Dissecting Gravity: From Customs Forms to Country-Level Trade Flows

DMITRY LIVDAN[1], and VLADIMIR SOKOLOV[2], and AMIR YARON[3]

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[1]Haas School of Business, University of California, Berkeley. email: livdan@haas.berkeley.edu.

[2]ICEF, Higher School of Economics, Moscow. email: vsokolov@hse.ru.

[3]Wharton School, University of Pennsylvania. email: yarona@wharton.upenn.edu.

Abstract

This paper studies the micro-foundations of the gravity equation of bilateral aggregate trade flows between any two countries. At the country level it states that the value of bilateral trade is inversely proportional to the distance between countries, typically measured between the capitals of those countries, and directly proportional to the gross national products of those countries. Using a unique and novel data set for Russian firms we study properties of firm-to-firm export flows from the most disaggregated level of individual customs forms to the firm-level, and then aggregate these flows to the country level. Our data set encodes all Russian exporters and foreign recipients and the import and export transactions that are tied to specific suppliers in every country as well as buyers in every destination country. The data includes good's classification, quantity, weight in kilograms, value in both local currency and USD, exact locations of good origination and delivery, including ports of entry and exit, delivery method, and some contractual details regarding payment obligations. Our first result is on the role of exact distance in the gravity equation at every level instead of the capital-to-capital surrogate distance. We find that using exact distance at the country level increases by 25% the absolute value of the coefficient on the log of distance, which is both statistically and economically significant. Using either distance, however, yields the traditional negative relation between the trade value value and distance at the country level. We then test the gravity relation at the shipment and firm level. We find that distance has no explanatory power for the cargo value while the unit cargo value increases with distance. We also find that cargo weight declines with distance. At the firm level we find an ambiguous effect of distance on the value of exports. The export value increases/decreases with distance with/without exporter and recipient fixed effects. We then study why the data aggregates at the country level to the classical gravity equation. We find that the most crucial property of the data leading to the correct aggregation is associated with the shipment level data. Specifically, we show that the average value per shipment should increase slower with distance than the decline in the average number of shipments with distance to yield the correct aggregation at the country level. We then demonstrate that as long as this condition is satisfied, the firm level aggregation may yield quite different results ranging from the traditional negative relation between value and distance, to no relation between them, to positive relation between them, thus making the firm-level evidence much less informative regarding the country-level gravity. We also provide support to theories emphasizing that higher quality and thus more expensive goods get shipped over longer distances.

1 Introduction

Following the seminal theoretical contributions on heterogeneous exporting firms by Melitz (2003) and Bernard et al. (2003) the international trade literature has been building up a number of important stylized facts. It is well known y now that firms that engage in international trade are larger and more productive relative to their domestic counterparts. The recent availability of the micro firm-level datasets has resulted in new facts regarding the exporting firm-destination country nexus. Bastos and Silva (2010) and Harrigan et al. (2015) have shown that firms send higher quality products to richer countries. Manova and Zhang (2012) find that firms with larger exports also send their products to a wider range of destination countries.

In this paper we employ the highly detailed customs level data from Russia that allows us to investigate the previously unexplored dimensions of the international trade and conduct the empirical analysis at different levels of data aggregation. The customs declarations of virtually all Russian exporting firms at the daily frequency over 2011 allow us to identify the unique cargo shipments between domestic exporting firms and foreign firms recipients. Furthermore, the customs forms data contains the precise identification on firms at both sides of the export transaction which enables us to calculate the exact door-to-door distance between firms and build the exporting as well as receiving firms' networks.

We calculate the cargo shipments characteristics such as dollar value, weight, mode of transportation, and variety of products in the shipment and examine how their variation is related to distance between firms, mode of transportation and characteristics of exporting and receiving firms. The high dimensionality of our data allows us to employ time, product and firm level fixed effects for exporters and recipients, thus enabling us to identify the parameters of interest through variation within exporters across recipients and vice versa.

We find positive assortative matching between Russian exporter and foreign importers based on trade size (Figure 3, Panel A), i.e., exporters with large/small export value are likely to match with recipients with large/small import value. We also find that exporters with large/small export value ship large/small number of cargoes to recipients with large/small import value (Figure 3, Panel B). We find negative distance conditional assortative matching between Russian exporter and foreign importers based on trade size (Figure 4, Panel A), i.e., large exporters trade with recipients of all sizes over long distances while only small recipients trade with exporters of all sizes over short distances. We also find negative distance conditional assortative matching between Russian exporter and foreign importers based on the number of cargoes (Figure 4, Panel B), i.e., exporters shipping large number of cargoes ship over long distances to all types of recipients while only recipients receiving small number of cargoes receive them over long distances.

Our first multivariate result is on the role of exact distance in the gravity equation at every level instead of the capital-to-capital surrogate distance. We find that using exact distance at the country level increases by 25% the absolute value of the coefficient on the log of distance, which is both statistically and economically significant. Using either distance, however, yields the traditional negative relation between the trade value value and distance at the country level.

Our second set of results applies to the shipment and firm level. We find that distance has no explanatory power for the cross-section of cargo values while the unit cargo value increases with distance. In addition we find that cargo weight declines with distance. At the firm level we find an ambiguous effect of distance on the value of exports. The export value increases/decreases with distance with/without exporter and recipient fixed effects.

Next we investigate the reason why the data aggregates at the country level to the classical gravity equation. We find that the most crucial property of the data leading to the correct aggregation is associated with the shipment level data. Specifically, we show that the cargo's intensive margin should increase slower with distance than the decline in the average number of shipments with distance to yield the correct aggregation at the country level. We then demonstrate that as long as this condition is satisfied, the firm level aggregation may yield quite different results ranging from the traditional negative relation between value and distance, to no relation between them, to positive relation between them, thus making the firm-level evidence much less informative regarding the country-level gravity. We also provide support to theories emphasizing that higher quality and thus more expensive goods get shipped over longer distances.

[TO BE CONTINUED...]

2 Data description

We use the recently released proprietary data on Russian exports at the transaction level. Our dataset is collected by customs authorities and contains 1,613,878 customs declaration submitted by exporting firms in 2011. Each customs declaration reports information on the date when the declared product left the country, 10-digit HS code classifying the declared product, net weight in kilograms, mode of transportation, F.O.B. (Free on board) value of exported product in US dollars, names and postal addresses of the foreign recipient firm and the Russian exporting firm.

Identification of the foreign recipient firms has been a serious challenge in empirical work preventing researchers from studying the international trade at the firm-to-firm level. Recently a number of papers were able to collect the firm-to-firm international trade data where identities of foreign recipients are obtained using decoding tools with the various degrees of precision (e.g., Bernard et al. (2016), Carballo et al. (2016), Kamal and Monarch (2016), Kamal and Sundaram (2016)).

