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Abstract: We build a model of administrative barriers to trade to understand how they affect trade volumes, shipping decisions and welfare. Because administrative costs are incurred with every shipment, exporters have to decide how to break up total trade into individual shipments. Consumers value frequent shipments, because they enable them to consume close to their preferred dates. Hence per-shipment costs create a welfare loss.

We derive a gravity equation in our model and show that administrative costs can be expressed as bilateral ad-valorem trade costs. We estimate the ad-valorem equivalent in Spanish shipment-level export data and find it to be large. A 50 percent reduction in per-shipment costs is equivalent to a 9 percentage point reduction in tariffs. Our model and estimates help explain why policy makers emphasize trade facilitation and why trade within customs unions is larger than trade within free trade areas.

Response to the editor
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We thank you for giving us the opportunity to revise the paper. Below we highlight the major changes and, in turn, respond to the referees' points in detail.

1. To explore the robustness and help the interpretation of our results, we now include more controls in our gravity equations and explore alternative econometric specifications. We also study the freight choices in a bit more detail. Broadly speaking, the results are robust to these changes.

2. We study the covariates of administrative barriers (Table 2). Indeed, as Referee 2 points out, these barriers are higher for poor countries. This motivates us to do a different counterfactual, where we reduce the administrative barriers to the level of those seen in rich countries. The average gain in welfare remains large, with poor countries gaining the most. We discuss the distributional effects of such a counterfactual policy in Section 5.

3. We have rewritten the discussion at numerous places to address the concerns of referees.

Response to Referee 1
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We thank you for your insightful and constructive comments. We feel like we could address most of them. We provide detailed response below.

1. "I think that it would be interesting to examine how differences in administrative costs shape differences in welfare gains across rich and poor countries as computed from the model."

We agree that this is an interesting direction. This comment motivated us to study the covariates of administrative barriers in Section 4.1 (Table 2). Administrative barriers tend to be lower for larger and richer countries that are closer to one another and are members of an FTA.

We also conducted the counterfactual you suggested, reducing administrative costs to the average of countries in the top income decile. The results are reported in Section 5, Table 6. In summary, the tariff-equivalent effects are between 13 percent for the lowest income decile and 1.5 percent for 9th income decile. Interestingly, there is much less variation in statury tariff rates across income groups than in the tariff-equivalent effects of administrative barriers. Hence a trade facilitation reform equalizing administrative barriers offers a stronger force for convergence than a tariff harmonization reform.

2. "Moreover, the decision on the timing to ship the item is interrelated with the chosen mode of transit (when you ship out the item depends whether you ship it via boat or plane for example). This issue is neither addressed in the theoretical nor in the empirical analysis."

Your comment raises two interesting questions. First, the mode of shipping might affect shipment frequency and size. In the model, this might be captured by changes in deep parameters such as delta and f. In the data, we would have to control for the mode of shipping. Second, the choice of shipping mode is endogenous and might be one of the margins through which firms react to administrative barriers.

In our companion paper, Hornok and Koren (2014), we study the correlation between per-shipment costs and shipping frequency after controlling for the mode of transport (Tables 3 and 4 in that paper).

High per-shipment costs are associated with less frequent (elasticity -0.10 to -0.26) and larger (elasticity 0.05 to 0.10) shipments.

We also conducted an empirical analysis of the margins through which exporters change their shipping frequency. Simply put, they may (i) send more of the same good in larger shipments, (ii) pick slower modes of transport that allow for larger shipments and (iii) send bulkier products instead of small products. We do an index-number analysis to decompose the aggregate response into these channels. The results are reported in Appendix B. The main results are that shipping frequency is negatively associated with administrative costs even after controlling for mode of shipping, and that the mode itself does not vary significantly with administrative barriers.

3. "Would the welfare formula (derived in the present paper) still apply if they were endogeneous and if there was free entry of firms? If not, the authors should acknowledge somewhere that the welfare result in the paper is a local result, which then changes the interpretation of the results of the quantitative exercise."

Thank you for pointing this out. We have indeed been somewhat vague about the applicability of ACR. We now state our relation to ACR more precisely on page 13. Shortly, our model satisfies R3 of ACR, but not the more restrictive R3' because firms make profits that are not a constant multiple of costs. We have also reworded the discussion of the counterfactual accordingly (page 21).

4. "have you considered using an interaction term in regression (11) for f_ij and customs union/FTA"

Table 4 now also reports interaction terms in addition to the different subsamples. For non-FTA country pairs, the elasticity of trade with respect to administrative costs is -1.17. This is significantly higher (hence, less in absolute value) for FTAs and even higher for customs unions.

Response to Referee 2
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We thank you for your insightful and constructive comments. We feel like we could address most of them. We provide detailed response below.

1. "The set of gravity variables includes the dummy for economic union. The coefficient before this dummy variable is around -1.7, which is highly confusing."

Thank you for drawing our attention to this point, this result is indeed puzzling. We have explored the multi-collinearity between the various forms of economic integration, and the robustness of our customs union result. In summary, a positive effect of customs unions is quite robust, but the effect is smaller than we previosly estimated. We are now referring to this more conservative estimate.

To give you the details, the economic union and the customs union dummies are indeed quite collinear. In 2006, there are 1090 country pairs that are in a customs union, 782 of which also form a common market, 208 an economic union. When we group all these customs union members together, the trade difference relative to FTA members turns insignificant in the OLS specification (Table A.9, column 2).

One possible explanation for the difference is the different collection of intra-EU trade data. Whereas the source of trade data for extra-EU trade is customs records, intra-EU trade flows are measured via the Intrastat firm survey. When we restrict the sample to country pairs for which at least one of the countries is outside the EU (and trade is hence measured via customs), we find that trade within customs unions is larger by 32 percent than trade in FTAs (see column 3). Consistent with this explanation, trade is only lower for intra-EU trade, whereas the external trade of EU countries is on average larger those of similar countries (column 4).

Because zero trade flows are quite prevalent in the data, especially for less integrated countries, we have also explored other econometric specifications for the gravity equation. For countries outside an FTA, 44 percent of trade flows are zero, so these observations are excluded from the loglinear specification. The fraction of zeroes is only 5 percent for FTA members, 9 percent for customs union members, and 2 percent for common market members.

Column 5 reports the marginal effects of a probit specification, where the dependent variable is a dummy for nonzero trade flow. Even conditional on a rich set of covariates, FTA members are 5.5 percent more likely to trade positive amounts; the probability of nonzero trade is an additional 11 percent higher for customs union members.

Column 6 reports a Poisson specification, which includes positive as well as zero trade flows. Santos Silva and Tenreyro (2006) argue for this specification not only due to the presence of zeroes, but also because it is more robust to heteroskedasticity in trade. In this specification, customs unions members trade 26 percent more than FTA members.

Taken together, we are confident that, conditional on our rish set of covariates, expected trade volumes in customs unions are larger than in FTAs.

2. "The Table 3 estimations are using data for 2006 that is driven by the data availability from Baier and Berngstrand (2007) database on international agreements. ... I suggest the authors to use later years (say, 2012), or a panel in their estimates."

We have updated the Baier-Bergstrand data until 2012 for our sample of importers in their relation to Spanish export. The results did not change qualitatively. Updating the entire bilateral dataset was beyond the scope of this paper, so that regression continues to use 2006 data.

3. "I have serious concerns regarding the fixed effect equation in Table 4, column (3). ... If the within variation is indeed small, authors should search for alternative methods (random effects? simple OLS?), or at least discuss the problem."

We realize we have not explained the time series variation of administrative barriers. We now do this on page 20. Indeed there is very little time variation, 91 percent of the variation in log shipping costs is soaked up by country fixed effects. Following your suggestions, we now include a random effects specification for our regressions. Our results are even stronger.

4. "The notation fij is confusing for the reader in section 4.2."

Indeed we have not clarified enough where this variation comes from. As there are administrative procedures for both exports and imports, we add the two. This way, fij = fi(export) + fj(import). We explain this better on page 17.

5. "Authors may consider the inclusion of additional variables in gravity equations (Table 3) and shipment equations (Table 4). For example, empirical analysis misses the dummy variable for currency union, since common currency facilitates trade between two countries and provides positive effects on trade."

We have included a host of new controls in our regressions, such as per capita income, bilateral tariff rates, a common currency indicator, and dummies for islands and each of the continents. These are reported in the new Table 4. Our main results did not change.

Response to Referee 3
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We thank you for your insightful and constructive comments. We feel like we could address some, though not all of them. We provide detailed response below.

1. "My primary concern is with its marginal contribution to the prior literature, in part given earlier work by the same authors."

We tried to highlight the contributions better on page 5. In particular, we discuss the differences to Alessandria, Kaboski and Midrigan (2010) and Kropf and Saure (2014) in more detail.

2a. "Firm heterogeneity is a key feature of international trade patterns, and fixed costs interact importantly with it."

We agree that firm heterogeneity is important. At the same time, our lack of firm-level data and our interest in the overall welfare effects motivated us to focus on the aggregate trade patterns. While we do not derive this in our framework, the result of Arkolakis, Costinot and Rodriguez-Clare (2012) suggests that under some conditions, the aggregate welfare properties of a Melitz-type model are identical to a Krugman-type model. We discuss our relation to ACR on page 13.

We hence view our contribution as complementary to Kropf and Saure (2014), who develop a heterogeneous-firm framework of fixed shipping costs (see our discussion on page 12).

2b. "The relationship between iceberg variable costs, per-unit variable costs, fixed trade costs per destination, fixed trade cost per shipment-destination, and fixed trade cost per container-destination is unclear in the theory."

We have tried to clarify this better in the paper. Please see page 8.

2c. "Multi-product firms capture the vast majority of international trade. If the authors are interested in unpacking the black box of fixed trade costs by modeling micro-foundations and examining costs per shipment or per container, it seems important to take into account the fact that firms can ship multiple products with the same shipment and/or container."

(We answer this comment together with 2d and 4 below.)

2d. "While I do believe that administrative trade costs are a very important trade deterrent and it is valuable to study them, I am not sure whether they operate through the mechanism proposed in this paper, i.e. the frequency vs. size of shipments. They may equally well act just like any other fixed trade cost in a Melitz-type world. The empirical analysis cannot directly establish the mechanism in question since it considers the number of Spanish shipments by country, rather than by country-product or country-product-firm."

4. "The discussion of costs per shipment vs. per container is muddled yet the distinction seems important given the authors' focus. Larger firms may use multiple containers per shipment, or ship multiple products in the same container. Multiple smaller firms can potentially share the same container."

5. "How does inventory holding by either the exporter or the importer affect trade patterns and consumer welfare? Could trade intermediaries overcome some of the distortions caused by administrative costs by bundling the sales of multiple smaller firms into a single shipment?"

