the term $(1-\bar{\gamma}_{ij}^{\sigma}(a))/(r\Delta_{ij}(a))$ tends to increase export volumes. The reason for this additional effect of productivity is the following: with an increase in productivity, firms can adjust their optimal frequency of shipments, which gives their exports an additional margin, thus increasing export volumes.

Finally, the aggregate volume of exports from country i to country j is

$$T_{ij} = \int_0^{\tilde{a}_{ij}} \frac{x_{ij}}{\Delta_{ij}(a)} \, dG(a) \tag{15}$$

where $\tilde{a}_{ij}$, from (13), is the cost of the marginal firm that just exports from country i to country j at zero net present value.

2.5 Inferring Trade Costs

In the previous sections, we computed general conditions of firms' optimal shipment size and frequency. Using these conditions, it is possible to infer the components of trade costs – fixed costs per shipment, variable transportation costs and market entry costs – from the firm characteristics and their choice variables. This relation will be particularly interesting in the case of fixed costs per shipment.

Fixed Costs per Shipment By combining the optimality condition (10) and the value per shipment (11) to eliminate A_{ij}, one can infer the following indirect measure for the fixed costs per shipment

$$f_{ij} = \frac{(\sigma-1)\bar{\gamma}_{ij}^{\sigma} - \sigma\bar{\gamma}_{ij}^{\sigma-1} + 1}{1-\bar{\gamma}_{ij}^{\sigma}} \frac{x_{ij}}{\sigma} \tag{16}$$

It is noteworthy that this expression for fixed costs per shipment does not depend on firm productivity, variable trade costs or on market characteristics of the exporting or importing country. The only relevant observables are the firms' choice variables, i.e. the value per shipment x_{ij} and the frequency Δ_{ij}, as well as the interest rate r and the elasticity σ. Intuitively, once total trade volume (x_{ij}/Δ_{ij}) is known, its decomposition into single shipments should not depend on characteristics of the countries but exclusively on the parameters governing the trade-off between higher trade costs (f_{ij}) and higher storage costs (r). As discussed in connection with Proposition 1, the elasticity σ impacts this trade-off through the consumers' sensitivity to absorb marginal storage costs. Therefore, σ enters the measure of fixed costs (16) as well.

In sum, the parameters f_{ij}, r and σ are sufficient to determine the decomposition of total trade into x_{ij} and Δ_{ij} – or reversely, f_{ij} can be inferred from the observables x_{ij} and Δ_{ij}, given that r and σ are known.

Variable Transport Costs With the expression (8), we can restate (11) as

$$x_{ij} = \left[\frac{\sigma\tau_{ij}aw_i}{(\sigma-1)P_j}\right]^{1-\sigma} Y_j \frac{1-\bar{\gamma}_{ij}^{\sigma}}{r\sigma} \tag{17}$$

which is a version of the gravity equation on the firm level. Notice that in this expression firm productivity $1/a$ appears explicitly, while it did not in expression (16) for fixed costs per shipment. Thus, estimates of the variable trade costs τ_{ij} must involve firm dummies and country dummies as long as firm productivity $1/a$ and ideal price index P_j are unobserved. Alternatively, estimates of variable trade costs could base information about the marginal costs as in the data used in Das et al (2007).

In sum, and very much in line with the standard framework[20], variable trade costs can be inferred from trade flows once firm productivity, market size and the prevailing price index are known.

Market Entry Costs Since no firm can be expected to have exactly the productivity that makes it the marginal exporter, the costs of market entry can only be proxied by an upper bound through (13). Specifically, we can use (11) to reformulate condition (13) as $x_{ij}\bar{\gamma}_{ij}^{\sigma-1}/(1-\bar{\gamma}_{ij}^{\sigma}) \geq F_{ij}$. Taking logs leads to

$$\ln(x_{ij}) + (\sigma-1)\ln(\bar{\gamma}_{ij}) - \ln(1-\bar{\gamma}_{ij}^{\sigma}) \geq \ln(F_{ij}) \tag{18}$$

For firms with the cutoff productivity level this inequality binds. Thus, for each country pair, the lowest value of the expression on the right observed throughout the universe of exporters constitutes an upper bound on the fixed costs of exporting.

[20] Setting the frequency Δ_{ij} in (17) to one, as exogenously fixed in Melitz 2003), and approximating $\left(1-\bar{\gamma}_{ij}^{\sigma}\right)/r\sigma \approx 1$, expression in (17) can, adapting notation, be rewritten as equation (4) in Melitz (2003).

Again, expression (18) is reminiscent of the Melitz (2003) framework, where the flow of (yearly) export profits need to cover market entry costs. Translated to the current setting, yearly profits are yearly revenues (x_{ij}/Δ_{ij}) times the effective markup $1/\sigma$ so that the net present value of operating profits equals $x_{ij}/(\sigma\Delta_{ij}(1-\bar{\gamma}_{ij}))$.[21]

3 Data

3.1 The Universe of Swiss Trade Data

Our data-source is the Swiss Customs (Oberzolldirektion) which records every legal transaction of cross-border trade. If a pharmaceutical firm sends two boxes of the same drug to the same destination on the same day, but involving two different custom forms, then two distinct transactions are recorded. We refer to these transactions as shipments.

The data span the period between the years 2005 and 2009 and report single cross-border transactions using an 8-digit goods classification system (tariff number). Year and month of the transaction are recorded.[22] Our core variable is the value of each shipment in Swiss francs (CHF).

We only consider goods that enter the official Swiss trade statistics – officially labeled *Total 1*. This definition excludes precious metals and antique furniture; we also exclude energy, which are transported in pipelines and transmission lines. All goods whose type of transportation is recorded as *self-propelled* are excluded as well.[23] This restriction leaves us with 8036 (8759) goods classes and 243 (239) countries appearing at least once in the export (import) data over the full range of five year.