We exploit the key advantage of our customs data and uniquely identify the foreign recipient firms by their reported names and addresses. Since we are interested in studying the spatial network of international trade patterns we assign different IDs to the recipient firms with the same name but different addresses. For example, Halliburton, Texas has a different ID from Halliburton, Australia[1]. This identification strategy results in 48,469 unique firm-recipients in our dataset. Reported tax IDs of Russian exporters required to be included on their customs declarations allow us to identify 20,025 unique firms involved in export. These data spans large public firms as well as individual entrepreneurs.

Altogether we have 88,633 exporter-importer relationships. Panel B of Table 1 shows that Russian exporters have larger trading networks abroad, mean number of importers per each exporter is equal to 4.4, than foreign importers have with Russian firms, mean number of exporters per importer is equal to 1.8.[2]

The reported postal addresses of exporters and recipients enable us to use Google geocoder to obtain the geo-coordinates of all exporters and recipients in the data-set and calculate the exact distance on a sphere between each pair of counterparties. By studying how distance between trading parties is related to the export volumes at different levels of data aggregation such as cargo shipment, firm-to-firm, and country-to-country we contribute to understanding how gravity in international trade works at each of these levels. Appendix B provides further information on the data creation and filtering.

Alongside the invoice value of exports in the original invoicing currency[3] and the agreed delivery conditions the declarant is also required to report the US dollar value of exports at the current

[1] See Data appendix for the description of the algorithm that we used for assigning the unique IDs to foreign firms recipients.

[2] For comparison, values of these two variables reported by Bernard et al. (2016) for Norway are 9 and 2 respectively.

[3] US dollar is the predominant currency of invoicing with 47.5% of all customs declarations being settled in USD. Russian ruble is the second most popular currency of invoicing and occupies 30.3% of all customs declarations in our data. Export declarations in Euro occur in 21.7% of all export contracts. Invoicing in other currencies takes place in less than 1% of export contracts.

exchange rate adjusted to the F.O.B. delivery conditions at the last port of departure of the Eurasian Customs Union (EACU)[4]. The official guidelines on customs declarations reporting stipulate the following rule for the F.O.B. adjustment: 1) if the export contract specifies the delivery city within the EACU other than the last port of departure the transportation costs to the border of the EACU are added to the exports value; 2) if the export contract specifies the delivery city outside of the EACU the transportation costs from the EACU border the city of delivery are subtracted from the exports value. This adjustment results in bringing all Russian exports to a common denominator and as a result we have the exports data in producer prices at the border of the EACU.

All customs declarations also report the delivery conditions of the export transactions. Nearly half of Russian exports (48.6%) are contracted under F.C.A. (Free carrier) conditions. C.P.T. (Carriage Paid to destination) and D.A.F. (Delivery at Frontier) respectively occupy 13.1% and 14.7% of all declarations.

The reported tax IDs of Russian exporting firms allow us to match their customs-level data with the firms' financial characteristics. We obtain annual values of total sales and total assets of exporting firms for the 2010-2011 period from the Ruslana database of Bureau Van Dijk.

The country-level data on GDP is obtained from the World Bank's WDI, the bilateral capital-to-capital distances between countries are obtained from CEPII[5]. Russian trade data contains 181 ISO country codes out of total of 249 Country Codes in the ISO Standard List.

3 Cargo shipments

We start our multivariate analysis with daily cargo shipments rather than with customs forms.[6] A major argument in favor of this choice is that both the number and content of customs forms are products of exogenous regulations imposed by the Federal Customs Service of Russia (FCSoR, www.russian-customs.org), rather than the equilibrium choice of a value-maximizing exporting firm. The exporter decides on the content of the cargo shipment it sends on date t to a foreign recipient, and then files as many customs forms per shipment as required by FCSoR. We, therefore, aggregate customs forms up to *daily* cargo shipments which are defined as all customs forms filed on day τ by a Russian exporter e to the same recipient r through the same customs office and using the same

[4] In 2011 EACU included Russia, Belarus and Kazakhstan.

[5] http://www.cepii.fr/anglaisgraph/bdd/distances.htm

[6] Our customs-form level results are available upon request. They are qualitatively similar to the cargo shipment-level results reported in this Section.

transportation method. For each cargo shipment we construct the value (in US$) of the shipment, VALUE, and net weight (in kg) of the shipment, EXP.WGHT, by adding up values and weights from all customs forms included in the shipment. We also define the exported cargo intensive margin, VALUE.PER.KILO, as the value of the cargo shipment scaled by its total weight. Finally, we define the exported cargo extensive margin, VARIETY, as the number of unique HS10 codes across all customs forms in the cargo shipment.

Each cargo shipment is delivered by a unique freight method. We designate a dummy variable for each individual freight method: AIR.TRANS for air transportation, RAIL.TRANS for railroad transportation, SHIP.TRANS for transportation by water, AUTO.TRANS for automobile transport, and OTHER.TRANS for all other transportation methods.[7] We use the railroad freight as the reference transportation method, as both western and eastern parts of Russia have well-developed railroad networks and railroad is the most reliable land-based method of transport for medium weight and up to very heavy shipments. Our results are robust to any alternative choice of the reference freight method.

We perform our analysis using variants of three descriptive linear equations. Let $\mathbf{X}_{r,d}$ denote a vector of importing firm belonging to country d characteristics in logs, including but not limited to a log of destination country real GDP, $\log(GDP_d)$, $\mathbf{X}_e$ denote a vector of exporting firm characteristics in logs, $\mathbf{I}_T$ denote a vector of the freight method dummies measured relative to the railroad freight, $\log(DIST^2_{e,r})$ denote a log of squared distance between exporting and importing firms, $\log(DIST^2_d)$ denote a log of squared distance between Moscow and the capital of exporting country d. Linear projections of log characteristic of a cargo shipment p shipped by a Russian firm e in month t to a recipient r located in a destination country d are given by

$$v_{perdt} = \alpha_{1t} + \alpha_{1p} + \beta \log(DIST^2_{e,r}) + \delta \mathbf{I}_T + \gamma \mathbf{X}_e + \eta \mathbf{X}_{r,d} + \epsilon_{perdt}, \quad (1)$$

$$v_{perdt} = \alpha_{1t} + \alpha_{1p} + \alpha_{1r} + \beta \log(DIST^2_{e,r}) + \delta \mathbf{I}_T + \gamma \mathbf{X}_e + \epsilon_{perdt}, \quad (2)$$

$$v_{perdt} = \alpha_{1t} + \alpha_{1p} + \alpha_{1r} + \alpha_{1e} + \beta \log(DIST^2_{e,r}) + \delta \mathbf{I}_T + \epsilon_{perdt}. \quad (3)$$

We use the exact firm-to-firm distance in kilometers measured on a sphere across all specifications. We square the distance thus adopting the null that at the country level $\beta = -1$[8] and making

[7] These include but not limited to regular mail, personal delivery, pipe, etc.