We agree that a deeper modeling of shipping, including multiple products or multiple firms per shipment, is an interesting direction. We added Appendix B discussing the role of the mode of transport in explaining the variation in the number and size of shipments. We also describe the shipment-level Spanish export data in a bit more detail in Section 4.1. Related to your question, we explored the bundling of shipments. For this exercise, we define a shipment based on shipping characteristics alone (such as date, final and transit country, vessel, containerization), while ignoring information on the product or its value. The vast majority, close to 60 percent, of such shipments contain only a single product item. We hence view the single-product, single-firm approximation of our model as empirically relevant. Given that we do not have firm identifiers in the data, this is the best approximation we can do.

We realize this evidence does not fully answer your questions, but we believe it proves that our particular cut of the data and the export decision is relevant.

2e. "Administrative barriers to trade are likely strongly correlated with other country characteristics such as other trade costs, economic development and other institutions that might independently influence trade flows."

We fully agree and have included a host of new controls in our regressions, such as per capita income, bilateral tariff rates, a common currency indicator, and dummies for islands and each of the continents. These are reported in Table 4. Our main results did not change.

Also see Section 5 on a new counterfactual exercise motivated by this comment and a comment from another referee.

3. "I am confused by the calculation of an ad-valorem equivalent of administrative fixed costs since observed trade values are endogenous to these fixed costs. Separately, should more attention be paid to the difference between trade volumes (i.e. quantities shipped) vs. trade values (i.e. quantity x price)?

Indeed the ad-valorem equivalent of shipping costs is endogenous. Our Proposition 3 gives a local characterization of welfare around the equilibrium, evaluated at equilibrium outcomes, much like a local version of Arkolakis et al (2012). (See the new discussion on page 13.) We find this characterization helpful for semi-structural welfare analysis, but could not be used to compare two completely different equilibria.

As to prices vs quantity, we have explore that question in Tables 5 and 6 in our companion paper, Hornok and Koren (forthcoming). The upshot is that countries with higher trade barriers receive both larger and more expensive shipments. We have decided to omit this dimension from the current work due to space constraints.

6. "The discussion of FTAs and CUs is somewhat unrelated to the main message of the paper. Could the results for the different country subsamples in part capture the fact that these subsamples have very different numbers of observations and within-sample variation in administrative costs?"

There is indeed some issues with multicollinearity. Nonetheless, our robustness analysis of the CU effect in Appendix A makes us believe that the expected amount of trade is indeed higher in CUs than FTAs.

7. It would be interesting to consider the role of global supply chains in future work, since administrative and other fixed and variable trade costs may differentially affect trade in intermediate inputs between firms compared to trade in final goods to final consumers or retailers.

This indeed sounds interesting, but as it would require a wholly different theoretical aproach, we leave it for future work.

8a. "There appears to be a typo on the LHS of equation 9 as the numerator and denominator contain the same variable."

Thank you, we corrected it.

8b. "It would be more customary to state Proposition 1 in the form of a comparative static only"

We have slightly reworded the proposition.

8c. "On top of page 21, it is not clear what is being calibrated, how and why"

We have slightly reworded the sentence.

Administrative Barriers to Trade

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Abstract

We build a model of administrative barriers to trade to understand how they affect trade volumes, shipping decisions and welfare. Because administrative costs are incurred with every shipment, exporters have to decide how to break up total trade into individual shipments. Consumers value frequent shipments, because they enable them to consume close to their preferred dates. Hence per-shipment costs create a welfare loss.

We derive a gravity equation in our model and show that administrative costs can be expressed as bilateral ad-valorem trade costs. We estimate the ad-valorem equivalent in Spanish shipment-level export data and find it to be large. A 50 percent reduction in per-shipment costs is equivalent to a 9 percentage point reduction in tariffs. Our model and estimates help explain why policy makers emphasize trade facilitation and why trade within customs unions is larger than trade within free trade areas.

Keywords: administative barriers, trade facilitation, customs union, gravity equation

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1. Introduction

Exporters and importers around the globe face many administrative barriers. They have to comply with complex regulations, deal with a large amount paperwork, subject their cargo to frequent inspections, and wait for lengthy customs clearance. Minimizing the burden of these procedures, "trade facilitation," has been a priority for policymakers from developed and developing countries alike. In December of 2013, all members of the World Trade Organization (WTO) have agreed to the Bali Package, the first comprehensive agreement of the Doha round of negotiations. The main component of the Bali Package is an agreement on trade facilitation, requiring WTO members to adopt a host of measures streamlining the customs process, such as pre-arrival processing of shipments, electronic documentation and payment, and the release of goods prior to the final determination of customs duties, "[w]ith a view to minimizing the incidence and complexity of import, export, and transit formalities and to decreasing and simplifying import, export, and transit documentation requirements [...]"[1]

Why do countries rush to facilitate trade? They hope to increase trade volumes without endangering government revenues by reducing inefficiencies. In fact, studies of various trade facilitation measures find that they are associated with larger trade volumes.[2] Even among countries within free trade areas (FTAs), tighter economic integraton and a reduction of administrative barriers often leads to higher trade.[3]

We build a model of administrative barriers to trade to understand how they affect trade volumes, shipping decisions and welfare. A large part of administrative trade barriers are costs that accrue per each shipment, such as filling in customs declaration and other forms, or having the cargo inspected by health and sanitary officials. Hornok and Koren (forthcoming) document

[1] World Trade Organization (2013), Article 10, 1.1.

[2] See Engman (2005) and Francois, van Meijl and van Tongeren (2005) for a survey of the empirical evidence. Moïsé, Orliac and Minor (2011) construct various trade facilitation indicators and find that, taken together, they can reduce trade costs by up to 10 percent.

[3] Hornok (2012) finds that countries joining the European Union (EU) in 2004 have witnessed a 5 percent reduction in trade costs even though they already had FTAs with the EU since the mide 1990s. Handley and Limão (2012) find similar trade-creating effect of the EU accession for Portugal. Chen and Novy (2011) estimate that EU countries within the Schengen area, which are not subject to border control, enjoy 10 percent lower trade frictions than other EU countries.

that countries with high administrative barriers to importing (as reported in the Doing Business survey of the World Bank) receive less frequent and larger shipments. The starting point of our model is hence a tradeoff between administrative costs and shipping frequency. In the presence of per-shipment administrative costs, exporters would want to send fewer and larger shipments. However, an exporter waiting to fill a container before sending it off or choosing a slower transport mode to accommodate a larger shipment sacrifices timely delivery of goods and risks losing orders to other, more flexible (e.g., local) suppliers. With infrequent shipments a supplier of such products can compete only for a fraction of consumers in a foreign market.

We first use our model to derive a modified gravity equation of trade flows, in which administrative barriers show up as an additional tax on imports. Intuitively, when administrative barriers are high and shipments are infrequent, customers suffer utility losses that can be quantified as an ad-valorem tax equivalent. They also substitute towards local products accordingly.

We then show how to measure the welfare losses from administrative barriers to trade by estimating two key elasticities from the data. First, we need to know the sensitivity of consumers to timely shipments. This can be recovered from the observed shipping choices of exporters: if customers are very sensitive to timeliness, firms send many small shipments. Second, we need to estimate shippers' reaction to administrative costs. Calculating deadweight losses from the elasticity of consumer and firm behavior to prices is in the spirit of semi-structural estimation of Harberger (1964), Chetty (2009) and Arkolakis et al. (2012).

In our empirical analysis, we first show that per-shipment trade costs are sizeable and important for trade flows. We use the Doing Business database to measure the cost of shipping. Across 161 countries, the average trade shipment was subject to $3,000 shipping cost in 2009. High shipping costs are associated with low volumes of trade: country pairs at the 25th percentile of per-shipment costs trade 68 percent more than country pairs at the 75th percentile. This magnitude is comparable to the trade creating effect of sharing a common border.

Administrative barriers of trade are larger in poor countries than in rich ones. Doubling the income of an importing country is associated with a 6 percent decrease in per-shipment costs. This pattern is consistent with the fact reported by Waugh (2010) that poor countries have higher trade barriers than rich ones, without correspondingly higher consumer prices of tradables. In our model, administrative barriers affect the convenience of imports and hence trade volumes, but not consumer prices.

In addition, we find that administrative costs help explain trade flows among countries with no preferential trade agreements and even within FTAs, but not within customs unions. One potential reason for this is that customs unions are subject to much less administrative barriers than FTAs and our measured administrative costs do not apply. In fact, this could provide a new explanation for why trade within customs unions is higher than trade within FTAs.[4] Traditionally, the analysis of FTAs relative to customs unions focused on tariff harmonization, rules of origin and political economy (Krueger, 1997 and Frankel, Stein and Wei, 1997 and 1998).

We then study how exporters break down trade into shipments by exploiting shipment-level data for Spain for the period 2006–2012. We find that countries facing higher administrative barriers receive fewer shipments. This is similar to the finding of Hornok and Koren (forthcoming).

Using our estimated elasticity of the number of shipments with respect to per-shipment costs, we can calibrate the welfare effect of these costs. We conduct two counterfactual trade facilitation experiments in the model. In the first one we reduce per-shipment costs by half. In the model, this is equivalent to about a 9 percent reduction in tariffs and results in about a 31 percent increase in trade volumes. The second exercise harmonizes administrative barriers so that each country matches the per-shipment cost of the average country in the top decile of GDP per capita. Because richer countries have lower trade barriers, this typically involves a reduction in per shipment costs. The tariff-equivalent effects of this policy vary substantially with development, being 13 percent for the lowest income decile and 2 percent for the highest.

Our counterfactual exercises suggest large trade creating effects of trade facilitation and large distributional effects from harmonizing administrative barriers.

Our emphasis on shipments as a fundamental unit of trade follows Armenter and Koren (2014), who discuss the implications of the relatively low number of shipments on empirical models of the extensive margin of trade.

We relate to the recent literature that challenges the dominance of iceberg trade costs in trade theory, such as Hummels and Skiba (2004) and

[4]See, for example, Roy (2010) and also Section 4 of this paper.

Irarrazabal, Moxnes and Opromolla (2010). They argue that a considerable part of trade costs are per unit costs, which has important implications for trade theory. Per unit trade costs do not necessarily leave the within-market relative prices and relative demand unaltered, hence, welfare costs of per unit trade frictions can be larger than those of iceberg costs.[5]

The importance of per-shipment trade costs or, in other words, fixed transaction costs has recently been emphasized by Alessandria, Kaboski and Midrigan (2010). They also argue that per-shipment costs lead to the lumpiness of trade transactions: firms economize on these costs by shipping products infrequently and in large shipments and maintaining large inventory holdings. Per-shipment costs cause frictions of a substantial magnitude (20 percent tariff equivalent) mostly due to inventory carrying expenses. We consider our paper complementary to Alessandria, Kaboski and Midrigan (2010) in that we exploit the cross-country variation in administrative barriers to show that shippers indeed respond by increasing the lumpiness of trade. Relative to their work, our focus is on characterizing the welfare consequences of administrative barriers in a simple-to-calibrate framework. We can do this by leveraging the semi-structural approach.