Tables 1a and 1b report the distribution of exports and imports in terms of values of shipments and number of shipments. The dimension of the distribution are goods (Columns 2 and 3 of each table), countries (Columns 4 and 5) and good-country-pairs (Columns 6 and 7).

[21]With the frequency $\Delta_{ij}=1$ in (17) and approximating $\left(1-\bar{\gamma}_{ij}\right)/(1-\bar{\gamma}_{ij}^{\sigma})\approx\sigma$, expression in (18) coincides with equation (5) in Melitz (2003).

[22]Days are reported as well but not reliably so: the majority of shipments are recorded on the first day of the corresponding month.

[23]Trade in energy comprises all goods transported via pipelines, which are recorded as one shipment per quarter and classification. Trade of self-propelled goods are in units. The restriction eliminates 0.204% of all observations for imports and 0.268% for exports. These correspond to 2.9% and 8.31% of export and import values, respectively.

According to Columns 2 and 3 of Table 1a, the top 0.1 percentile of goods accounts for 29% of the value of Swiss exports and 4.3% of all Swiss export shipments (aggregating export destinations). The top one percentile makes well over 50% of the value of Swiss exports and 19% of all export shipments while the top five percent account for close to 80% of the value of Swiss exports and close to 50% of all export shipments. Columns 4 and 5 report the distribution along the country dimension (indicating aggregates over all export goods): the top 1 percentile of countries (that is, Germany and U.S.) accounts for 20% of the value of Swiss exports and 29% of all export shipments. The according numbers for the 5th percentile are 72% for both, values and shipments.

Table 1b replicates the numbers from Table 1a for Swiss imports. By and large, the table shows a similar pattern. As a noteworthy difference, imports are less concentrated to the top percentiles of goods than exports while, conversely, exports are relatively less concentrated along the country dimension. The former observation reflects a balancing of the Swiss demand and consumption basket, the latter feature may reflect the fact that Switzerland's specialized goods niche products are required in all countries. Both properties can be expected for a small open and industrialized economy.

Two additional features of our data are worth to mention. First, the data include the transportation type of shipments, distinguishing between the seven classes *train, road, waterway, airfreight, postal service, pipeline/transmission-line* and *self-propelled*. These categories, however, do not reflect the predominant transportation type used for the entire shipment, but rather the type used to pass the Swiss custom. Therefore, records of waterway are relatively scarce representing 0.4% (0.1%) of all export (import) shipments and 1.9% (1.3%) of all values respectively. The transportation-mode must therefore be interpreted with caution. The majority of records are road transportation representing 75.2% (86.1%) of all shipments and 62.8% (77.3%) of all values followed by airfreight representing 21.3% (9.0%) of all shipments and 30.8% (13.5%) of all values.

Second, our data is special in that it comprises transactions of any positive value exceeding 300 CHF. In this dimension, it is quite distinct from the commonly used US custom data, which only reports transactions valued at or above the threshold of $2500. When considering transactions below 2500 CHF, these transactions account for 66.1% (73.7%) of all transactions for exports (imports) and 2.7% (5.2%) of the total trade volume reported in the data.[24]

3.2 Firm Level Data

Our theory is based on firm decisions and need to be tested using firm level data. Unfortunately, the universe of Swiss trade data does not include a firm identifier. However, a subset of the transaction data is collected through an electronic system that incorporates the names of the exporting and importing firms or individuals.[25] We refer to the dataset of export as the *subset of firm level data*. The electronic system is a rather novel tool to Swiss Customs and firms use it on a voluntary basis.

The voluntary use of the electronic system may raise concerns about a selection issue: it seems likely that those firms that routinely export tend to use the electronic facility. In this case, it appears reasonable that the selection of firms induces a downward bias of the average imputed fixed cost per shipment.[26]

The corresponding data cover neither a constant share of exports nor do firms which use the system necessarily report all of their transactions through it. For the years 2005 to 2009 covered by our data, the subset of data identifying firms aggregate to a total of 21.8, 24.5, 40.4, 43.0, and 43.9% of total export volumes (in CHF) for each of the five years. In order to exploit the useful information of the subset of firm data, we identify the good categories in which "almost all" transactions are recorded in the subset of firm level data. In particular, we focus on good categories for which the subset reports more than 95% of total export value within each of the years.

We exclude the years 2005 and 2006 from our analysis as its inclusion would limit the coverage of firm data too severely. Moreover, we exclude observations of the years 2008 and 2009 since for these years our model's assumption of a steady economic environment is clearly violated.[27]

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[24] Over the period considered, the US Dollar was above parity to the Swiss franc so that the threshold applied by U.S. customs would be even stricter.

[25] As firm names are not standardized in the dataset provided by Swiss Customs, we need to clean the data from different versions of spelling in order to obtain proper firm identifiers. We restrict this process to firms for which there are at least than 24 observations.

[26] Notice, moreover, that fixed effects included in the regressions below do capture these firm-specific effects. The estimation results are therefore unaffected by the sample selection.

[27] The Baltic Dry Index, a direct measure of commodity shipping prices, fell between May 20^{th} and December 3^{rd} 2008 from 11,793 to 663 points. See http://www.bloomberg.com/.