[8] We adopt the null hypothesis that the value of exports declines with distance as distance squared at all aggregation levels, e.g., customs form, shipment, firm, and country.

elasticity of the export value to distance equal to 2β. The parameters used in equations (1-3) are: α_{1t} is a time fixed effect with a unit of time equal to one month; α_{1p} is a product fixed effect with product categories measured by 10-digit Harmonized System (HS10) product codes; α_{1e} is the Russian exporter fixed effect; α_{1r} is the recipient's fixed effect. The error term is ϵ_{perdt}. β is the parameter of main interest, as it answers the question: how does value of exports at the customs forms-level vary with distance between the exporting and importing firms? Parameter δ helps to understand how the value of exports vary with the transportation method, while parameters γ and η explain how export values vary with characteristics of exporting and importing firms as well as destination countries. Except for the transportation method dummies we use natural logs of characteristics and response variables across all specifications.

In each specification we control for seasonality by incorporating monthly fixed effects thus restricting identification to monthly variations in all relevant characteristics. In addition, each specification includes product fixed effects, thus identifying β, δ, γ, and η through variation both within recipients and exporters across products and across recipients and exporters. Since majority of cargo shipments consists of multiple products (average number is 2.8) it is difficult to use product fixed effects directly. We circumvent this obstacle by using code for the highest valued good per shipment to construct product fixed effects.[9]

Specification (1) controls for the unobserved heterogeneity across recipients and exporters using vectors of recipient-country and exporter characteristics, $\mathbf{X}_{r,d}$ and $\mathbf{X}_e$ respectively. We use two distinct recipient characteristics in our specifications which we treat as exogenous. We control for the importing firm's trading network in Russia by including the total number of its Russian trading partners, N(EpI). We also control for recipient i's aggregate demand for Russian products by using the total variety of products, IMP.VARIETY, measured as the total number of different HS10 codes imported by i during the sample period. We control for the aggregate demand from the recipient i's country of origin by using its real GDP.

We use four exporter characteristics. We proxy for the exporter's financial quality with the average of total 2010 and 2011 sales and asset turnover[10]. Higher sales and lower asset turnover imply a higher financial quality, larger firm. In addition, we use aggregate exported product variety,

[9]Our results are robust to alternative specifications such as value-weighing all codes or using weight instead of value.

[10]The results are robust to using either 2010 or 2011 sales data, or both. Using the average sales allows us to significantly boost the sample size as a number of Russian firms are missing 2011 financials while having 2010 financials readily available.

measured as the total number of different HS10 codes exported by a Russian firm within the sample period, as another exporting firm characteristic. Finally, we control for the exporter's foreign trading network by including the number its foreign trading counterparties.

We add recipient fixed effects to (1) in specification (2) which subsume recipient characteristics. Finally, in specification (3) we add exporter fixed effects to (2). Such procedure allows us to quantify a direct improvement in identification from incorporating an additional fixed effect.

In all equations, the error term ϵ_{perdt} has the interpretation of unmeasured factors that lead exporting firms to optimally ship more expensive products to some recipients and less expensive products to other recipients. When recipient(exporter) fixed effects are included, an intuitive interpretation of ϵ_{perdt} is as a firm-specific supply(demand), or vise versa, shock: for a given recipient(exporter) supply is randomly less costly (demand is randomly higher) from some exporters(recipients) than others. In the final specification ϵ_{perdt} can be interpreted as a shock to trading costs, including storage, shipment timing and delivery availability, within and across exporters and recipients.

We decompose the value of a cargo shipment into its intensive margin defined as the exported unit value per kilogram and exported cargo weight.[11] The goal is to test the idea that costs of exporting a cargo unit depend on its weight rather than value (for example, the costs of exporting depend on the number of cans rather than quality of their content). In this case, increases in distance or reductions in recipient purchasing power may lead to a change in the composition of exports towards higher-value products. Lighter and more valuable per unit of weight products make exports profitable despite incurring the fixed and variable trade costs of servicing the remote foreign market. A joint hypothesis is that differences in value-to-weight ratio across products may in turn be explained by differences in their quality, which we hope to capture using recipient fixed effects. We therefore estimate gravity equations for the value of exported cargo shipment and each of these two components. Furthermore, we estimate gravity equation for the extensive-margin adjustment cargo content which we measure as a variety of goods per cargo shipment.

Table 2 reports our estimates. We use the natural log of export value in US$ as a response variable in Columns (1) through (3), the natural log of value per kilogram as a response variable in Columns (4) and (5), the natural log of weight in kilograms[12] as a response variable in Columns 6 and 7, and the natural log of the variety of products per shipment in Columns 8 and 9. Columns

[11]Baldwin and Harrigan (2011) use similar decomposition for the US country-level exports. They interpret value-per-kilo as a proxy for the unit price.

[12]As we have already mentioned, Russian customs regulations require reporting all units in kilograms, thus providing a convenient way to measure the total quantities imported by foreign firms.

1, 4, 6, and 8 employ the specification (1). Column 2 employs specification (2), and specification (3) is used in Columns 3, 5, 7, and 9. Since columns 4 and 6 and 5 and 7 combine to make up cargo value in columns 1 and 3, by the properties of ordinary least squares, the sums of the coefficients across the two components equal those for the cargo value.

Columns 1 through 3 demonstrate our main result that distance between trading partners does not explain variation in cargo shipment values. The elasticity of the export value to distance is neither statistically nor economically significant across all three specifications (1-3). The sign of the distance elasticity is positive in columns one and three, while it is negative in column two. In order to interpret this finding we investigate the distance elasticity of cargo value per kilogram and cargo weight.

The intensive margin - exported unit value per kilogram - is increasing with distance. This result is in the spirit of the "shipping the good apples out (while keeping the bad ones for internal consumption)" story originally proposed by Alchian and Allen (1964). Distance elasticity is both statistically and economically significant in specification (1) reported in column 4 of Table 2. Its magnitude of 0.29 is larger than estimates reported by Martin (2012) for French exporters, Bastos and Silva (2010) for Portuguese exporters, Gorg et al. (2010) for Hungarian exporters, Harrigan, Ma, and Shlychkov (2015) for the U.S. exporters, and Manova and Zhang (2012) for Chinese exporters. Distance elasticity of export unit value found for these countries falls within [0.01, 0.19] interval and it is *always* statistically significant. When we include exporter and recipient fixed effects into gravity regression, the magnitude of distance elasticity of export unit value is reduced to 0.01, which is on the lowest end of estimates reported by other authors, and it loses its economic and statistical significance. Therefore, just like in the case of cargo value, distance fails to explain the variation in unit cargo value within both recipients and exporters and across them.