Our work is most related to Kropf and Sauré (2014), who build a heterogenous-firm trade model to study how fixed costs per shipment affect shipment size. They characterize the size and frequency of shipments as a function of firm productivity, and also show aggregate exports follow from firm-level trade patterns. They then recover shipment costs from the observed shipment sizes, showing that these imputed costs are large and correlate plausibly with geographic variables and trade agreements. Given our lack of firm-level data, our model is admittedly simpler, but our focus here is also different: we want to understand the welfare consequences of administrative trade costs in a tractable aggregate framework. For this purpose, we derive a standard gravity equation in our model, and show how our model can be calibrated using a limited set of aggregate moments. We also offer new evidence on the trade effects of administrative barriers within and outside customs unions and conduct various counterfactual experiments.

[5] Hummels and Skiba (2004) obtain an interesting side result on a rich panel data set, which is consistent with the presence of per-shipment costs. The per unit freight cost depends negatively on total traded quantity. Hence, the larger the size of a shipment in terms of product units, the less the per-unit freight cost is.

2. A model of the shipping frequency of trade

This section presents a model that determines the number and timing of shipments to be sent to a destination market. Sending shipments more frequently is beneficial, because consumers value timely shipment. Producers engage in monopolistic competition as consumers value the differentiated products they offer. Each producer can then send multiple shipments to better satisfy the demands of its consumers.

There are J countries, each hosting an exogenous number of sellers and consumers. A seller can sell to a domestic consumer at no shipping cost. It can also sell to a foreign destination j, in which case it has to pay iceberg shipping costs as well as the administrative cost of exporting to country j.

The difference between administrative barriers and other trade costs is that the former apply for every shipment. We hence model them as per-shipment costs that are pure waste.

We characterize the shipping problem of sellers, and derive a gravity equation for trade flows between countries. We show that administrative costs act as an ad-valorem tax on bilateral trade. We then discuss the welfare implications of administrative costs, deriving a semi-structural formula for consumer surplus in the spirit of Harberger (1964), Chetty (2009) and Arkolakis et al. (2012).

2.1. Consumers

There is a unit mass of consumers in every destination country j.[6] Consumers are heterogeneous with respect to their preferred date of consumption: some need the good on January 1, some on January 2, etc. The preferred date is indexed by $t \in [0, 1]$, and can be represented by points on a circle.[7] The distribution of t across consumers is uniform, that is, there are no seasonal effects in demand.

Consumers are willing to consume at a date other than their preferred date, but they incur a cost doing so. In the spirit of the trade literature, we model the cost of substitution with an iceberg transaction cost.[8] A consumer

[6]Because preferences are homothetic, this is without loss of generality.

[7]Note that this puts an upper bound of $\frac{1}{2}$ on the distance between the firm and the consumer. We are following the "circular city" discrete choice model of Salop (1979).

[8]This is different from the tradition of address models that feature linear or quadratic costs, but gives more tractable results.

with preferred date t who consumes one unit of the good at date s only enjoys $e^{-\delta|t-s|}$ *effective units*. The parameter $\delta > 0$ captures the taste for timeliness.[9] Consumers are more willing to purchase at dates that are closer to their preferred date and they suffer from early and late purchases symmetrically.

Other than the time cost, consumers value the shipments *from the same producer* as perfect substitutes. The utility of a type-t consumer purchasing from producer ω is

$$X_j(t,\omega) = \sum_{s\in S(\omega)} e^{-\delta|t-s|} x_j(t,\omega,s). \tag{1}$$

Clearly, because of perfect substitution, the consumer will only purchase the shipment(s) with the closest shipping dates, as adjusted by price, $e^{-\delta|t-s|}/p_s$.

The consumer has constant-elasticity-of-substitution (CES) preferences over the bundles $X_j(t,\omega)$ offered by different firms.

$$U_j(t) = \int_\omega X_j(t,\omega)^{1-1/\sigma} d\omega, \tag{2}$$

where σ is the elasticity of substitution. Let E_j denote the total income and, in the absence of trade imbalances, total expenditure of consumers in country j. By our assumption of symmetry, all consumer types have the same income $E_j(t) = E_j$.

2.2. Exporters

There is a fixed M_i measure of firms producing in each country i. Because there are no entry costs, each firm exports to each destination country j.[10]

Exporters decide how many shipments to send at what times. Sending a shipment incurs a per-shipment cost of f_{ij}. They then decide how to price their product. Both decisions are done simultaneously by the firms.

The marginal cost of production of supplier ω is constant at $c(\omega)$.[11] It takes gross iceberg costs $t_{ij} > 1$ for goods to reach country j from country

[9] As an alternative, but mathematically identical interpretation, we may say that the consumer has to incur time costs of waiting or consuming too early (e.g., storage) so that the total price paid by her is proportional to $e^{\delta|t-s|}$.

[10] The working paper version of Hornok and Koren (2012) endogenizes the measure of exporters via free entry into each destination j.

[11] We will later assume symmetry across firms from the same country—a Krugman (1980) model. For now, however, we keep the dependence on ω in notation to illustrate how our model can be extended in a Melitz (2003) framework.

i. This involves the per-unit costs of shipping, such as freight charges and insurance. (It does not include per-shipment costs.) The cost-insurance-freigh value of a good in country j is hence $c(\omega)t_{ij}$. We abstract from capacity constraints in shipping, that is, any amount can be shipped to the country at this marginal costs.

Hence the total cost of getting a shipment with $x_j(\omega)$ units of the good to consumers in country j from country i (the home country of firm ω) is

$$c(\omega)t_{ij}x_j(\omega) + f_{ij}.$$

Because we do not study free entry, we abstract from entry costs for both production and market access.

Given this cost structure, we can write the profit function of a producer ω from country i selling to country j as

$$\pi_j(\omega) = \int_t \sum_{s=s_1,\ldots,s_{n_j(\omega)}} [p_j(t,\omega,s) - c(\omega)t_{ij}]x_j(t,\omega,s)dt - n_j(\omega)f_{ij}. \tag{3}$$

Net revenue is markup times the quantity sold to all different types of consumers at different shipping dates. The per-shipment costs have to be incurred based on the number of shipping dates, which we denote by $n_j(\omega)$.[12]

2.3. Equilibrium

An *equilibrium* of this economy is a product price $p_j(t,\omega,s)$, the number of shipments per firm $n_j(\omega)$, and quantity $x_j(t,\omega,s)$ such that (i) consumer demand maximizes utility, (ii) prices maximize firm profits given other firms' prices, (iii) shipping frequency maximizes firm profits conditional on the shipping choices of other firms, and (iv) goods markets clear.

To construct the equilibrium, we move backwards. We first solve the pricing decision of the firm at given shipping dates. We then show that shipments are going to be equally spaced throughout the year. Given the revenues the firm is collecting from n equally spaced and optimally priced shipments, we can solve for the optimal number of shipments.

[12]Clearly, the firm would not send two shipments on the same date, as it would only reach the same type of consumers. More on the equilibrium shipping dates below.

Pricing. The revenue function of firm ω for its shipment at time s, coming from consumer t is

$$R_j(t,\omega,s) = \max_p E_j(t)\left[\frac{pe^{\delta|s-t|}}{P_j(t)}\right]^{1-\sigma}, \tag{4}$$

where $E_j(t)$ is the expenditure of consumer t, p is the price of the product, and

$$P_j(t) = \left[\int_\omega p_j(\omega)^{1-\sigma}e^{-(\sigma-1)\delta|t-s(\omega)|}d\omega\right]^{1/(1-\sigma)}$$

is the ideal price index of consumer t.

Because there is a continuum of competitors, an individual firm does not affect the price index $P_j(t)$ nor expenditure $E_j(t)$. This implies that the firm's demand is isoelastic with elasticity σ. As a consequence, the firm will follow the inverse elasticity rule in its optimal pricing,

$$p_j(\omega) = \frac{\sigma}{\sigma-1}c_i(\omega)t_{ij}. \tag{5}$$

Price is a constant markup over the constant marginal cost. Firms may be heterogeneous in their marginal cost because of differences in productivity or factor prices in their source country. Importantly, a given firm charges the same price for each shipment date.

Shipping dates. Clearly, revenue (4) is concave in $|s-t|$, the deviation of shipping times from optimal. Because of that, the firm would like to keep shipments equally distant from all consumers. This implies that shipments will be equally spaced, $s_2 - s_1 = s_3 - s_2 = ... = 1/n$. The date of the first shipment is indeterminate, and we assume that firms randomize across all possible dates uniformly.

Because all shipments have the same price, consumers will pick the one closest to their preferred date t. (Other shipments are strictly inferior.) The set of consumers purchasing from a particular shipment s is $t \in [s-\frac{1}{2n}, s+\frac{1}{2n})$.

An equal-spaced shipping equilibrium is shown on Figure 1.

Revenue. To obtain the revenue from a shipment s, we integrate across the set of buyers buying from that shipment,

$$R_j(\omega,s) = \int_{t=s-\frac{1}{2n}}^{s+\frac{1}{2n}} E_j(t)\left[\frac{p_j(\omega)}{P_j(t)}\right]^{1-\sigma} e^{-(\sigma-1)\delta|s-t|}dt = E_j\left[\frac{p_j(\omega)}{P_j}\right]^{1-\sigma}\int_{t=s-\frac{1}{2n}}^{s+\frac{1}{2n}} e^{-(\sigma-1)\delta|s-t|}dt,$$

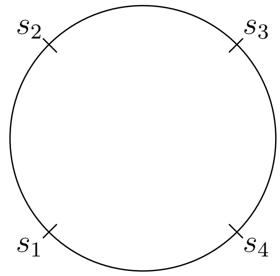

Figure 1: Symmetric equilibrium shipping dates

where we have exploited the symmetry of consumers. The integral in the last term evaluates to

$$\int_{t=s-\frac{1}{2n}}^{s+\frac{1}{2n}} e^{-(\sigma-1)\delta|s-t|}dt = 2 \cdot \frac{1-e^{-\frac{1}{2}(\sigma-1)\delta/n}}{(\sigma-1)\delta}.$$

Because of the symmetry of consumers, each shipment brings the same revenue. The revenue from all shipments is then

$$R_j(\omega) = n_j(\omega)R_j(\omega, s) = E_j \left[\frac{p_j(\omega)}{P_j}\right]^{1-\sigma} \frac{1-e^{-\frac{1}{2}(\sigma-1)\delta/n_j(\omega)}}{\frac{1}{2}(\sigma-1)\delta/n_j(\omega)}. \tag{6}$$

Let $r_j(\omega)$ denote the revenue of the firm if it sends timely shipments ($n \to \infty$),

$$r_j(\omega) = E_j \left[\frac{p_j(\omega)}{P_j}\right]^{1-\sigma},$$

and $\tau(n)$ denote the ad-valorem equivalent of infrequent shipments,

$$\tau(n) = \left[\frac{\frac{1}{2}(\sigma-1)\delta/n}{1-e^{-\frac{1}{2}(\sigma-1)\delta/n}}\right]^{1/(\sigma-1)}.$$

The function $\tau(n)$ is independent of j or ω. We can write the revenue of a firm ω as

$$R_j(\omega) = r_j(\omega)\tau[n_j(\omega)]^{1-\sigma}. \tag{7}$$

The revenue of a firm is the product of two components: one depending only on market size and relative price as in a Krugman model, the other solely a function of shipping frequency. The ad-valorem equivalent of infrequent shipping, $\tau(n)$, has the following properties. It is decreasing in n: the more shipments the firm sends the more consumers it can reach at a low utility cost. Because they appreciate the close shipping dates, they will perceive this firm as relatively cheap. At the extreme, if $n \to \infty$, $\tau(n)$ converges to 1, and the firm sells $r(\omega)$. From the firm's point of view, the demand for timely shipping is fully captured by the function $\tau(n)$, which acts as an ad-valorem tax on the firm's product. Later we will show that this analogy also applies to welfare calculations.