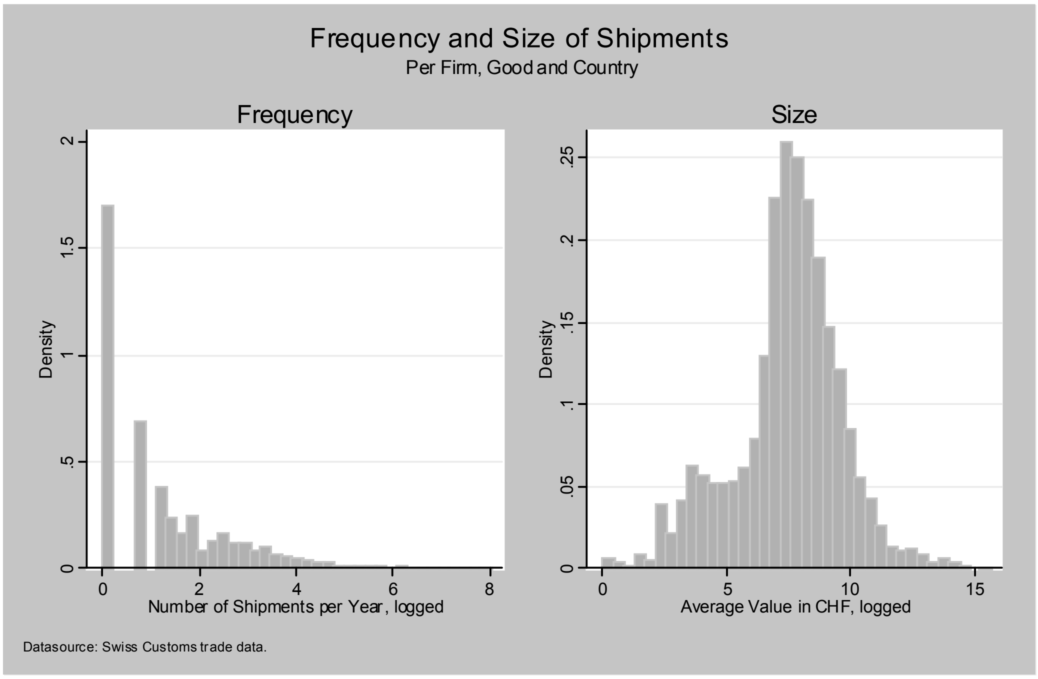

Figure 1: Average frequency and size of shipments of Swiss exports (both logged) for the period 2007 for selected combinations of firm, good and destination country. Data cover 389 firms that export 294 different good classes. Selection is based on good classes for which subset of firm-level export data covers at least 95% of total trade volume in the year 2007.

Overall, we deal with the year 2007, to which we apply the criterion of 95% coverage described above to select firm level data of Swiss exports. Filtering the data according to the thus defined criteria leaves us with 389 firms that export 294 different goods. Of these firms, 144 export exactly one good, 295 export three goods or less, 367 export ten goods or less and 19 export more than ten goods (with the maximal number of 32 goods). These firms account for 91 660 individual transactions of a total value of CHF 3.591 billion, or 1.74 percent of total exports.

Based on these shipments, and for each combination of firm-good-destination, we compute the average value per shipment and the yearly number of shipment for 2007. Figure 1 plots a histogram of these variables; there are 384 observations for 62 different countries. The mean of both variables corresponds to a value of 1707 CHF per shipment and about 3.5 shipments per year.[28]

In addition, Figure 2 graphs a scatterplot of the frequency and the average value

[28] Excluding the observations with one transaction per year renders corresponding means of 2399 CHF and 7.4 shipments.

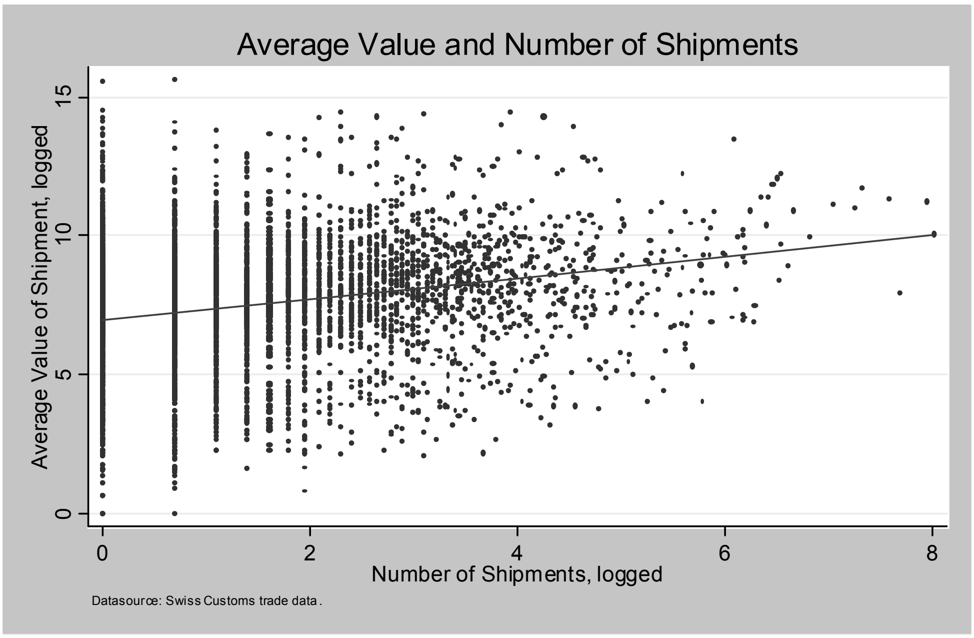

Figure 2: Scatterplot between average frequency and size of shipments (both logged) for selected combinations of firm, good and destination country of Swiss exporters for the period 2007. See also note of Figure 1.

per shipment. The figure shows that, in line with Propositions 1 and 2 above, the two margins frequency and size of shipment tend to co-move. It should not be surprising that the correlation is not perfect. There might be differences in how firms organize and standardize their export shipment. In particular, firms shipping to many different destinations might have a mechanical packing procedure than small firms shipping just across the border to Germany or Italy. Also the ad valorem storage costs, which enters the expression in (16), may differ across goods, e.g. due to intrinsic differences between durable and perishable goods. Such factors should be expected to generate variation that blurs the relation between the number and the value of shipments.[29]

Notice that, when computing the frequency and the average value per shipment for each firm-good-destination plotted in Figures 1 and 2, we eliminate some heterogeneity within each firm-good-destination. Specifically, not all shipments of a good

[29] Computing the average value of shippments neglects some, potentially important, heterogeneity. Clearly, the shipping patterns of a firm-country-product are not constant in our data. However, a variance decomposition shows that firm-country-product effects explain almost 80 percent of the variation in our (logged) value per shipment. We accept this fit as a justification of our assumption regarding the smoothness of shipments.

by one firm to a specific destination are of the exact same size. However, the larger part of the variation in the transaction level data is explained by the combination of firm, good and destination. Thus, 53.9% of the variation in value per shipment is explained when regressing on the value of the 91660 single transactions on the 3951 firm-good-destination dummies. We do not expect values of shipments to be literally constant over time, as price changes by individual firms, seasonal demand changes or other factors induce time variation in the value of shipments. But we read the substantial part of the transaction-level variation explained by the dummies to be reflecting firm's strategy to smooth shipments.