Cargo weight declines with distance. Distance elasticity of weight is equal to -0.022 in specification (1) reported in column 4 of Table 2 and it is both statistically and economically significant. Cargo weight declines with distance almost as fast as the intensive margin, value-per-kilo, increases with distance, thus making distance elasticity of value neither economically nor statistically significant. Distance elasticity loses its statistical and economic significance in specification (3) reported in column 5 of Table 2, where exporter and recipient fixed effects are included. The finding that the intensive margin - the cargo value per kilogram - is increasing in distance and cargo weight is decreasing with distance provides support to the idea that costs of exporting depend on weight rather than value. As distance increases, exporters substitute cheaper per unit of weight cargoes for lighter but more expensive per unit of weight cargoes. However, our results from specification (3) indicate that distance is not a good proxy for transportation costs within individual exporters and/or recipients at the cargo shipment level.

Cargo extensive margin - the number of HS10 good codes per cargo or VARIETY - declines with distance in specification (1) reported in column 8 of Table 2. This result is consistent with the findings of Bertrand et. al. (2007) for the US manufacturing firms. It indicates that as trading costs increase with distance, exporting firms respond by reducing the cargo's extensive margins, variety and weight, while increasing its intensive margin, value per kilogram. Once again, distance elasticity of variety loses its significance when exporter and recipient fixed effects are included into gravity regression as reported in column (9).

So far our results show that distance fails to explain variation in cargo shipment value in all specifications and its intensive and extensive margins within recipients and exporters. To understand these results lets assume there exists a single commodity, thus accounting for product fixed affects, the same number of shipments, N,[13] is shipped to distance D. The value of each cargo is drawn from the following model

$$\log(v_{ij}(D)) = \log(W_j) + \log(F(D, \varepsilon_i)). \tag{4}$$

Value generating function (4) accounts for two independent sources of heterogeneity across cargoes shipped to the same distance D: cargo weight W_j[14] and cargo specific shock ε_i. Our simple stylized "model" is consistent with the classic model of the spatial distribution of alternative production activities by Johann von Thünen (1826) with competitive exporters shipping at costs. Therefore, function $F(D, \varepsilon_i)$ captures cargo specific fixed and variable unit transportation costs to distance D. The heterogeneity of unit transportation costs for the same commodity can be due to the unobserved by the econometrician quality of the commodity. For example, wine can be either expensive or cheap and the expensive wine is flown by air (high marginal costs) while cheap wine is transported by train (low marginal costs) to the same destination. $F(D, \varepsilon_i)$ is monotonically increasing with distance while holding ε_i fixed thus reflecting the fact the unit value is increasing with distance.

The data generating function embeds three factors of value variation across two points in space: D, W, and ε. In the data there are close to 89,000 unique exporter-recipient pairs thus leading to a lot of distance-specific variability. However, there exists much more variability in the data due to

[13] N can be equal, for example, to seven which is the average number of shipments in the data. Our conclusions are robust to the assumption of N being independent of distance.

[14] For simplicity we assume that W_j does not depend on distance. Our conclusions are robust to this assumption.

both weight and ε than due to distance. If most of the variability in cargo values between any two distances in the data comes from $\log(W_j)$ rather than from ε_i, then the sensitivity of $\log(v_{ij}(D))$ to distance will be attenuated more than the sensitivity of $\log(v_{ij}(D)/W_j)$ to distance will be attenuated. In other words, the econometrician will measure the value elasticity to distance with higher error than the one she will measure the unit value elasticity to distance with. In summary, with many different sources of the variability in cargo value which are independent or only weakly dependent on the distance, it simply lacks power to explain the cross-section of cargo values. The distance gains more explanatory power in explaining the variation in unit cargo values since the variation due to cargo weights, which is the major source of value variation, is removed. Now lets consider the case of estimating the relation (4) separately for each exporter/recipient, i.e., the exporter/recipient fixed effects. The average Russian exporter ships seven shipments to each of four destinations (the average recipient receives shipments from two Russian destinations). Therefore, there will be a lot of variation in the exported value at the exporter/recipient level due to $\log(W_j)$ and ε_i but not due to D thus making the empirical value-distance relation moot.

We now turn our attention to transportation dummies which capture the variation in value and unit value due to the cargo specific component of trading costs, ε_i. According to Roberts (1999) the average unit transportation costs are the highest for parcels and then decline as the freight method changes in the following order: light truck, truckload, unit-railcar, multi-railcar, unit train, and barge. Coefficients on air and auto transportation dummies are negative and remain both statistically and economically significant even after we control for unobservable heterogeneity in exported products, exporters, and recipients. Negative sign on both dummies implies that railroads are used to ship more valuable cargoes than either air or auto transport are used for. This result, however, can be attributed to differences in cargo capacity and transportation costs between different transportation method. For instance, heavier and larger cargoes can be shipped by train than by either a plane or a car. Furthermore, since a train can transport significantly more cargoes than either a plane or a car, it has lower fixed and variable transportation costs per cargo. In the presence of fixed transportation costs and with a fixed cargo weight, firms make positive profit on cargoes with a value-per-kilo above a certain threshold. With a fixed value-per-kilo, higher variable transportation costs lead to lower cargo weight. Columns 4 through 7 of Table 2 provide support to these observations. Columns 4 and 5 confirm that more valuable per unit of weight products are shipped by air and auto transport than by train. Columns 6 and 7 show that railroads are used to transport much heavier cargoes than planes and cars are used to transport. Overall, a train is capable of transporting so much more weight than either a plane or a car that, overall, we observe that the average cargo shipped by train is more valuable than the average cargo shipped by either of other two transportation methods.

Coefficient on the ship transportation dummy is positive and both statistically and economically significant in columns 1 and 2 of Table 2. However, it loses its significance, both economic and statistical, in column 3 where exporter fixed effects are added. A possible explanation for this result is that with only recipient fixed effects the identification is limited to a small number of recipients located in countries allowing for both land and water transportation from Russia.[15] These recipients minimize transportation costs by differentiating across goods-location combinations. For example, an recipient in Helsinki may receive Russian vodka from Saint-Petersburg by sea and coal from Kuznetsk by train. With the exporter fixed effects, most of the identification comes from the variation within exporters since there exists a significantly more exporters using both land and water transportation in our data than recipients receiving shipments by both land and water. Exporters using both railroads and ships tend to use intermodal ISO containers. Since dimensions of ISO containers are standardized and the majority (more than 75%) of Russian firms export less than four different, according to HS10 product classification, goods, we observe very little difference in value, unit value, and weight of goods shipped by train and ship when we control for exporters' unobserved heterogeneity.