With this notation, we can write the price index of consumers in country j as

$$P_j = \left[\int_\omega p_j(\omega)^{1-\sigma} \tau[n_j(\omega)]^{1-\sigma} d\omega \right]^{1/(1-\sigma)}.$$

Number of shipments. The firm cares about the net revenue coming from its sales. Because markup is constant, net revenue is just a constant $1/\sigma$ fraction of gross revenue. Choosing the profit-maximizing number of shipments involves maximizing

$$\frac{r_j(\omega)\tau(n)^{1-\sigma}}{\sigma} - nf_{ij}$$

with respect to n. Net revenue is $r_j(\omega)\tau(n)^{1-\sigma}/\sigma$ and each shipment incurs the per-shipment cost f_{ij}. Revenue R_j only depends on the number of shipments through $\tau(n)$.

Proposition 1. *The profit-maximizing number of shipments is implicitly given by*

$$\frac{dR_j/\sigma}{dn} = \frac{1-\sigma}{\sigma} r_j(\omega)\tau(n)^{-\sigma}\tau'(n) = f_{ij}. \tag{8}$$

It increases in δ (less patient consumers), increases in σ (consumers willing to substitute to other firms), increases in E_j/P_j (bigger firms in equilibrium) and decreases in f_{ij} (costly shipments).

The number of shipments only depends on the ratio of maximal firm size $r_j(\omega)$ and per-shipment cost f_{ij}. Everything that makes the firm larger in a market (large market size, weak competition, low costs of production and shipping) increases the optimal frequency of shipments. Large firms lose more by not satisfying their customers' need for timeliness and they are willing to incur per-shipment costs more frequently. Intuitively, lower per-shipment costs also imply more frequent shipments. At the extreme, as f_{ij} tends to zero, the firm sends instantenous shipments, $n_j(\omega) \to \infty$ and τ converges to one.

To anticipate the calculation of the welfare effect, we rewrite (8) as an expression of an elasticity,

$$\frac{-n_j(\omega)\tau'[n_j(\omega)]}{\tau[n_j(\omega)]} = \frac{\sigma}{\sigma-1}\frac{n_j(\omega)f_{ij}}{R_j(\omega)}. \tag{9}$$

The left-hand side of this equation is the absolute value of the elasticity of τ with respect to n. The right-hand side is a constant markup times total shipping costs paid by the firm (nf), divided by total revenue of the firm. The last fraction can hence be thought of as the ad-valorem amount of shipping costs.

The intuition for this result is that the more elastic τ is with respect to the number of shipments, the less willing is the firm to sacrifice revenue with infrequent shipments. It will hence send many small shipments, making the ad-valorem amount of shipping costs large. We can use this formula to recover the elasticity of τ from the data.

Trade flows. The analysis so far is conditional on firm-level unit costs. To derive aggregate trade flows, we need to take a stand on these costs. Because we do not have firm-level data, we take the simple view that firms within the same country are identical in their cost of production, $c_i(\omega) \equiv c_i$. An alternative approach, pursued by Kropf and Sauré (2014) would be to assume heterogeneous firms with Pareto-distributed unit costs. Chaney (2008) and Arkolakis et al. (2012) discuss under what conditions such a heterogeneous-firm model leads to a similar gravity equation to the one we derive below.

Given the symmetry in costs, firms charge the same price in a given destination country j,

$$p_j(\omega) = \frac{\sigma}{\sigma-1}c_i t_{ij}$$

and the price index can be written as

$$P_j = \frac{\sigma}{\sigma-1}\left[\sum_i M_i c_i^{1-\sigma} t_{ij}^{1-\sigma}\tau(n_{ij})^{1-\sigma}\right]^{1/(1-\sigma)}. \tag{10}$$

The source countries differ in the number of exporters M_i, the marginal cost of production c_i, the iceberg trade cost t_{ij}, and the ad-valorem loss from infrequent shipments $\tau(n_{ij})$. All these enter the price index of consumers.

Proposition 2. *The total value of exports from country i to country j is given by*

$$T_{ij} = \frac{E_i E_j}{E_w} \frac{t_{ij}^{1-\sigma} \tau(n_{ij})^{1-\sigma}}{\tilde{\Pi}_i^{1-\sigma} \tilde{P}_j^{1-\sigma}},$$

with

$$\tilde{\Pi}_i^{1-\sigma} \equiv \sum_j \frac{E_j}{E_w} t_{ij}^{1-\sigma} \tau(n_{ij})^{1-\sigma} \tilde{P}_j^{\sigma-1}$$

and

$$\tilde{P}_j^{1-\sigma} \equiv \sum_i \frac{E_i}{E_w} \tilde{\Pi}_i^{\sigma-1} t_{ij}^{1-\sigma} \tau(n_{ij})^{1-\sigma}.$$

This is exactly the gravity equation in Anderson and van Wincoop (2003) and Eaton and Kortum (2002), except for the additional term $\tau(n_{ij})$. Infrequent shipment hence acts as a bilateral trade cost between countries. We can use this insight to calculate the magnitude of trade losses from administrative barriers.

3. Welfare

What is the welfare cost of administrative barriers? Here we calculate how welfare depends on the choice of shipping frequency. The utility of the representative consumer is a monotonic function of real income E_j/P_j. We hence need to calculate the income and the price index faced by the representative consumer.

Our gravity equation satisfies Restriction 3 (CES import demand) of Arkolakis et al. (2012), but not Restriction 2 (constant profit shares) and Restriction 3' (identical elasticity of trade flows to wages and trade costs). This is because profits net of shipping costs are a nonlinear function of revenue and trade policy hence also changes the profit to cost ratio of the economy. We thus cannot use the result of Arkolakis et al. (2012) to characterize welfare across all equilibria. We can still use a loglinear approximation around the equilibriums to show how the additional inconvenience from an infinitesimal increase in shipping costs maps into welfare losses for the consumer.

Because we only consider changes to f_{ij} when analyzing welfare, we can treat customer income E_j as fixed as long as j is a small country. In this case, changes in the profits of exporters in country i do not matter for consumer income in country j. We can focus on changes to the price index.[13]

Recall from (10) the price index

$$P_j = \frac{\sigma}{\sigma - 1} \left[\sum_i M_i c_i^{1-\sigma} t_{ij}^{1-\sigma} \tau(n_{ij})^{1-\sigma} \right]^{1/(1-\sigma)}.$$

As the constant markup formula shows, individual product prices do not depend on n_{ij} or f_{ij}. We are hence interested in how τ changes. We begin by log differentiating the price index with respect to the number of shipments per firm n_{ij},

$$\frac{d \ln P_j}{d \ln n_{ij}} = -\frac{T_{ij}}{E_j} \frac{-n_{ij}\tau'(n_{ij})}{\tau(n_{ij})}.$$

Countries that receive more shipments have lower perceived prices and higher customer utility. The effect on the price index depends on the size of the trade flow (timely shipments form a small trade partner being less important) and on the elasticity of τ with respect to n. We can use (9) to substitute in for this elasticity,

$$\frac{d \ln P_j}{d \ln n_{ij}} = -\frac{\sigma}{\sigma - 1} \frac{T_{ij}}{E_j} \frac{n_{ij} f_{ij}}{R_{ij}}.$$

This leads to the followig proposition.

Proposition 3. *The elasticity of the price index with respect to the per-shipment cost is given by*

$$\frac{d \ln P_j}{d \ln f_{ij}} = \sum_i \frac{T_{ij}}{E_j} \psi_{ij},$$

with

$$\psi_{ij} = \frac{\sigma}{1 - \sigma} \frac{d \ln n_{ij}}{d \ln f_{ij}} \frac{n_{ij} f_{ij}}{R_{ij}}.$$

The welfare effect of a change in per-shipment costs is a weighted average across source countries. The contribution of country i to this welfare effect is ψ_{ij}. We use this result in the counterfactual exercise in Section 5 when we estimate ψ_{ij}.

[13]An alternative way to close the model would be to assume free entry of exporters. In this case, profits would be zero, and consumer income would be simply wage income. This would also be unchanged if all both production costs and per shipment costs were denominated in labor.

4. Evidence on administrative barriers and trade

We study how administrative barriers affect trade flows. We first estimate a gravity equation for bilateral trade volumes, including cost of shipping as an additional bilateral trade cost. We then show how shipping costs affect the number of shipments going to a country.

4.1. Data and measurement

We identify administrative costs from the Doing Business survey of the World Bank, from 2006 to 2012. Doing Business measures the costs of exporting and importing a standard containerized cargo, noting the various customs and administrative procedures, documents, and the time and moneythey take. Our measure of shipping costs are the total monetary cost per shipment incurred by the exporter and the importer. Although not all components of these costs are strictily administrative, these correspond to the per-shipment cost in our model.[14]

Table 1 reports the average shipping costs across counries, broken down by the type of procedure and the direction of trade (export or import). Taken together, the average trade transaction would be subject to a total of $3,000 cost and a waiting time of 50 days.

Table 1: Average per-shipment costs across countries

	Exporting		Importing	
	Monetary	Time	Monetary	Time
Document preparation	$275	12.0	$307	13.8
Customs clearance and inspection	$160	3.0	$207	3.7
Port and terminal handling	$282	4.1	$318	4.7
Transit from port to destination	$670	5.0	$772	4.6
Total	$1,387	24.1	$1,604	26.8

Note: Based on Doing Business survey from 2009. Time costs are in days, monetary costs in US dollars.

To study the covariates (though not necessarily determinants) of administrative barriers, we regress the log total per shipment costs (including both

[14] Hornok and Koren (forthcoming) also discuss the various components of per-shipment costs separately. Documentation and customs takes about the third of the monetary costs and two thirds of the time costs of shipping.

exporting and importing costs) on a host of country and country-pair observables. Table 2 reports the results. Administrative barriers tend to be lower for larger and richer countries that are closer to one another and are members of an FTA.