3.3 Control Variables

The following additional data are used as control variables in the estimations below: language commonality, a trade agreements, distance from Switzerland and GDP as well as GDP per capita data.

World Bank WDI database provides the trade partners' GDP as well as GDP per capita data (both in constant US dollars). Distance, defined as distance from Switzerland's capital (Bern) to the trading partner's capital, is provided by the Center for International Prospective Studies (CEPII)[30]. A common language dummy is constructed using data from the CIA World Fact Book. We set this dummy to one if one of the official Swiss languages is an official language in a partner country as well or if an official Swiss language is spoken by at least 25% of the population of the respective partner country. Data on Swiss trade agreements is available from the Swiss federal office of economics (SECO).[31] Using this data we construct an indicator function for trade agreements which is one if the agreement is in office for at least half of a respective period of analysis.

4 Estimations

In general, the trade data used to infer fixed costs per shipment, variable transportation costs and market entry costs. In our empirical exercise, however, we will focus on the imputed fixed costs per shipment since, first, this concept is rather novel and has not been estimated before. Second, the expressions of the other types of

[30] French: Centre d'Etudes Prospectives et d'Information Internationale.
[31] French: Secrétariat d'Etat à l'économie.

trade costs are not very different from those of the standard Melitz (2003) model.[32] Specifically, in the current section we aim to use expression (16) to analyze the fixed costs per shipment.

All of the relevant expressions for our estimations exercise involve the demand elasticity and the interest rate. The former can generally be estimated (see e.g. Broda and Weinstein (2004)) but performing such an exercise is beyond the scope of the present paper. Instead, in our benchmark we set the interest rate to $r = 0.05$ and the substitution elasticity to $\sigma = 10$ (see Broda and Weinstein 2004 for the distribution of elasticities on the good level). We also vary these parameters within the conventional ranges $r \in [.05, .1]$ and $\sigma \in [2, 15]$, which does not affect our qualitative results.

Taking the natural logarithm of our indirect measure of fixed costs per shipment (equation (16)) we get

$$\ln(f_{ij}) = \ln\left((\sigma - 1)\bar{\gamma}_{ij}^{\sigma} - \sigma\bar{\gamma}_{ij}^{\sigma-1} + 1\right) - \ln\left(1 - \bar{\gamma}_{ij}^{\sigma}\right) + \ln\left(x_{ij}\right) - \ln(\sigma)$$

Since we use Swiss export data, we have $i = CH$.

Figure 3 plots the histogram of the imputed fixed costs per shipment in CHF (left panel, logged). These costs range from zero to values close to one percent. Their substantial variation may partly be attributable to measurement errors. More interestingly, it is likely that there is variation of fixed costs per shipment due to effects that are specific to goods and countries. In our econometric analysis below, we try to assess the latter ones in more detail.

The histogram on the right hand side represents the (logged) fixed costs of shipment in percent of export value. The average fixed costs per shipment thus amounts to 1.01% of export value (or a net present value of 7 790 CHF). We view this value as reasonable and economically significant.[33]

Referring to per period fixed costs, Das et al (2007) write that "these costs, on average, are negligible." Our estimates, instead, indicate that the fixed costs per

[32] While in theory it is possible to infer market entry costs through (13), we are unable to estimate variable transport costs with our data due to the lack of proxies for the ideal price index and firm productivity (see discussion in connection with equation (17)).

[33] When the interest rate ranges in $r \in [.025, .1]$, the corresponding numbers vary between $0,56\%$ and 2.05%; when the elasticity ranges in $\sigma \in [2, 15]$, the numbers vary between $0,64\%$ and 1.09%.

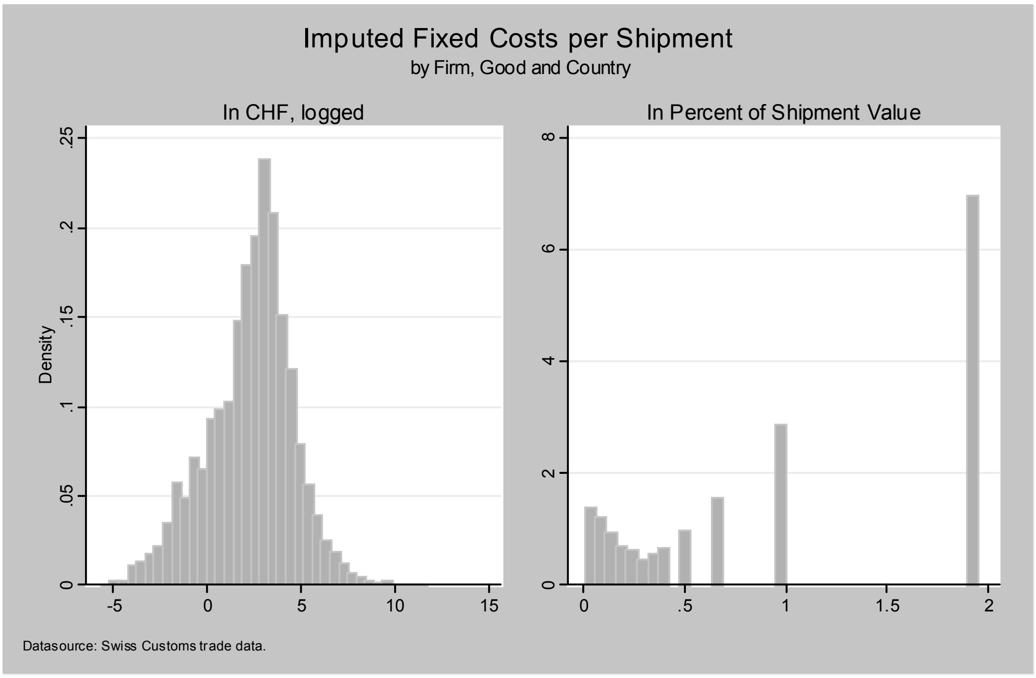

Figure 3: Histogram of fixed costs per shipment imputed through equation (16) for selected combinations of firm, good and destination country of Swiss exporters for the period 2007. See also note of Figure 1.

shipment are quite large. Too large, in any case, to be ignored in trade models that react sensitively to the shape and size of trade costs.