Transportation methods other than plane, ship, and car, OTHER.TRANS, are used to deliver cargo shipments similar to those delivered by the air transport. Although these cargoes have higher intensive margin, they are on average less valuable than cargoes shipped by train since they tend to be on average significantly lighter than cargoes shipped by train. A typical example would be an object of art privately delivered by a currier to a foreign client.

Adjusted within R^2 from the specification (2) reported in columns 3, 5, and 7 of Table 2 show that transportation dummies explain approximately 2% of variation in value and unit value, and 3% of variation in weight. Overall, these results provide robust evidence that cargo's transportation method embeds important information about cargo value, unit value, and weight.[16] For example, diamonds are light, have high value per kilogram, and are shipped by air regardless of the destination.

[15]There is a limited number of such countries with ports on Baltic (Sweden, Finland, Norway, Denmark, Germany, Poland, Latvia, Estonia), Black (Ukraine, Turkey), and Caspian (Azerbaijan, Iran, Turkmenistan) seas.

[16]As a robustness check we have included the interaction of transportation dummies with distance in specifications (1-3). The coefficients on transportation dummies do not change when we include their interactions with distance and we, therefore, do not report these results. They are, however, available from authors upon request.

Iron ore is cheap and it is shipped in large volumes by train to nearby destinations and by ship to farther destinations. Once, however, data is aggregated to the firm level, the direct information about the transportation method is lost. We will argue that distance is an imperfect proxy for the transportation methods used by exporter-recipient and recipient-exporter pairs.

Next, we are going to discuss the effect of recipient and exporter trade networks as well as other characteristics on export cargo value, unit value, weight, and variety. Value elasticities to recipient characteristics are all statistically and economically significant across specifications (1) and (2). The elasticity of value to the recipient Russian trade network size, N(EpI), is equal to -0.035, implying that doubling the size of the recipient's trade network leads to 3.5% decline in the exported value. Recipients with larger Russian trade networks tend to import lighter cargoes with less variety per cargo as as evident from columns 6 and 8 of Table 2 respectively. On the other hand, the elasticity of cargo's intensive margin to N(EpI) is close to zero as depicted in column 4, thus leading to a negative relation between the export cargo value and the size of the recipient's Russian trade network.[17]

Interestingly enough, recipients with larger Russian trading networks tend to export larger variety of Russian products, as indicated by 60% correlation between log(N(EpI)) and log(VARIETY.IMP) from Panel F in Table **??**. Firms can increase the overall extensive margin of their imports by either increasing variety per shipment or by importing different commodities from different Russian exporters with less variety per cargo, or both. Panel 8 from Table 2 yields a VARIETY elasticity to the recipient's network size, N(EpI), of -0.125 which is both statistically and economically significant. Therefore, recipients with larger Russian trading networks, while importing commodities with on average similar intensive margin, increase the overall extensive margin of their imports by adding an additional exporter instead of increasing extensive margin per shipment. This evidence points towards a tradeoff between transportation and other costs per shipment versus fixed and variable costs of having larger trade network.[18]

Recipients preferring higher extensive margin of trade, VARIETY.IMP, import more valuable and heavier cargoes with elasticities equal to 0.125 and 0.116 respectively (both elasticities are statistically and economically significant). The elasticity of cargo's intensive margin to VARIETY.IMP is close to zero, thus leading to a positive relation between export cargo value and VARIETY.IMP.

[17] Table 4 provides extra support to this statement by showing that the value per shipment declines with the size of the recipient's trading network in Russia.

[18] Table 4 provides extra support to this hypothesis. It shows that the Russian exporters ship less shipments to recipients with large trading network in Russia.

Overall, recipients use two different channels to capture the same extensive trade margin. Recipients finding it cheaper to make their trade network larger than to pay higher transportation costs per cargo control the extensive trade margin by increasing the size of their trade network while reducing the average variety and weight per cargo. Recipients facing the opposite trade-off choose to have smaller trade networks while importing heavier cargoes with more variety.

Several characteristics of Russian exporters help explain variation in export value, unit value, weight, and variety. The most intriguing characteristic is the size of exporter's network, N(IpE), as it has not been previously used in gravity regressions. Russian exporters with larger trade network export less valuable cargoes, with the elasticity equal to -0.121, cargoes with lower intensive margin, with the elasticity equal to -0.026, and lighter cargoes, with the elasticity equal to -0.095. All three elasticities are statistically and economically significant. In addition, exporters with larger trading networks tend to ship cargoes with lower extensive trade margin. When combined with the results for recipient characteristics, this evidence can be rationalized as follows. Russian exporters with larger trade networks export mostly to recipients with larger trade network in Russia who tend to import lighter cargoes with less variety, which in turn are less valuable.

The balance-sheet level exporter characteristics, log(SALES) and log(ASSET.TRN), proxy for exporter's financial quality with higher value of log(SALES) and lower value of log(ASSET.TRN) both indicating higher financial quality of the exporter. More financially sound exporters ship heavier more valuable cargoes with higher intensive margins. Similar evidence for has been found by Harrigan, Ma, and Shlychkov (2015) for the U.S. and Manova and Zhang (2012) for China. However, log(SALES) does not explain variation in the cargo extensive margin, while VARIETY elasticity to log(ASSET.TRN) is positive and statistically significant at 10% implying that exporters with less asset turnover ship cargoes with less variety. The exporters' extensive margin of trade, VARIETY.EXP, fails to explain variation in cargo value, unit value, and weight.

Finally, we find a statistically significant effect of market size measured by log real GDP on cargo value, weight, and the extensive trade margin: larger markets export more valuable (elasticity of 0.047), heavier (elasticity of 0.051) cargoes with more variety (elasticity of 0.010). This market size effect conforms with greater demand for higher quality goods from larger markets, previously discussed by Baldwin and Harrigan (2009), Bastos and Silva (2010), and Manova and Zhang (2012).

We re-estimate specifications (1-3) using distance measured between Moscow and the capital of the destination country. Since there exists very little difference between two sets of results we have chosen to make them available upon request.