By far the most variation in administrative barriers is due to the level of development of the exporter and the importer. Doubling the GDP per capita of an importer is associated with a 6 percent decline in per-shipment trade costs. Twice as rich exporters, in turn, have 4 percent lower shipping costs. Motivated by this observation, we will study the effects of the counterfactual policy of reducing administrative barriers to rich-country levels.[15]

Data on trade flows comes from the UN Comtrade database. We use bilateral distance measures and geographical variables from CEPII, and gross domestic product data from the World Bank. To estimate how shipping choices depend on administrative costs, we need information on shipments. We use the shipment-level export database of the Spanish *Agencia Tributaria*. This contains information on every single international shipment leaving Spain. It records the date of shipment, its product code, value and weight, destination and transit countries, and the specifics of shipping, such as the mode of transport, the flag of vessel and whether the cargo is containerized. *Agencia Tributaria* does not make firm identifiers available, so, even though each shipment is made by a single firm, we cannot conduct firm-level analysis.

Table 3 reports some shipment-level statistics about Spanish export in 2009. It shows, for selected destinations, the shipment value of the median product, the number of times it is shipped in a month, and the number of months it is shipped in a year. Our first observation is that shipments are relatively large and infrequent. The average shipment size across all importers in \$13,234 and the typical product only ships twice a year to the typical destination. This observation, noted before by Armenter and Koren (2014) and Hornok and Koren (forthcoming) motivated us to model shipments as infrequently spread through time. We also find that countries with lower per-shipment costs receive smaller and more frequent shipments.

In our model, a shipment can only contain a single type of product from a single firm. In practice, shipments may be consolidated. Multiproduct firms may send different products or freight forwarders may send cargo of

[15] We thank a referee for suggesting this policy exercise.

different firms in the same shipment. To check how important this model restriction is, we explored the bundling of shipments. For this exercise, we define a shipment based on shipping characteristics alone (such as date, final and transit country, vessel, containerization), while ignoring information on the product or its value. The vast majority, close to 60 percent, of such shipments contain only a single product item. We hence view the single-product, single-firm approximation of our model as empirically relevant.

In order to differentiate customs unions from free trade areas, we use the May 2013 version of the database created by Baier and Bergstrand (2007) to measure economic integration agreements. Because that data ends in 2005 and Doing Business starts in 2006, we use the year 2006 in our estimation of trade volumes.

4.2. Trade volumes

We first estimate a gravity equation of bilateral imports. We are interested in the trade-creating effect of customs unions relative to free trade areas, as well as the effects of per-shipment costs.

Our main specification is derived from Proposition 2. We let the iceberg trade cost t_{ij} depend on geographic variables such as distance, landlocked status, adjacency, colonial history, and the economic integration of the countries, such as membership in FTA, tariff rates or the use of a common currency. The ad-valorem equivalent of shipping costs, $\tau(n_{ij})$, in turn, depends on the per-shipment costs accrued by exporters from country i to country j. The estimating equation is

$$\ln T_{ij} = \beta_0 + \beta_1 \mathrm{FTA}_{ij} + \beta_2 \mathrm{CU}_{ij} + \beta_3 \ln f_{ij} + \beta_4' \mathrm{gravity}_{ij} + u_{ij}. \tag{11}$$

Imports from country i to country j depend on an FTA and a customs union dummy, per-shipment costs, as well as standard gravity control variables. Note that f_{ij} is the sum of export-specific costs in country i and import-specific costs in country j.

The unilateral controls variables include total nominal GDP, GDP per capita in PPP terms (World Bank), an indicator for whether the country is an island, and an indicator for its continent (CEPII GeoDist). Bilateral controls include distance, adjacency, former colonial status, indicators for common language, common currency and common legal origins (CEPII GeoDist) and average bilateral tariff rate (CEPII MacMap). We also control for whether one or both country is in the European Union, because within-EU trade data is collected differently.[16]

Table 4 reports the results. All specifications are estimated by ordinary least squares (OLS). Columns 1 through 2 are estimated on the full sample of 178 exporter countries and 148 importer countries. The specifications vary by the degree of economic integration of the country pairs. We include an FTA and a customs union dummy, as well as our measure of shipping costs. The omitted category of economic integration includes country pairs with no trade agreement, or only preferential trade agreements short of an FTA.

All standard gravity variables have the expected sign and magnitude. As column 1 shows, countries in FTAs trade much more with one another than countries outside. An FTA is associated with a more than two-fold increase in trade. We separate customs unions from FTAs. Since all customs unions are also FTAs, the estimated effect of a customs union is *in addition to* the effect of being in an FTA. That is, customs unions are associated with a 44 percent increase in trade relative to FTAs.[17] This is consistent with the model and the fact that customs unions require much less administration than FTAs.

Column 2 reports the elasticity of trade volumes with respect to per-shipment cost to be strongly negative at -1.06. The interquartile range of per-shipment costs is \$1900 to \$3100. This implies that country pairs at the 25th percentile of shipping costs trade 68 percent more than country pairs at the 75th percentile.[18]

What is the relationship between administrative costs, FTAs and customs unions? To answer this question, we break the sample into three. Column 3 includes country pairs that are not members of an FTA. Column 4 includes country pairs that are in an FTA but not in a customs union. Column 5 includes members of customs unions. We are interested in how the effect of shipping costs varies across these samples. Since the Doing Business survey asks about a standard cargo, it does not allow for the special administrative

[16] See Appendix A for a discussion.

[17] This result is somewhat sensitive to how we treat intra-EU trade. Table A.9 in Appendix A provides additional robustness checks. Our preferred estimates range from 32 percent to 44 percent.

[18] Although quite speculatively, we could explain the trade effects of customs unions if they corresponded to a $\exp(-0.44/1.06) \cdot 100 - 100 = 34$ percent decrease in per-shipment costs.

provisions of FTAs and customs unions.

We find that the negative effect of per-shipment cost is strong among countries outside of FTAs. The effect is similar among FTA members. The negative effect of shipping costs disappears for customs union members. Indeed, for these country pairs, much of the shipping costs do not apply, as there is no customs clearance and documentation needs are much reduced.

Column 6 reports a regression in which we interact shipping cost with FTA and customs union indicators. This is different from the regressions on the three subsamples in that other variables are restricted to have the same coefficient. Again, we see large negative association of shipping costs with trade for non-FTA members, somewhat smaller effects for FTA members, and the effect disappears for customs unions. The differences between the three groups are highly significant.

4.3. Shipments

We then turn to see how exporters break down total trade into shipments. We use shipment-level export data from Spain for the period 2006–2012. We identify the number of shipments n_{ij} as the total number of shipments going from Spain to country j in given year. One drawback of the Spanish data is that it contains no firm identifiers. We thus cannot calculate the number of shipments per firm, we use the total number instead. Although admittedly a limitation, this measure is consistent with the model, where all firms are symmetric, and the total number of shipments $N_{ij} = M_i n_{ij}$ is just a constant multiple of the number of shipments per firm.

Equation 12 is our estimating equation. The log number of shipments depends on per-shipment costs as well as standard gravity variables, including importer size (GDP), distance, a landlocked importer indicator, an adjacency indicator and former colony dummy. Country 0 is Spain. We omit Spain-specific variables because they are soaked up by time dummies ν_t. One specifications also includes an importer country fixed effect μ_j.

$$\ln N_{0jt} = \beta_1 \ln f_{0jt} + \beta_2' \text{gravity}_{0jt} + \mu_j + \nu_t + u_{0jt}. \tag{12}$$

Table 5 reports the estimates. Because reporting standards are different for intra-EU trade, we only include non-EU destinations.

Column 1 reports a simple OLS estimate for the 131 non-EU destinations. Countries with higher per-shipment cost receive significantly fewer shipments, with an elasticity of -1.34. The interquartile range of per-shipment costs for non-EU destinations is \$2000 to \$3000. A country with

$2000 per-shipment costs receives 72 percent more shipments from Spain than a country with $3000 costs.

Column 2 reports a specification with destination fixed effects. Such fixed effects can soak up any time-invariant heterogeneity across countries and their relation to Spain. (This is why the gravity variables are omitted.) The coefficient of per-shipment costs is still negative but no longer significant, with a p-value of 0.235.[19]

The fixed effect estimate is very noisy because there is little time-series variation in administrative costs. An analysis of variance reveals that 91 percent of the variation in log shipping cost is soaked up destination country dummies. An additional 5 percent can be attributed to common time dummies, leaving about 4 percent idiosyncratic time variation.

In column 3 we report a random effect specification, which allows for time-invariant heterogeneity across countries, but restricts these error terms to be orthogonal to explanatory variables and to have a normal distribution. Given these restrictions, the random effects estimator uses both cross-section and time-series variation. The estimated elasticity of the number of shipments with respect to shipping costs is -0.764. Our preferred estimate of this elasticity is the more conservative -0.451. We will use this estimate in the baseline counterfactual exercise, and explore sensitivity to other values.

In Hornok and Koren (forthcoming), we have estimated product-level regressions to determine the elasticity of the number of shipments and the average shipment size with respect to per-shipment costs. Countries with higher per-shipment import costs receive fewer and larger shipments from both the U.S. and Spain. The elasticity of the number of shipments is between -0.262 and -0.104.[20] Our estimates are larger. One possible explanation is that there are many zero trade flows at the product level, which biases a log-linear estimation. Missing trade is not an issue at the country level with a large exporting country such as Spain.

Table 5 of Hornok and Koren (forthcoming) also shows that shipments are spread throughout the year: countries with high per-shipment cost receive shipments in fewer months. These empirical patterns motivated our model.

We also conducted an empirical analysis of the margins through which

[19]This p-value is calculated with standard errors clustered by destination. The White heteroskedasticity-corrected p-value is 0.065.

[20]Hornok and Koren (forthcoming), Tables 3-4.

exporters change their shipping frequency. Simply put, they may (i) send more of the same good in larger shipments, (ii) pick slower modes of transport that allow for larger shipments and (iii) send bulkier products instead of small products. We do an index-number analysis to decompose the aggregate response into these channels. The results are reported in Appendix B. The main results are that shipping frequency is negatively associated with administrative costs even after controlling for mode of shipping, and that the mode itself does not vary significantly with administrative barriers.

5. The effects of a reduction in administrative costs

To quantify the effects of administrative costs in the model, we conduct two simple counterfactual exercises. In the first trade facilitation scenario, we reduce per-shipment costs f_{ij} by half. The second exercise exploits the cross-country variation in administrative costs. We change the administrative cost of each country to that of the average country in the top income decile. Because poorer countries have higher shipping costs, this scenario affects them more. The average import cost in the top income decile is \$942, whereas the average export cost is \$913.

As seen from Propositions 2 and 3, both the trade volume and the welfare effects are as if bilateral tariffs changed. We hence only need to calculate the tariff equivalent changes, ψ_{ij}. We can only do this for the trade relations of Spain, because we need shipment-level data to calibrate the ad-valorem equivalent of per-shipment costs. Because of this data limitation and because our semi-structural approach only applies locally, the counterfactual exercises below should be understood as partial equilibrium changes. More specifically, we do not study the effect of the trade facilitation reform on firm profits and the potential spillovers across countries. We can however, characterize changes in consumer surplus and changes in bilateral trade volumes as long as the trade policy changes are small.