4.1 The Econometric Model

We aim to extract the determinants and drivers of the fixed costs per shipment. Specifically, we formulate an empirical model as

$$\ln(f_{ijs}) = \alpha + \beta X_{ij} + \sum\nolimits_{s \in S} \gamma_s D_s + \varepsilon_{ijs}$$

where matrix X_{ij} stands for a set of economic variables, which we can reasonably suspect to impact fixed costs per shipment: dummies for common language, bilateral trade agreements as well as distance; dummies for the transportation modes, i.e. railway, air and mail. Further, D_s are dummies of our good category, which we include to capture good-specific effects (see discussion of Figure 3). Finally ε_{ijs} is a measurement error, assumed to be normally distributed. We perform OLS estimations with clustered error estimation to correct for heteroskedasticity bias.

4.2 Estimation Results

Table 2 reports our estimates. Columns I - III present the results for specifications where the variables *Common Language, Trade Agreement* and *Distance* of the destination country from Switzerland (measured in km between capitals and logged) enter separately in the regression. The coefficients are significant at the 5 percent level except the one for Trade Agreement (marginally significant on the 10 percent level) and all have the expected sign: setup cost tends to decrease with language commonalities, under trade agreements and with geographic proximity. Columns IV - VI shows that these results remain largely unchanged when controlling for GDP and per capita GDP of the destination country (both logged). In this specification, the estimated coefficients are all significant, (Language is significant on the 1 percent level). The estimations suggests that the effect of a common official language is huge, implying a reduction of fixed costs per shipment of about 54% ($\exp(-.786) \approx 0.456$). Similarly, the establishment of a trade agreement would imply a reduction of this type of costs of about 41% ($\exp(-.528) \approx 0.59$); and finally, a doubling of bilateral distance increases the respective shipment costs by about 7%.[34]

Interestingly, fixed costs per shipment tend to decrease in destination GDP. This effect might be driven by the fact that larger economies (such as the USA) cannot be treated as a single region as shipments to the East Coast and the West Coast cannot be naturally bundled into one shipment but require, instead, different shipments. These effects can increase the number of shipments at any given trade volume and hence decrease the imputed fixed costs per shipment. Conversely, fixed costs per shipment tend to increase in destination GDP per capita, which might be explained by higher wages and thus higher total costs of the procedure of customs clearance at the destination ports. Consistent with our theory, however, neither GDP nor GDP per capita significantly impacts the fixed costs of exporting.

Table 3 reports the results of regressions including dummies for the different types transportation *Train, Air* and *Water*. The dummy for transportation on the road is dropped and the coefficients are therefore to be read relative to predominant transportation with trucks. These dummies capture the transportation type that occurs most frequently within the respective combination of firm-good-country. As

[34] Here and in the following regressions, the estimated coefficients remain largely unchanged in terms of magnitude when changing the demand elasticity and interest rate in the ranges [2,15] and [0.025,0.1].

we pointed out in the previous section, the coefficients on the transportation dummies are to be read with caution, as they capture the transportation mode at the moment the goods cross the Swiss borders. Nevertheless, the estimation results appear to make sense: the coefficient on *Train* and *Water* suggests that, other things equal, shipping goods by truck involves much smaller fixed costs per shipment than those associated with organizing containers ready for transport via rail or waterway.[35] This result is not surprising, as the main advantage of transportation by truck are flexibility and decentralized operating conditions. Indeed, the point estimates suggest that the corresponding fixed costs are roughly four and eight fold for the rail and the plane, respectively ($\exp(1.332) \approx 3.79$ and $\exp(2.106) \approx 8.215$). The differences between fixed costs per shipment by plane and by road are much smaller and not significant.

Of course the choice of the means of transport is endogenous – e.g. heavy and bulky goods are unlikely to be shipped by plane. This observation implies that our estimates of the coefficients on the transport type are subject to a potential endogeneity bias. Remember, however, that all regressions include good dummies, so that the respective estimates rely on the variation within the good classes, not across goods. Arising biases are therefore unrelated to good composition.

4.3 Robustness Checks and Further Discussion

We are concerned about three potential problems of our analysis. First, our data includes observations that do not fit our theoretical framework. E.g., we include observations that are recorded on a per-unit basis or that reflect sporadic transaction of private persons. Second, the analysis is restricted to the relatively narrow timespan of one year. Third, our modeling setup relies on the assumption that there is no upper bound on the size of shipment. In this section we address the first two concerns with standard robustness checks and the third concern by taking a look at the weights of our shipments.

For the first robustness check, we generate a reduced dataset based on three filtering criteria that eliminate those observations that are misfit to our framework. First, using the reported weights of shipments in our dataset, we drop good categories for which all shipments contain only a single unit of the good. These are the categories "motor vehicles for the transport of goods (less than 1200 kg)" (tariff number

[35] Keep in mind that fixed costs per shipment are connected to management and organization of freight and are independent of the costs of container rental.