4 Firm- and country-level results

In this section we further aggregate our customs forms to the firm level and then to country level. The firm level is arguably the most important one as all decisions about shipments are made at this level. If we treat the distance to destination as fixed, then each exporter decides on the total value of trade at this destination, the intensive margin of trade - value per shipment, the total weight shipped, the weight per shipment, and the extensive margin of trade - the number of shipments. We, therefore, going to use all five of them as response variables in a variant of specifications (1)-(3) adjusted for the aggregation. Linear projections of log characteristic of the annual trade by a Russian firm e and a recipient r located in a destination country d are given by

$$v_{erid} = \alpha_{1d} + \alpha_{1i} + \beta \log(DIST^2_{e,r}) + \delta \mathbf{I}_T + \gamma \mathbf{X}_e + \eta \mathbf{X}_r + \epsilon_{erid}, \quad (5)$$

$$v_{erid} = \alpha_{1i} + \alpha_{1r} + \alpha_{1e} + \beta \log(DIST^2_{e,r}) + \delta \mathbf{I}_T + \epsilon_{erid}. \quad (6)$$

Specifications (5) and (6) share the same set of firm-level characteristics, $\mathbf{X}_e$ and $\mathbf{X}_r$, with specifications (1)-(3), with the exception of the destination country's GDP. Since data at this level is aggregated over the whole year using time fixed effects is no longer possible. In addition, individual product fixed effects are also not viable as exporters/recipients ship/receive large number of products at the firm level. Instead, we will use industry fixed effects, α_{1i}, where by industry we designate the SH10 code of the most valuable product shipped. We keep the exporter and recipient fixed effects and add the destination country fixed effects. Finally we include a vector of dummies, $\mathbf{I}_T$, for the most frequently used freight method between the exporter-recipient pair as well as their interactions with distance.

Table 4 reports our results. Our main result is that the export value increases with distance when exporter and recipient fixed effects are not in the regression (column 1) and it falls with distance when exporter and recipient fixed effects are include in the regression (column 2). To understand these results we note that the intensive trade margin is strongly (elasticity of 0.106) increasing with distance in the absence of exporter and recipient fixed effects (column 3) and it is weakly (elasticity of 0.026) increasing with distance in the absence of exporter and recipient fixed effects (column 4). The number of shipments falls with distance both with (column 9) and without (column 10) exporter and recipient fixed effects. The number of shipments falls faster with distance when exporter and recipient fixed effects are included with the elasticity of -0.90. Since the number of shipments falls faster with distance than the intensive margin increases with distance, the total export value falls with distance.

We use a simple numerical example shown in Figure 5 to illustrate the effect of recipient's fixed effects on distance elasticity. Consider 11 recipients, 12 exporters, and 1 good with 2 varieties (cheap at \$1 and expensive at \$4). Each one of 10 recipients (red dashed circle) import only 1 unit of the cheap good from 10 nearby exporters (red). The 11th recipient (blue dashed box) imports 5 units of cheap good from a nearby exporter (red) and 1 unit of expensive good from the exporter located far away (blue). The example is consistent with the empirical observation that the number of shipments falls with distance both in aggregate and at the firm level. Without the recipient fixed effects, the distance elasticity is proportional to the difference between the average values shipped far, \$4, and nearby, \$1.36, and it is positive since a lot of cheap units get shipped nearby. With the recipient fixed effects, distance elasticity compares values across distances within recipients. In this case all identification comes from a single recipient receiving goods both from afar and nearby. Since the total value of goods shipped from nearby is \$5, it is greater than the total value of goods shipped from afar, \$4.

Export weight declines with distance with the effect of distance being more significant when exporter and recipient fixed effects are both present (column 6). This is because weight-per-shipment is independent of distance regardless of the specification (columns 5 and 6) while the number of shipments falls with distance. These findings lay further support to the idea that costs of export depend on the export weight rather than the export value.

[TO BE CONTINUED...]

We proceed by further aggregating the data up to the country level. We consider the following specification

$$y_i = \alpha + \beta \cdot \log(\mathrm{DIST}_i^2) + \eta \cdot \log(\mathrm{GDP}_i) + \delta \cdot \mathrm{NNHBR}_i + \epsilon_i, \tag{7}$$

where NNHBR_i is a dummy equal to one if country i has a border with Russia and it is equal to zero otherwise. We use logs of the total value of exports, the number of Russian firms exporting to country i, the number of shipments, and the value per firm per shipment in the left hand side of (7). We use two different measures of country-to-country distance in our regressions. The first one is constructed as the distance averaged across all exporter-recipient from country i pairs (columns 1 and 2). The second one is the distance between Moscow and the capital of country i (columns 3 and 4). Only specifications 2 and 4 use $\mathrm{N(EpC}_i)$ as the explanatory variable.

Head and Mayer (2014) compile 1,835 estimates of the distance elasticity in gravity type regressions from 161 published papers. The mean distance elasticity is -0.93 (median -0.89 and s.d. 0.4) among all estimates. The distance elasticity is remarkably stable, hovering around -1 over a century and a half of data. Column 1 of Table 5 reports that the value elasticity of distance, $2\beta = -2.34$, is more than 2.5 times smaller in our data than the median value reported by Head and Mayer (2014). Column 2 indicates that the distance elasticity estimate is equal to -1.73 when capital-to-capital distance is used. Russia is the largest country on the planet with an area of $17,075,200 km^2$ which is almost twice the area of Canada, the second largest country. It is, therefore, plausible that distance as a proxy for trade costs is more important for Russian exporters than for exporters from any other country.

Our data allows us to evaluate the magnitude of the correction to the distance elasticity due to a precise distance measure. The change is equal to 24.8% and it is both statistically and economically significant. It indicates that while firms minimize fixed and variable distance related trade costs by concentrating majority of their trading with nearest neighbors, there still exists a large number of shipments crossing the vast Russian territory. This result is most important to countries with a large geographic area like USA, China, Canada, and India. For these countries, the economic impact of distance on trade is underestimated.

[TO BE CONTINUED...]

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Appendix A

Chaney (2016) Calculations for Weibull Distribution

We perform the same exercise as Chaney (2016). We have for the average distance

$$\int_0^\infty x^2 f_K(x)dx = K^\mu \left(\int_0^\infty x^2 f_{K_{\min}}(x)dx \right), \ \mu > 0.$$

We also use the same normalization $K_{\min} = 1$ and

$$\int_0^\infty x^2 f_1(x)dx = 1.$$

Aggregate exports at distance x, $\varphi(x)$, are given by

$$\varphi(x) \propto \int_1^\infty \left(K f_K(x)\right) \lambda K^{\lambda-1} e^{-K^\lambda} dK = \lambda \int_1^\infty f_K(x) K^\lambda e^{-K^\lambda} dK.$$

We now introduce the scaled function

$$g_K(x) \equiv K^{\mu/2} f_K(K^{\mu/2}x),$$

and perform the change of variables

$$K = \left(\frac{x}{u}\right)^{2/\mu}, \ dK = -\frac{2}{\mu}\left(\frac{x}{u}\right)^{2/\mu} \frac{du}{u}.$$

We then obtain

$$\varphi(x) \propto \lambda x^{\frac{2(\lambda+1)-\mu}{\mu}} \int_0^x u^{-\frac{2(\lambda+1)}{\mu}} e^{-\left(\frac{x}{u}\right)^{2\lambda/\mu}} g_{\left(\frac{x}{u}\right)^{2/\mu}}(u)du.$$

Lets also say the when $x \to \infty$ the integral in the above expression is finite. Then

$$\varphi(x) \propto x^{\frac{2(\lambda+1)-\mu}{\mu}} \text{ as } x \to \infty.$$

Therefore as long as

$$2(\lambda + 1) > \mu,$$

we have a positive relation between the aggregate exports and the distance.