To calculate ψ_{ij}, we need to know σ. Following Simonovska and Waugh (2014), we calibrate $\sigma = 4.1$. This means that a 1 percent increase in ad-valorem trade costs reduces trade by $\sigma - 1 = 3.1$ percent. It also implies a 32 percent markup. We also report results with the estimates of Eaton and Kortum (2002), $\sigma = 8.2$

We set the value of $d \ln n_{ij}/d \ln f_{ij}$ in Proposition 3 to -0.451 from Table 3. The ad-valorem amount of per-shipment costs is calculated for each destination j as

$$\frac{\hat{f}_{0j} N_{0j}}{T_{0j}},$$

where $\hat{f}_{0j}$ is the dollar measure of shipping costs in Doing Business with the exporter being Spain, N_{0j} is the total number of shipments from Spain to country j, and T_{0j} is total imports of country j from Spain.

Table 6 reports the average tariff equivalent effects of reducing f_{ij} across the ten income deciles. The first column reports the average per-shipment cost in the income decile. Consistent with the evidence presented in Table 2, poorer countries have higher shipping costs. The second column reports the effects of reducing shipping costs by 50 percent. For example, for the lowest income decile, such a policy would be equivalent to a 11.6 percent decline in tariffs, whereas for the 9th decile, this would be equivalent to a 5.2 percent tariff decline.

The effects are heterogeneous, because the effect of a shipping cost reduction on the import price index is not linear (recall Proposition 3). Countries with large per-shipment costs enjoy a bigger gain from a 50 percent reduction.

The third column reports the tariff equivalent effect of setting each administrative cost to the average of the top income decile. This effect has a clear tendency with income per capita. Countries in the poorest decile see an effect equivalent to a 13.4 percent tariff reduction, whereas the average effect for countries in the 9th decile is 1.5 percent. (Note that even importers in the top decile gain from Spain reducing its somewhat higher-than-average shipping costs.)

For comparison, the last column of Table 6 shows the average bilateral tariff rate with respect to Spain. Recall that only non-EU countries are included in this exercise, hence, even for rich countries, the tariffs are substantial. There is much less variation in statury tariff rates across income groups than in the tariff-equivalent effects of administrative barriers. Hence a trade facilitation reform equalizing administrative barriers offers a stronger force for convergence than a tariff harmonization reform.

5.1. Alternative calibrations

Table 7 reports the average tariff-equivalent effects across non-EU countries for alternative calibrations for the shipment elasticity and the elasticity of substitution. Reducing per-shipment costs by half is equivalent to reducing tariffs by 7.7 to 15.8 precentage points. A larger shipment elasticity (which imply that timeliness is more important) corresponds to a larger gain from administrative barrier reduction. The gain does not depend heavily on σ.

The average effects are smaller in the scenario where we match the shipping cost of rich countries, because this corresponds to a smaller than 50 percent reduction for most countries. The equivalent tariff reductions range between 3.9 and 7.7 percent.

Table 8 reports the average percentage increases in bilateral imports from Spain. Given that Spain is a small trade partner for most of the 131 countries, this exercise ignores third-country effects. Trade volumes go up dramatically after this reduction in per-shipment costs, especially for high σ. With $\sigma = 8.2$, the trade creating effect of trade facilitation reform ranges from 31.3 to 148.0 percent. Even with $\sigma = 4.1$, we see a 14.6 to 57.5 percent trade increase. These magnitudes are comparable to the trade creating effects of customs unions (Table 4).

There is a wide distribution of the effects across countries, because they are subject to different per-shipment costs. Figure 2 plots the tariff equivalent of the per-shipment cost reduction for the cross-section of non-EU countries. For the bulk of the countries, the counterfactual trade facilitation reform is equivalent to 0 to 20 percentage point reduction in tariffs.

6. Conclusion

We built a model of administrative barriers to trade to understand how they affect trade volumes, shipping decisions and welfare. Because administrative costs are incurred with every shipment, exporters have to decide how to break up total trade into individual shipments. Consumers value frequent shipments, because they enable them to consume close to their preferred dates. Hence per-shipment costs create a welfare loss.

We derived a gravity equation in our model and show that administrative costs can be expressed as bilateral ad-valorem trade costs. We estimated the ad-valorem equivalent in Spanish shipment-level export data and find it to be large. A 50 percent reduction in per-shipment costs is equivalent to a 9 percentage point reduction in tariffs. Our model and estimates help explain why policy makers emphasize trade facilitation and why trade within customs unions is larger than trade within free trade areas.

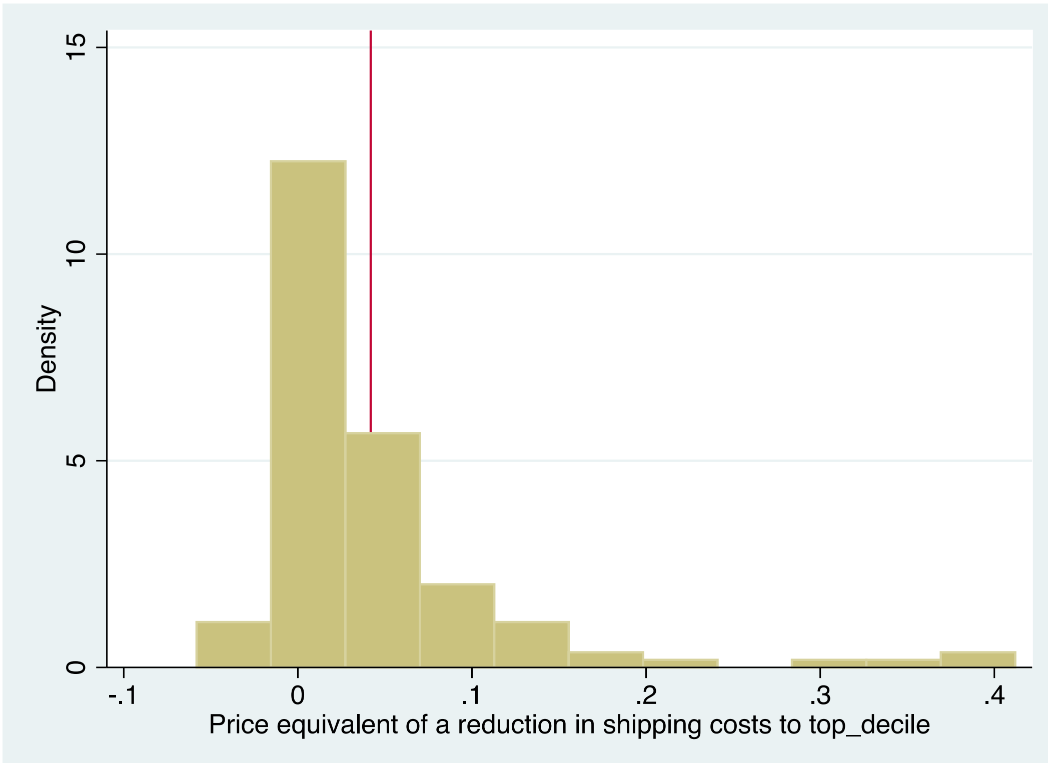

Figure 2: Tariff equivalent of shipping cost reduction

Appendix A. Proof of Proposition 2

We can write firm revenue as

$$R_{ij} = r_{ij}\tau(n_{ij})^{1-\sigma},$$

where

$$r_{ij} = E_j \frac{c_i^{1-\sigma} t_{ij}^{1-\sigma}}{\sum_k M_{kj} c_k^{1-\sigma} t_{kj}^{1-\sigma} \tau(n_{kj})^{1-\sigma}}$$

Total import from country i to country j is

$$T_{ij} = M_i r_{ij} \tau(n_{ij})^{1-\sigma} = E_j \frac{M_i c_i^{1-\sigma} t_{ij}^{1-\sigma} \tau(n_{ij})^{1-\sigma}}{\sum_k M_k c_k^{1-\sigma} t_{kj}^{1-\sigma} \tau(n_{kj})^{1-\sigma}.}$$

With $\tilde{P}_j$ denoting $(1-1/\sigma)P_j$,

$$T_{ij} = E_j M_i c_i^{1-\sigma} t_{ij}^{1-\sigma} \tau(n_{ij})^{1-\sigma} \tilde{P}_j^{\sigma-1}.$$

Add up all the sales of country i,

$$\sum_j T_{ij} \equiv E_i = M_i c_i^{1-\sigma} \sum_j E_j t_{ij}^{1-\sigma} \tau(n_{ij})^{1-\sigma} \tilde{P}_j^{\sigma-1}.$$

$$M_i c_i^{1-\sigma} = \frac{E_i}{\sum_j E_j t_{ij}^{1-\sigma} \tau(n_{ij})^{1-\sigma} \tilde{P}_j^{\sigma-1}.}$$

Let

$$\tilde{\Pi}_i^{1-\sigma} \equiv \sum_j \frac{E_j}{E_w} t_{ij}^{1-\sigma} \tau(n_{ij})^{1-\sigma} \tilde{P}_j^{\sigma-1}$$

so that we can write the above more succinctly as

$$M_i c_i^{1-\sigma} = \frac{E_i}{E_w} \tilde{\Pi}_i^{\sigma-1}.$$

$$\tilde{P}_j^{1-\sigma} = \sum_i \frac{E_i}{E_w} \tilde{\Pi}_i^{\sigma-1} t_{ij}^{1-\sigma} \tau(n_{ij})^{1-\sigma}.$$

Substituting in, we get the result.

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Appendix A. FTAs vs customs unions: robustness analysis

This section addresses a multicollinearity problem of indicators of economic integration.[21] In 2006, there were 1090 country pairs in customs unions, 782 of which also formed a common market, 208 an economic union. It may be difficult to separately identify the effect of each subgroup on trade.

Column 1 of Table A.9 regresses log total import value on an FTA indicator and the same set of controls as in Table 4. Country pairs in FTAs trade about twice as much as other comparable country pairs. Column 2 includes a separate indicator for customs unions. Since all customs unions are also FTAs, the estimated effect of a customs union is *in addition to* the effect of being in an FTA. The estimated coefficient is not significantly different from zero, hence, customs unions seem to trade about as much as FTAs.

However, customs unions include the European Union, where trade data is collected differently. Whereas the source of trade data for extra-EU trade is customs records, intra-EU trade flows are measured via the Intrastat firm survey. When we restrict the sample to country pairs for which at least one of the countries is outside the EU (and trade is hence measured via customs),

[21] We thank a referee for pointing out this problem.

we find that trade within customs unions is larger by 32 percent than trade in FTAs (see column 3). Consistent with this explanation, trade is only lower for intra-EU trade, whereas the external trade of EU countries is on average larger those of similar countries (column 4).

Because zero trade flows are quite prevalent in the data, especially for less integrated countries, we have also explored other econometric specifications for the gravity equation. For countries outside an FTA, 44 percent of trade flows are zero, so these observations are excluded from the loglinear specification. The fraction of zeroes is only 5 percent for FTA members, 9 percent for customs union members, and 2 percent for common market members.

Column 5 reports the marginal effects of a probit specification, where the dependent variable is a dummy for nonzero trade flow. Even conditional on a rich set of covariates, FTA members are 5.5 percent more likely to trade positive amounts; the probability of nonzero trade is an additional 11 percent higher for customs union members.