8704.3110), "motor vehicles for the transport of goods (between 1200-1600 kg)" (tariff number 8704.3120),. By the same token, we eliminate exports of "wood in chips or particles" (tariff number 4401.2200) and "lamp-holders, plugs and sockets (between 0.3 and 3kg)" (tariff number 8536.6952) and "articles of goldsmiths' and silversmith's wares" (tariff number 7114.1990). Second, we eliminate shipments within categories and firms, typically apparel exporting firms, whose transactions consist of small shipments to individuals. Finally, we eliminate firm-good-destination combinations with only one shipment in 2007. These might well be transaction of tourists or individuals who sent goods that they purchased in Switzerland to their home address. Filtering the data according to these criteria leaves us with 227 firms that export 157 different goods.

For the second robustness check, we address concerns related to the narrow timespan. To this aim, we generate another dataset using both years 2006 and 2007. We return to the unrestricted sample and only filter our data for both years applying the requirement of 95% coverage described above (see section 3.2). This criteria leaves us with 85 firms that export 60 different goods. Three of the firms export exactly two distinct goods, two export exactly three distinct goods, and ten of these firms export more than four goods.

With both datasets, we replicate the previous estimations, reporting the corresponding results in Tables A1 - A2 in the appendix. For the restricted sample (Table A1 in the Appendix), the fit of the model is better. The estimated coefficients of interest still have the expected signs, but are now significant at the one percent level (Columns I - III). The effect of language similarities, however, is now estimated to be less strong. Similarly, both the magnitude and significance increase for the coefficients on the dummies, indicating transportation on rail and water (Columns V - VII). The better fit of the data should not come as a surprise since the selection of firms is intended to exclude those firms for which the trade-off between shipment volume and frequency, and hence the theory, does not properly apply. Table A2 reports the regression results based on data from 2006 and 2007. By and large, they confirm our previous findings. The effects of transportation mode are estimated to be weaker, which is possibly the result of the reduced sample size.

A third important concern may stem from the modeling assumption that there is no upper bound on the size of shipment. Thus, one may be worried that containers used for international shipments of goods do have a limitation of space and weight, which could cap the optimal shipment size of the firms. While volume is not reported in

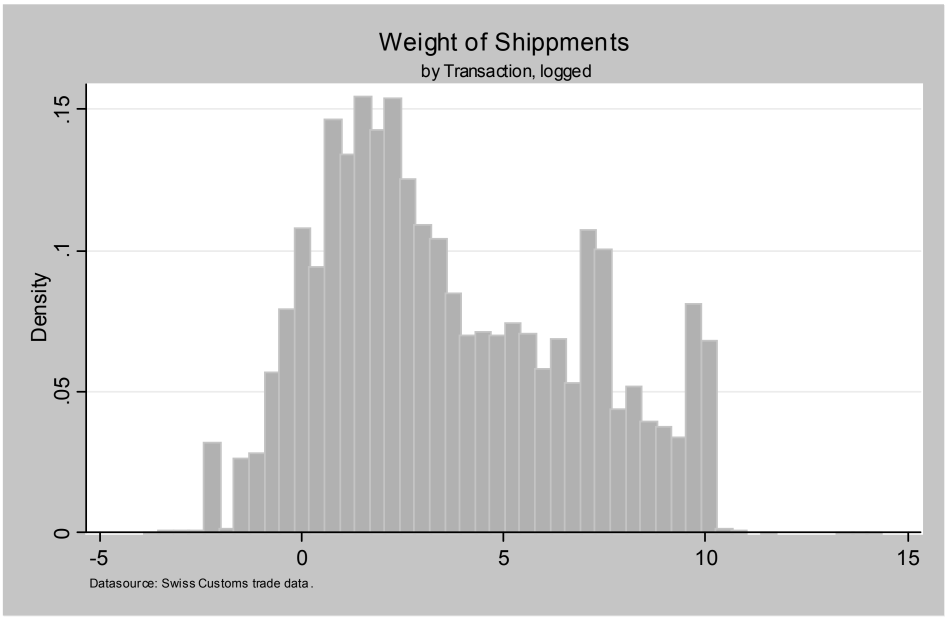

Figure 4: Histogram of weight per shipment (kilogram, logged) for selected combinations of firm, good and destination country of Swiss exporters for the year 2007. See also note of Figure 1.

our dataset, there is a way to address this concern with the maximum net loading weight of containers. Specifically, the maximum weight of the frequently used 40' ISO Freight container is typically around 26 tons. In reality, the product specific maximum weight restrictions might be somewhat below this value given that a 40' container accommodates 20 standard pallets and the maximum per pallet load varies from product to product. Overall, we thus expect a maximum shipment weight to be close to but lower than 26'000 kg. To assess whether this maximal weight is a binding constraint for the average form, we take a look at the (logged) weight per transaction. Figure 4 plots these weights for the set of transactions underlying our firm data. Indeed, an upper bound appears to cap the upper end of the distribution almost precisely at our expected level of $ln(26'000) \approx 10.67$. Notice, however, that the mass of the observations is well below this threshold and only a very small fraction of the shipments seem to be truly affected by the limitation of shipment containers. In sum, the concerns related to maximum shipment size due to technological restrictions seem to be unwarranted.[36]

[36]The fact that observations exist with weight exceeding the maximum loading weight of containers should not come as a surprise, since most, but not all, goods are shipped via container.

5 Conclusion

This paper has analyzed the role, size and determinants of fixed costs per shipment. Our theory rests on the assumption that exporting firms optimally trade off the fixed costs of exporting and storage costs at export markets. Conceptually, we have shown that fixed costs per shipment introduce a new margin along which trade volumes expand and contract. Being substitutable with storage costs, fixed costs per shipment smear the border between fix and variable costs of trade. This feature raises questions concerning the appropriate measurement of variable trade costs. Most importantly, we have presented a method to infer the fixed costs per shipment from cross-border trade data on the transaction level. This methodology enables us to disentangle and analyze fixed costs per shipment. We do so using disaggregated Swiss export and import data. Our findings suggest that fixed costs per shipment are economically significant and considerably larger than the per-period fixed costs estimated in earlier studies. In particular, our estimates suggest that for the average Swiss exporters the fixed costs per shipment are one percent of the value of export or at a net present value of 7790 CHF.