Appendix B

Creation of the unique IDs for foreign firm recipients using their reported names and postal addresses from multiple customs declarations is naturally an imperfect exercise. Alternative spellings of the firms' names or different conventions of including or not including the firms' types such as Inc. or Ltd. create a problem for the correct identification of the unique foreign firms IDs from customs forms. Fortunately for us this problem is greatly alleviated for the postal addresses since the customs declarations and the raw data files that we possess keep country names, zip codes, street names, building numbers in separate variables.

To assign the unique foreign firm IDs by names and addresses we wrote an algorithm that utilizes the Stata module reclink2, developed by Wasi and Flaaen (2014). This procedure uses fuzzy matching of string variables allowing the user to place different weights on the importance of different components of the string variables. Before we start this process, we carefully abbreviate all common words that frequently appear in the firm names and addresses. After we launch the algorithm the reclink2 procedure generates a field similarity score from 0 to 1 for each pair of matched observations. As common in the literature (See Kamal and Monarch (2016)) we consider customs declarations with the field similarity score that falls into the range [0.98-1] to belong to the same foreign firm recipient and assign the same ID to such declarations.

In order to ensure the fully correct matching we underwent several passes of manual re-assignments of the foreign firm IDs that were not correctly picked up by the reclink2 procedure. We performed multiple sorting of our dataset on names, address of foreign firms and tax IDs of the Russian firms, visually checked the similarities of firms' names and addresses and manually performing IDs re-assignments of if it was necessary.

Several passes of the automated and manual procedures described above make us confident that we have produced a near perfect identification of the unique IDs for foreign firm recipients in our dataset.

Table 1: Descriptive statistics

The table reports descriptive statistics at the custom declaration and shipment levels (Panel A) as well as firm and country (Panel B) in our sample for 2011.

Panel A: Customs Declaration- and Shipment-Level

VARIABLES	N	Mean	Std	Min	p50	Max
Customs form level:						
Net exported weight (EXP.WGHT, tons)	1613878	422.648	12,944.754	0.000	10.774	9397329.920
Exported value (VALUE, US$1,000)	1613878	225.632	4,683.140	0.100	9.42	1633121.250
Air transportation indicator (AIR.TRANS)	1613878	0.058	0.234	0.000	0.000	1.000
Rail transportation indicator (RAIL.TRANS)	1613878	0.253	0.435	0.000	0.000	1.000
Auto transportation indicator (AUTO.TRANS)	1613878	0.422	0.494	0.000	0.000	1.000
Ship transportation indicator (SEA.TRANS)	1613878	0.142	0.349	0.000	0.000	1.000
Mail transportation indicator (MAIL.TRANS)	1613878	0.002	0.042	0.000	0.000	1.000
Pipe transportation indicator (PIPE.TRANS)	1613878	0.001	0.035	0.000	0.000	1.000
Shipment level:						
Net exported weight (EXP.WGHT, tons)	592857	1,150.538	22,706.936	0.000	43.798	9397329.920
Exported value (VALUE, US$1,000)	592857	614.256	8,917.400	0.101	33.998	1633121.280
Air transportation indicator (AIR.TRANS)	592857	0.054	0.226	0.000	0.000	1.000
Rail transportation indicator (RAIL.TRANS)	592857	0.297	0.457	0.000	0.000	1.000
Auto transportation indicator (AUTO.TRANS)	592857	0.363	0.481	0.000	0.000	1.000
Ship transportation indicator (SEA.TRANS)	592857	0.163	0.369	0.000	0.000	1.000
Mail transportation indicator (MAIL.TRANS)	592857	0.003	0.053	0.000	0.000	1.000
Pipe transportation indicator (PIPE.TRANS)	592857	0.002	0.049	0.000	0.000	1.000
Number of goods per shipment (VARIETY)	592857	2.805	10.000	1	1	1,838

Continued

Table 1: Descriptive statistics—*Continued*

Panel B: Firm- and Country-Level

VARIABLES	N	Mean	Std	Min	p50	Max
Firm level (per firm-firm pair):						
Exported value (VALUE, US$1,000)	88,633	4,109.888	119,661.799	0.102	69.49	16628838.72
Net exported weight (EXP.WGHT, tons)	88,633	7,699.866	206,579.676	0.000	47.246	32581069.83
Average exported cargo shipment value (US$1000)	88,627	387.890	5,993.109	0.063	26.748	1032003.540
Average exported cargo shipment weight (kg)	88,627	710.437	14,219.982	0.000	20.000	2961915.439
Number of shipments	88,627	7	16	1	2	363
Exact firm-to-firm distance on a sphere (DIST(FtF), km)	88,451	2,624.616	2,290.706	1.229	2009.173	18,747.168
Total imported weight per recipient (IMP.WGHT, tons)	48,469	14,076.65	328193.3	0.000	32.743	35802916.178
Number of exporters per recipient (N(EpI))	48,469	1.828	3.168	1	1	193
Number of imported goods per recipient (IMP.VARIETY)	48,469	4.454	13.43	1	1	894
Number of recipients per exporter (N(IpE))	20,025	4.418	10.94	1	2	300
Number of exported goods per exporter (EXP.VARIETY)	20,025	6.405	19	1	2	909
Exporter's revenue (SALES, Million rubles)	12,479	2,506.83	36.695.81	0.000	128.665	3,206,865
Exporter's asset turnover (ASSET.TRN)	12,477	4.562	135.862	0.000	1.688	14,125.333
Country level:						
Average exported value (VALUE, US$1M)	181	2,026.301	5,432.687	0.076	125.726	39,317.912
Average exported weight (EXP.WGHT, Million kg)	181	3,789.181	10,419.209	0.000	194.507	67,329.237
Average cargo shipment value (US$1000)	181	1605.987	6632.161	9.484	495.361	81887.449
Number of cargo shipments per country	181	3,275	9,706	1	205	81,806
Average firm-to-firm distance (DIST(FtF), km)	181	4,685.149	2,404.463	815.056	4223.399	11,881.275
Capital-to-capital distance (DIST(CtC), km)	179	5,947.988	3,644.942	763.406	6185.184	16,774.488
Number of exporters per country (EpC)	181	287	601	1	42	5,264
GDP (US$1M)	181	388,742.773	1427074.541	59.45	31078.86	15517926
GDP per capita (US$, per capita)	181	18,249.421	24,352.643	350.3	7318.7	157,093
Neighboring country indicator (NNHBR)	181	0.077	0.268	0	0	1