Column 6 reports a Poisson specification, which includes positive as well as zero trade flows. Santos Silva and Tenreyro (2006) argue for this specification not only due to the presence of zeroes, but also because it is more robust to heteroskedasticity in trade. In this specification, customs unions members trade 26 percent more than FTA members.

Taken together, we are confident that, conditional on our rish set of covariates, expected trade volumes in customs unions are larger than in FTAs.

Appendix B. A decomposition of aggregate exports

In this appendix we develop a decomposition of aggregate exports to a country into four margins: the number of shipments, the shipment size for a given product and transport mode, the transport mode, and the product composition margins. The four margins separate four possible ways of adjustment. In response to higher administrative barriers firms may reduce the number of shipments, pack larger quantities of goods in one shipment, switch to a transport mode that allows larger shipments (sea or ground), or change the export product mix towards products that are typically shipped in large shipments.

Let g index products, m modes of shipment (air, sea, ground), and j importer countries. Let country 0 be the benchmark importer (the average of all of the importers in the sample), for which the share of product-level zeros are the lowest. In fact, we want all products to have nonzero share, so that the share of different modes of transport are well defined for the benchmark country.[22]

Let n_{jgm} denote the number of shipments of good g through mode m going to country j. Similarly, q_{jgm} denotes the average shipment size for this trade flow in quantity units, p_{jgm} is the price per quantity unit. We introduce the notation

$$s_{jgm} = \frac{n_{jgm}}{\sum_k n_{jgk}}$$

for the mode composition of good g in country j, and

$$s_{jg} = \frac{\sum_k n_{jgk}}{\sum_l \sum_k n_{jlk}}$$

for the product composition of country j. We define s_{0gm} and s_{0g} similarly for the benchmark (average) importer.

We decompose the ratio of total trade value (X) to country j and the benchmark country,

$$\frac{X_j}{X_0} = \frac{\sum_g \sum_m n_{jgm} p_{jgm} q_{jgm}}{\sum_g \sum_m n_{0gm} p_{0gm} q_{0gm}} = \frac{n_j \sum_g s_{jg} \sum_m s_{jgm} p_{jgm} q_{jgm}}{n_0 \sum_g s_{0g} \sum_m s_{0gm} p_{0gm} q_{0gm}},$$

as follows,

$$\frac{X_j}{X_0} = \frac{n_j}{n_0} \cdot \frac{\sum_g s_{jg} \sum_m s_{jgm} p_{jgm} q_{jgm}}{\sum_g s_{jg} \sum_m s_{jgm} p_{0gm} q_{0gm}} \cdot \\ \frac{\sum_g s_{jg} \sum_m s_{jgm} p_{0gm} q_{0gm}}{\sum_g s_{jg} \sum_m s_{0gm} p_{0gm} q_{0gm}} \cdot \frac{\sum_g s_{jg} \sum_m s_{0gm} p_{0gm} q_{0gm}}{\sum_g s_{0g} \sum_m s_{0gm} p_{0gm} q_{0gm}}.$$

The first term is the shipment extensive margin. It shows how the number of shipments sent to j differs from the number of shipments sent to the average importer. The ratio is greater than 1 if more than average shipments are sent to j. The second term is the *within* shipment size margin. It tells how shipment sizes differ in the two countries for *the same product and mode of transport*. The fourth term is a mode of transportation margin. If it is

[22]Note that the mode of transport will not be well defined for a product/country pair if there are no such shipments. This will not be a problem because this term will carry a zero weight in the index numbers below.

greater than 1, transport modes that accommodate larger-sized shipments (sea, ground) are overrepresented in j relative to the benchmark country. The last term is the product composition effect. It shows to what extent physical shipment sizes differ in the two countries as a result of differences in the product compositions. If bulky items and/or items that typically travel in large shipments are overrepresented in the imports of j, the ratio gets larger than 1.

We express the same decomposition identity simply as

$$X_{j,\text{total}} = X_{j,\text{extensive}} \cdot X_{j,\text{within}} \cdot X_{j,\text{transport}} \cdot X_{j,\text{prodcomp}}. \tag{B.1}$$

If administrative trade barriers make firms send less and larger shipments, one should see the shipment *extensive* margin to respond negatively and the *within* shipment size margin positively to larger administrative costs. If firms facing per shipment administrative costs choose to switch to a large-shipment transport mode, the transport margin should respond positively. If firms shift the composition of the traded product mix towards typically large shipment products, it should show up as a positive response on the product composition margin.

We run simple cross section regressions with elements of decomposition (B.1) (in logs) on the left-hand side and the log total shipping cost (f_{ij}) and other "gravity" regressors on the right-hand side. The estimating equation is

$$\ln X_{j,z} = \beta \cdot lnf_{ij} + \gamma \cdot \text{other regressors}_j + \nu + \eta_j, \tag{B.2}$$

where $z \in$ [total, extensive, price, within, transport, prodcomp] denotes the different margins, ν is a constant and η_j is the error term. Additional regressors include GDP, GDP per capita, distance, bilateral tariff rates, and geographic variables. We estimate (B.2) with simple OLS and robust standard errors in the case of the total margin. In the case of the five margins, we exploit the correlatedness of the errors and apply Seemingly Unrelated Regressions Estimation (SURE). The Breusch-Pagan test always rejects the independence of errors.

Similarly to the results reported in Table 4, higher shipping costs are associated with lower trade volumes (column 1). The negative relation is even stronger for the number of shipments: a 1 percent increase in shipping costs is associated with a 1.3 percent decline in the number of shipments, holding the mode of transportation and product composition fixed (column 2). The shipments going to high administrative barrier countries tend to be larger, both for a given product (column 3), and because of a tendency to send bulkier products (column 5). However, there is no significant response of the mode of transportation (column 4).

Table 2: Covariates of shipping costs

Exporter GDP (log)	-0.017***
	(0.001)
Importer GDP (log)	-0.020***
	(0.001)
Exporter GDP per capita PPP (log)	-0.060***
	(0.003)
Importer GDP per capita PPP (log)	-0.086***
	(0.003)
Free trade area (dummy)	-0.131***
	(0.010)
Customs union (dummy)	0.010
	(0.015)
Exporter is island (dummy)	-0.099***
	(0.007)
Importer is island (dummy)	-0.025***
	(0.007)
Distance (log)	-0.048***
	(0.004)
Adjacent country (dummy)	-0.028
	(0.022)
Former colony (dummy)	0.119***
	(0.018)
Common colonizer (dummy)	-0.093***
	(0.010)
Same country ever (dummy)	-0.053**
	(0.025)
Common language (dummy)	0.061***
	(0.008)
Common currency (dummy)	0.166***
	(0.021)
Common legal origin (dummy)	-0.027***
	(0.006)
Bilateral tariff (log)	-0.128***
	(0.035)
Constant	10.515***
	(0.051)
Observations	22,479
R-squared	0.253

Note: Dependent variable is log total export plus import cost per shipment. The full sample includes the pairs of 178 exporting and 148 importing countries in 2006. The regression includes dummies for the continent of both exporter and importer. Robust standard errors in parantheses. See Table 4 for details on variable definitions. * significant at 10%, ** 5%, *** 1%.

Table 3: Shipping costs and the number of shipments

	Median shipment value (US$)	Number of times good shipped in a month	Number of months in year good shipped
Selected low per-shipment cost importers			
France	$14,203	1.5	9
Germany	$14,217	1.3	7
Japan	$9,674	1.0	2
USA	$15,592	1.0	3
Selected high per-shipment cost importers			
Algeria	$15,894	1.0	2
China	$19,442	1.0	2
Russia	$12,263	1.0	2
South Africa	$11,725	1.0	2
All importers	$13,234	1.0	2

Notes: Reproduced from Hornok and Koren (forthcoming), Table 2. Spanish exports to 144 non-EU and 25 EU importers in 2009 in 8,381 eight-digit product lines (N=3,019,277). The median value of individual shipments is converted to U.S. dollars with monthly average USD/EUR exchange rates. Shipment frequency statistics are for the median product. Trade in fuels and low-value shipments (less than EUR 2,000 for Spain) are excluded.

Table 4: Gravity equation estimates for bilateral imports

	(1) Full	(2) Full	(3) No FTA	(4) FTA but no CU	(5) CU	(6) Full
Free trade area (dummy)	0.799***	0.649***				-6.813***
	(0.066)	(0.073)				(1.618)
Customs union (dummy)	0.367***	0.523***				-5.820**
	(0.104)	(0.140)				(2.751)
Total export+import cost per shipment (log)		-1.063***	-1.108***	-1.171***	-0.364	-1.174***
		(0.065)	(0.069)	(0.269)	(0.367)	(0.069)
FTA_shipping_cost						0.976***
						(0.214)
CU_shipping_cost						0.749**
						(0.365)
Exporter GDP (log)	1.264***	1.238***	1.265***	1.173***	0.962***	1.235***
	(0.011)	(0.012)	(0.013)	(0.050)	(0.031)	(0.012)
Importer GDP (log)	1.094***	1.072***	1.098***	1.018***	0.831***	1.069***
	(0.011)	(0.012)	(0.013)	(0.047)	(0.032)	(0.012)
Distance (log)	-1.216***	-1.298***	-1.252***	-1.099***	-1.193***	-1.288***
	(0.032)	(0.036)	(0.042)	(0.081)	(0.102)	(0.036)
Exporter GDP per capita PPP (log)	-0.106***	-0.070**	-0.060*	0.039	0.102	-0.060**
	(0.025)	(0.030)	(0.031)	(0.121)	(0.151)	(0.030)
Importer GDP per capita PPP (log)	-0.246***	-0.246***	-0.205***	-0.583***	-0.311*	-0.228***
	(0.025)	(0.030)	(0.031)	(0.142)	(0.163)	(0.030)
Exporter is EU member (dummy)	0.254***	0.170**				
	(0.061)	(0.072)				
Importer is EU member (dummy)	0.438***	0.247***				
	(0.072)	(0.080)				
Both countries EU members (dummy)	-1.152***	-1.383***				
	(0.115)	(0.151)				
Exporter is island (dummy)	0.287***	0.311***	0.308***	0.182	-0.288**	0.297***
	(0.049)	(0.055)	(0.060)	(0.211)	(0.144)	(0.056)
Importer is island (dummy)	0.231***	0.306***	0.278***	0.793***	0.304*	0.292***
	(0.052)	(0.058)	(0.063)	(0.234)	(0.155)	(0.058)
Adjacent country (dummy)	0.359***	0.385***	0.738***	0.814***	0.001	0.351**
	(0.130)	(0.141)	(0.221)	(0.250)	(0.196)	(0.140)
Former colony (dummy)	0.625***	0.748***	0.835***	0.436*	0.911***	0.793***
	(0.105)	(0.114)	(0.133)	(0.223)	(0.283)	(0.114)
Common colonizer (dummy)	1.005***	1.028***	0.858***	1.376***	1.089***	0.994***
	(0.077)	(0.091)	(0.099)	(0.274)	(0.363)	(0.091)
Same country ever (dummy)	0.755***	0.424**	0.543*	0.476	-0.491*	0.361*
	(0.171)	(0.186)	(0.323)	(0.304)	(0.298)	(0.186)
Common language (dummy)	0.708***	0.693***	0.673***	0.495**	0.171	0.710***
	(0.063)	(0.071)	(0.077)	(0.220)	(0.242)	(0.071)
Common currency (dummy)	-0.011	0.059	1.297***	-2.059***	-0.071	-0.203
	(0.154)	(0.159)	(0.401)	(0.678)	(0.129)	(0.156)
Common legal origin (dummy)	0.159***	0.219***	0.226***	0.461***	0.312***	0.222***
	(0.044)	(0.050)	(0.055)	(0.147)	(0.105)	(0.050)
Bilateral tariff (log)	-0.673*	-0.725*	-0.218	-6.439***	5.262*	-0.734*
	(0.354)	(0.421)	(0.407)	(2.050)	(3.078)	(0.420)
Constant	-30.723***	-20.791***	-22.584***	-15.058***	-14.328***	-20.063***
	(0.420)	(0.791)	(0.865)	(2.778)	(3.866)	(0.808)
Observations	19,125	14,490	12,688	1,049	753	14,490
R-squared	0.676	0.703	0.663	0.743	0.869	0.703

Note: Dependent variable is log import value. The full sample includes the pairs of 178 exporting and 148 importing countries in 2006. All regressions include dummies for the continent of both exporter and importer. Robust standard errors in parantheses. * significant at 10%, ** 5%, *** 1%.