A Appendix

A.1 Proofs

Proof of (11). According to the concept of iceberg costs, the value of goods boarded for shipment consists of the product consumed quantity q_j and τ_j. Thus, using (2), (3) and (4)

$$x_{ij} = \int_0^{\Delta t_{ij}} \tau_{ij}\tilde{p}q_{ji}(a,t')dt' = \left[\frac{\sigma}{\sigma-1}\frac{\tau_j a w_i}{P_j}\right]^{1-\sigma} Y_j \frac{1-\bar{\gamma}_{ij}^{\sigma}}{\sigma r} = \frac{A_{ij}}{r}\left(1-\bar{\gamma}_{ij}^{\sigma}\right)$$

Proof of (12). Take (11) to compute

$$\begin{aligned} \frac{d}{dA_j}\ln\left(x_j\right) &= \frac{1}{A_j} - \frac{\sigma\bar{\gamma}_j^{\sigma-1}}{1-\bar{\gamma}_j^{\sigma}}\frac{r\sigma f_j}{A_j^2}\frac{1}{\left(\sigma-1\right)\sigma\bar{\gamma}_j^{\sigma-2}\left(1-\bar{\gamma}_j\right)} \\ &= \frac{1}{A_j}\frac{1}{\left(\sigma-1\right)\left(1-\bar{\gamma}_j\right)\left(1-\bar{\gamma}_j^{\sigma}\right)}\left(\left(\sigma-1\right)\left(1-\bar{\gamma}_j\right)\left(1-\bar{\gamma}_j^{\sigma}\right) - \bar{\gamma}_j\frac{r\sigma f_j}{A_j}\right) \\ &= \frac{1}{A_j}\frac{\sigma-1+\bar{\gamma}_j^{\sigma}-\sigma\bar{\gamma}_j}{\left(\sigma-1\right)\left(1-\bar{\gamma}_j\right)\left(1-\bar{\gamma}_j^{\sigma}\right)} \end{aligned}$$

where the last step follows from (10).

Proof of (13). Use $F_{ij} \leq NPV_{ij}$ and NPV_{ij} from (9) to check that

$$F_{ij} \leq \frac{1}{1-\bar{\gamma}_{ij}}\left\{A_{ij}\frac{1-\bar{\gamma}_{ij}^{\sigma}}{r\sigma} - f_{ij}\right\} = \frac{1}{1-\bar{\gamma}_{ij}}\frac{A_{ij}}{r\sigma}\left\{1-\bar{\gamma}_{ij}^{\sigma} - r\sigma f_{ij}/A_{ij}\right\} = \frac{A_{ij}}{r}\bar{\gamma}_{ij}^{\sigma-1}$$

where the last step follows from (10).

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Table 1a: ***Export-Distribution along the Good / Country Dimension***

Percentile	Percent Values	Percent no. Shipm.	Percent Values	Percent no. Shipm.	Percent Values	Percent no. Shipm.
0.1	28.15%	6.37%	.	.	38.29%	11.30%
0.2	35.43%	7.24%	.	.	46.92%	18.26%
0.5	45.31%	13.78%	20.08%	28.28%	59.18%	29.79%
1	53.81%	22.88%	30.13%	33.62%	68.86%	41.48%
2	63.65%	35.50%	46.19%	50.34%	78.26%	54.51%
5	77.84%	56.86%	71.55%	73.04%	89.02%	71.72%
10	88.51%	73.76%	84.61%	83.96%	94.83%	83.58%
20	96.24%	89.18%	95.38%	94.63%	98.28%	92.63%
50	99.76%	98.96%	99.73%	99.44%	99.86%	98.83%
100	100%	100%	100%	100%	100%	100%

Table 1b: ***Import-Distribution along the Good / Country Dimension***

	Goods		Countries		Good-Country Pairs	
Percentile	Percent Values	Percent no. Shipm.	Percent Values	Percent no. Shipm.	Percent Values	Percent no. Shipm.
0.1	15.82%	1.75%	.	.	29.78%	12.83%
0.2	21.05%	4.63%	.	.	37.66%	20.83%
0.5	30.77%	12.18%	33.34%	44.69%	50.34%	33.32%
1	39.06%	21.20%	44.91%	56.95%	61.26%	45.40%
2	48.74%	31.09%	59.69%	69.83%	72.66%	59.29%
5	64.08%	49.25%	84.17%	90.08%	86.27%	76.86%
10	76.79%	64.81%	93.25%	96.23%	93.76%	87.93%
20	88.83%	81.52%	98.46%	99.06%	98.06%	95.60%
50	98.73%	97.07%	99.96%	99.97%	99.86%	99.47%
100	100%	100%	100%	100%	100%	100%

Table 2 - Fixed Costs of Shipment, Trade Frictions - Full Sample, 2007

	I	II	III	IV	V	VI	VII
Dependent Variable: Imputed Fixed Costs of Shipment							
Language	-0.850**			-0.786***			-0.636**
	[0.332]			[0.281]			[0.246]
Trade Agr.		-0.541*			-0.528**		-0.207
		[0.301]			[0.250]		[0.162]
Log Distance			0.0644**			0.0716**	0.0291*
			[0.0300]			[0.0287]	[0.0150]
Log GDP				-0.117***	-0.138**	-0.179**	-0.120***
				[0.0427]	[0.0571]	[0.0731]	[0.0408]
Log GDP p.c.				0.179**	0.248**	0.200**	0.208**
				[0.0826]	[0.102]	[0.0959]	[0.0921]
Constant	2.530***	2.509***	2.044***	3.822***	3.710***	4.771***	3.578***
	[0.0546]	[0.0652]	[0.240]	[1.009]	[1.249]	[1.544]	[0.951]
Observations	5343	5343	5293	5204	5204	5191	5191
R-squ. Adj.	0.341	0.326	0.325	0.346	0.334	0.337	0.351
Cluster Groups	148	148	142	129	129	128	128
Good Dummies	yes	yes	yes	yes	yes	yes	yes