Table 5: Shipping costs and the number of shipments

	(1) OLS	(2) FE	(3) RE
Total export+import cost per shipment (log)	-1.342***	-0.451	-0.764***
	(0.212)	(0.378)	(0.246)
Importer GDP (log)	0.890***	0.511**	0.874***
	(0.048)	(0.256)	(0.049)
Importer GDP per capita PPP (log)	0.266***	0.945**	0.361***
	(0.086)	(0.476)	(0.105)
Importer is island (dummy)	0.522**		0.534**
	(0.246)		(0.247)
Distance (log)	-1.381***		-1.336***
	(0.294)		(0.291)
Former colony (dummy)	-0.082		-0.025
	(0.234)		(0.244)
Common language (dummy)	1.803***		1.805***
	(0.264)		(0.255)
Common legal origin (dummy)	0.902***		0.963***
	(0.165)		(0.168)
Bilateral tariff (log)	-2.274		-2.442
	(1.986)		(2.021)
Constant	6.390**	-9.067*	0.974
	(3.182)	(5.080)	(3.408)
Observations	892	892	892
R-squared	0.906	0.988	
Number of countries	131	131	131

Note: Dependent variable is the log number of shipments. The sample includes exports from Spain to 124 non-EU countries between 2006 and 2012. All specifications have year fixed effects. Standard errors are clustered by importing country. * significant at 10%, ** 5%, *** 1%.

Table 6: Effects of reducing per-shipment cost by income decile of importer

Income decile	Average shipping cost	Percentage tariff decline equivalent to reducing shipping costs by 50 percent	Percentage tariff decline equivalent to reducing shipping costs to top decile level	Average tariff
1 (lowest)	$3,558	11.6	13.4	11.7
2	$3,134	8.9	6.4	11.8
3	$2,972	10.3	8.6	13.5
4	$2,434	8.7	6.1	11.4
5	$2,351	7.4	2.0	8.0
6	$2,246	10.4	1.4	9.6
7	$2,817	12.1	5.9	8.7
8	$2,332	8.5	2.1	7.6
9	$2,394	5.2	1.5	10.3
10 (highest)	$1,992	10.8	1.9	5.3

Table 7: Tariff-equivalent effects (percent)

	Shipment elasticity -0.451		Shipment elasticity -0.764	
	Elasticity of substition (σ)			
Scenario	4.1	8.2	4.1	8.2
50 percent decline	9.0	7.7	15.8	13.4
Matching top decile	4.5	3.9	7.7	6.6

Table 8: Trade response (percent)

	Shipment elasticity -0.451		Shipment elasticity -0.764	
	Elasticity of substition (σ)			
Scenario	4.1	8.2	4.1	8.2
50 percent decline	30.7	70.9	57.5	148.0
Matching top decile	14.6	31.3	25.9	58.6

Table A.9: FTAs, customs unions and trade flows

	(1) FTAs	(2) FTAs and CUs	(3) Non-EU sample	(4) EU dummies	(5) Nonzero trade (probit)	(6) Import (Poisson)
Free trade area (dummy)	0.805***	0.811***	0.796***	0.799***	0.055***	0.188*
	(0.059)	(0.065)	(0.066)	(0.066)	(0.015)	(0.098)
Customs union (dummy)		-0.018	0.277***	0.367***	0.110***	0.228**
		(0.082)	(0.106)	(0.104)	(0.015)	(0.106)
Exporter is EU member (dummy)				0.254***		
				(0.061)		
Importer is EU member (dummy)				0.438***		
				(0.072)		
Both countries EU members (dummy)				-1.152***		
				(0.115)		
Exporter GDP (log)	1.263***	1.263***	1.276***	1.264***	0.089***	0.862***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.002)	(0.025)
Importer GDP (log)	1.099***	1.099***	1.110***	1.094***	0.083***	0.848***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.002)	(0.020)
Distance (log)	-1.192***	-1.192***	-1.197***	-1.216***	-0.100***	-0.648***
	(0.031)	(0.031)	(0.032)	(0.032)	(0.004)	(0.051)
Exporter GDP per capita PPP (log)	-0.101***	-0.101***	-0.108***	-0.106***	-0.023***	-0.047
	(0.025)	(0.025)	(0.025)	(0.025)	(0.003)	(0.055)
Importer GDP per capita PPP (log)	-0.233***	-0.233***	-0.238***	-0.246***	-0.019***	-0.084*
	(0.025)	(0.025)	(0.025)	(0.025)	(0.003)	(0.046)
Exporter is island (dummy)	0.286***	0.286***	0.307***	0.287***	0.041***	-0.125
	(0.049)	(0.049)	(0.050)	(0.049)	(0.006)	(0.084)
Importer is island (dummy)	0.232***	0.232***	0.248***	0.231***	0.043***	-0.074
	(0.052)	(0.052)	(0.053)	(0.052)	(0.006)	(0.078)
Adjacent country (dummy)	0.358***	0.359***	0.465***	0.359***	-0.184***	0.255***
	(0.131)	(0.131)	(0.144)	(0.130)	(0.043)	(0.098)
Former colony (dummy)	0.720***	0.720***	0.724***	0.625***	-0.062	-0.093
	(0.106)	(0.106)	(0.109)	(0.105)	(0.064)	(0.123)
Common colonizer (dummy)	1.003***	1.004***	0.981***	1.005***	0.032***	0.307
	(0.077)	(0.077)	(0.078)	(0.077)	(0.007)	(0.198)
Same country ever (dummy)	0.855***	0.856***	0.765***	0.755***	0.127***	0.487*
	(0.171)	(0.171)	(0.188)	(0.171)	(0.011)	(0.270)
Common language (dummy)	0.721***	0.721***	0.711***	0.708***	0.084***	0.313***
	(0.063)	(0.063)	(0.064)	(0.063)	(0.006)	(0.102)
Common currency (dummy)	-0.074	-0.066	0.352	-0.011	-0.068**	0.042
	(0.151)	(0.155)	(0.241)	(0.154)	(0.033)	(0.085)
Common legal origin (dummy)	0.165***	0.165***	0.158***	0.159***	0.020***	0.029
	(0.044)	(0.044)	(0.045)	(0.044)	(0.005)	(0.070)
Bilateral tariff (log)	-0.792**	-0.793**	-0.746**	-0.673*	0.039	-6.611***
	(0.357)	(0.357)	(0.356)	(0.354)	(0.029)	(1.018)
Constant	-31.133***	-31.132***	-31.525***	-30.723***		-32.013***
	(0.412)	(0.412)	(0.416)	(0.420)		(0.889)
Observations	19,125	19,125	18,663	19,125	30,764	30,764
R-squared	0.675	0.675	0.656	0.676		

Note: Dependent variable is log import value. The full sample includes the pairs of 178 exporting and 148 importing countries in 2006. All regressions include dummies for the continent of both exporter and importer. Robust standard errors in parantheses. * significant at 10%, ** 5%, *** 1%.

Table B.10: Decomposing trade into margins

	(1) total	(2) extensive	(3) within	(4) transport	(5) prodcomp
Total export+import cost per shipment (log)	-0.677**	-1.334***	0.380***	-0.079	0.355**
	(0.328)	(0.257)	(0.141)	(0.063)	(0.173)
Importer GDP (log)	0.975***	0.884***	0.089***	0.007	-0.005
	(0.071)	(0.045)	(0.025)	(0.011)	(0.030)
Importer GDP per capita PPP (log)	0.294**	0.299***	0.011	0.009	-0.026
	(0.122)	(0.088)	(0.048)	(0.021)	(0.059)
Distance (log)	-1.379***	-1.347***	0.187**	-0.091**	-0.128
	(0.200)	(0.154)	(0.084)	(0.037)	(0.104)
Importer is island (dummy)	0.569*	0.450**	0.004	0.088	0.026
	(0.326)	(0.227)	(0.125)	(0.055)	(0.153)
Former colony (dummy)	-0.585	-0.248	-0.120	-0.002	-0.215
	(0.418)	(0.444)	(0.244)	(0.108)	(0.299)
Common language (dummy)	1.550***	1.487***	-0.308	0.153	0.218
	(0.457)	(0.436)	(0.240)	(0.106)	(0.294)
Common legal origin (dummy)	0.923***	0.933***	0.274***	-0.070	-0.214*
	(0.229)	(0.181)	(0.100)	(0.044)	(0.122)
Bilateral tariff (log)	0.970	-1.396	0.720	-0.083	1.730
	(2.295)	(1.705)	(0.937)	(0.416)	(1.150)
Constant	-12.329***	-4.720	-7.435***	1.062	-1.237
	(3.707)	(3.075)	(1.690)	(0.750)	(2.074)
Observations	124	124	124	124	124
R-squared	0.866	0.910	0.202	0.128	0.136

Note: Dependent variables are described in the text. The sample includes exports from Spain to 124 non-EU countries in 2006. Robust standard errors in parantheses. * significant at 10%, ** 5%, *** 1%.

***Highlights (for review)**

We build a model of administrative barriers to trade to understand how they affect trade volumes, shipping decisions and welfare.
Per-shipment costs create a welfare loss.
We derive a gravity equation in our model and show that administrative costs can be expressed as bilateral ad-valorem trade costs.
A 50 percent reduction in per-shipment costs is equivalent to a 9 percentage point reduction in tariffs.
Our model and estimates help explain why policy makers emphasize trade facilitation and why trade within customs unions is larger than trade within free trade areas.