*** significant at 10%; ** significant at 5%; *** significant at 1%. Robust standard errors in brackets.**

Table 3 - Fixed Costs of Shipment by Transportation Mode- Full Sample, 2007

	I	II	III	IV	V	VI	VII
Dependent Variable: Imputed Fixed Costs of Shipment							
T.M. Rail	1.283***			1.332***			1.442***
	[0.317]			[0.316]			[0.316]
T.M. Air		-0.175			-0.157		-0.142
		[0.216]			[0.203]		[0.202]
T.M. Water			2.046***			2.106***	2.284***
			[0.477]			[0.466]	[0.479]
Log GDP				-0.167**	-0.166**	-0.168**	-0.168**
				[0.0804]	[0.0832]	[0.0807]	[0.0817]
Log GDP p.c.				0.168*	0.161*	0.166*	0.178**
				[0.0867]	[0.0876]	[0.0868]	[0.0866]
Constant	2.238***	2.291***	2.245***	4.984**	5.066**	5.027**	4.934**
	[0.160]	[0.200]	[0.159]	[1.924]	[1.985]	[1.929]	[1.937]
Observations	5343	5343	5343	5204	5204	5204	5204
R-squ. Adj.	0.317	0.314	0.317	0.328	0.325	0.328	0.332
Cluster Groups	148	148	148	129	129	129	129
Good Dummies	yes	yes	yes	yes	yes	yes	yes

*** significant at 10%; ** significant at 5%; *** significant at 1%. Robust standard errors in brackets.**

Table A1 - Fixed Costs of Shipment, Trade Frictions and Transportation Mode - Limited Sample, 2007

	I	II	III	IV	V	VI	VII	VIII	IX
Dependent Variable: Imputed Fixed Costs of Shipment									
Language	-0.484***			-0.261					-0.265
	[0.182]			[0.166]					[0.165]
Trade Agr.		-0.509***		-0.240*					-0.248*
		[0.139]		[0.128]					[0.126]
Log Distance			0.0777***	0.0475**					0.0361*
			[0.0186]	[0.0205]					[0.0194]
T.M. Rail					2.122***			2.336***	1.971***
					[0.518]			[0.507]	[0.546]
T.M. Air						0.249		0.256	-0.0310
						[0.212]		[0.207]	[0.226]
T.M. Water							3.118***	3.404***	2.985***
							[0.358]	[0.312]	[0.325]
Log GDP	-0.0754*	-0.0823*	-0.119**	-0.0912**	-0.105*	-0.0991	-0.0982	-0.108*	-0.0948**
	[0.0434]	[0.0423]	[0.0526]	[0.0381]	[0.0630]	[0.0617]	[0.0631]	[0.0594]	[0.0382]
Log GDP p.c.	-0.0162	0.0441	-0.00665	0.0490	-0.0400	-0.0672	-0.0442	-0.0152	0.0873
	[0.0967]	[0.0992]	[0.0996]	[0.0977]	[0.0904]	[0.0891]	[0.0855]	[0.0835]	[0.0938]
Constant	4.226***	3.905***	4.880***	3.889***	5.073***	5.186***	4.949***	4.850***	3.610***
	[1.353]	[1.245]	[1.445]	[1.041]	[1.819]	[1.827]	[1.869]	[1.698]	[1.027]
Observations	1556	1556	1556	1556	1556	1556	1556	1556	1556
R-squ. Adj.	0.481	0.483	0.488	0.493	0.477	0.470	0.478	0.489	0.506
Cluster Groups	89	89	89	89	89	89	89	89	89
Good Dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes

*** significant at 10%; ** significant at 5%; *** significant at 1%. Robust standard errors in brackets.**

Table A2 - Fixed Costs of Shipment, Trade Frictions and Transportation Mode - Full Sample, 2006/07

	I	II	III	IV	V	VI	VII	VIII	IX
Dependent Variable: Imputed Fixed Costs of Shipment									
Language	-0.906**			-0.651*					-0.640*
	[0.436]			[0.377]					[0.376]
Trade Agr.		-0.765**		-0.258					-0.244
		[0.379]		[0.235]					[0.236]
Log Distance			0.111**	0.0674**					0.0659**
			[0.0423]	[0.0263]					[0.0261]
T.M. Rail					1.678*			1.742*	0.872
					[0.875]			[0.917]	[0.905]
T.M. Air						0.340		0.349	-0.0858
						[0.517]		[0.512]	[0.461]
T.M. Water							3.934***	3.969***	2.907***
							[1.174]	[1.171]	[1.083]
Log GDP	-0.183**	-0.188**	-0.240**	-0.193**	-0.225*	-0.225*	-0.228**	-0.234**	-0.199**
	[0.0827]	[0.0865]	[0.101]	[0.0767]	[0.114]	[0.116]	[0.113]	[0.115]	[0.0785]
Log GDP p.c.	0.0901	0.174	0.174	0.175	0.0795	0.0839	0.0785	0.0833	0.170
	[0.125]	[0.137]	[0.127]	[0.130]	[0.125]	[0.126]	[0.123]	[0.125]	[0.129]
Constant	6.866***	6.174***	6.812***	6.077***	7.725***	7.681***	7.828***	7.903***	6.271***
	[1.967]	[2.039]	[2.261]	[1.718]	[2.839]	[2.826]	[2.780]	[2.766]	[1.703]
Observations	1043	1043	1039	1039	1043	1043	1043	1043	1039
R-squ. Adj.	0.451	0.440	0.452	0.468	0.421	0.420	0.425	0.426	0.470
Cluster Groups	97	97	96	96	97	97	97	97	96
Good Dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes

*** significant at 10%; ** significant at 5%; *** significant at 1%. Robust standard errors in brackets.**

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