Table 2: Cargo shipments

The value (weight) of cargo shipment shipped on day t by the exporter i to recipient j is calculated by adding values from all custom forms filed on day t by the exporter i as going to the recipient j. VARIETY is defined as the total number of different goods per cargo shipment as per WTO 10-digit good code. All other cargo shipment level values are calculated by aggregating values from all customs forms included in the individual cargo shipment. VARIETY.EXP(IMP) is defined as the total number of different goods shipped (received) by exporter (recipient) as per WTO 10-digit good code. N(IpE) is the size of the exporter's trading network, i.e., number of recipients the exporter i trades with. N(EpI) is the size of the recipient's trading network in Russia, i.e., number of Russian exporters the recipient i trades with. IMP.WGHT is the total weight imported by the recipient i. XXX.TRANS is the transportation dummy with sea shipment serving as the reference. Double-clustered by exporter and recipient standard errors are reported in parentheses with significance levels indicated by * (5%), ** (1%), *** (0.1%).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Value			Value-per-Kilo		Weight		Variety	
Cargo shipment level variables:									
log(DIST^2)	0.008	-0.014	0.004	0.029***	0.010	-0.022**	-0.006	-0.011**	0.002
	(0.007)	(0.009)	(0.017)	(0.004)	(0.006)	(0.007)	(0.016)	(0.004)	(0.008)
AIR.TRANS	-1.562***	-1.544***	-1.417***	1.730***	0.621***	-3.291***	-2.039***	-0.167***	-0.220***
	(0.066)	(0.093)	(0.125)	(0.099)	(0.065)	(0.101)	(0.108)	(0.034)	(0.041)
SHIP.TRANS	0.222***	0.191***	0.009	0.111***	0.014	0.112*	-0.004	0.106***	0.074***
	(0.047)	(0.052)	(0.037)	(0.016)	(0.008)	(0.048)	(0.037)	(0.025)	(0.017)
AUTO.TRANS	-0.646***	-0.547***	-0.482***	0.159***	0.049***	-0.805***	-0.531***	0.099***	0.083***
	(0.038)	(0.052)	(0.043)	(0.017)	(0.013)	(0.038)	(0.045)	(0.017)	(0.023)
OTHER.TRANS	-0.875**	-0.240	-0.098	1.071***	0.189***	-1.948***	-0.285	-0.107*	-0.155
	(0.298)	(0.265)	(0.175)	(0.209)	(0.048)	(0.472)	(0.191)	(0.053)	(0.097)
Recipient characteristics:									
log(N(EpI))	-0.035*	-0.032*		0.008		-0.043**		-0.125***	
	(0.014)	(0.014)		(0.008)		(0.015)		(0.009)	
log(IMP.VARIETY)	0.125***	0.124***		0.009		0.116***		0.203***	
	(0.015)	(0.016)		(0.008)		(0.016)		(0.009)	

Continued

Table 2: Cargo shipments—*Continued*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Value			Value-per-Kilo		Weight		Variety	
Exporter characteristics:									
log(N(IpE))	-0.121***			-0.026**		-0.095***		-0.046***	
	(0.014)			(0.009)		(0.015)		(0.007)	
log(EXP.VARIETY)	0.006			-0.007		0.013		0.150***	
	(0.016)			(0.012)		(0.016)		(0.011)	
log(SALES)	0.134***			0.015**		0.119***		0.008	
	(0.008)			(0.005)		(0.009)		(0.005)	
log(ASSET.TRN)	-0.101***			-0.048***		-0.053***		0.015*	
	(0.012)			(0.009)		(0.012)		(0.008)	
Country level variables:									
log(GDP)	0.047***	0.050***		-0.004		0.051***		0.010*	
	(0.006)	(0.006)		(0.003)		(0.006)		(0.004)	
Month FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Exporter FE		YES	YES		YES		YES		YES
Recipient FE			YES		YES		YES		YES
R^2	0.651	0.738	0.830	0.925	0.986	0.828	0.926	0.414	0.638
Adjusted R^2	0.647	0.729	0.809	0.924	0.984	0.826	0.916	0.407	0.592
Adjusted Within R^2	0.151	0.0738	0.0173	0.141	0.0186	0.194	0.0276	0.118	0.00210
Observations	458,688	458,688	458,688	458,688	458,688	458,688	458,688	458,688	458,688

Table 3: Cargo-level exports with transportation method

All variables, except transportation dummies and their interaction with distance, are the same as in Table 2. Railroad shipping is used as a reference. All regressions include month, product, exporter, and recipient fixed effects. Double-clustered by exporter and recipient standard errors are reported in parentheses with significance levels indicated by * (10%), ** (5%), *** (1%).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Value		Value-per-Kilo		Weight		Variety	
$\log(\text{DIST}^2)$	0.014	0.007	0.010	0.013*	0.004	-0.006	-0.000	0.009
	(0.018)	(0.019)	(0.006)	(0.006)	(0.016)	(0.018)	(0.008)	(0.009)
AIR.TRANS		-1.615***		0.726***		-2.339***		-0.299***
		(0.109)		(0.071)		(0.131)		(0.057)
AIR.TRANS$\times\log(\text{DIST}^2)$		0.078		-0.046		0.123*		0.027
		(0.048)		(0.026)		(0.055)		(0.021)
SHIP.TRANS		0.172		0.031*		0.141		0.083*
		(0.119)		(0.013)		(0.119)		(0.040)
SHIP.TRANS$\times\log(\text{DIST}^2)$		-0.069		-0.010*		-0.059		-0.007
		(0.042)		(0.005)		(0.042)		(0.013)
AUTO.TRANS		-0.477***		0.056**		-0.533***		0.105**
		(0.058)		(0.019)		(0.058)		(0.032)
AUTO.TRANS$\times\log(\text{DIST}^2)$		0.001		-0.004		0.005		-0.021
		(0.019)		(0.007)		(0.019)		(0.012)
OTHER.TRANS		-0.434*		0.280***		-0.713***		-0.245
		(0.185)		(0.065)		(0.196)		(0.130)
OTHER.TRANS$\times\log(\text{DIST}^2)$		0.251**		-0.067**		0.319***		0.068
		(0.086)		(0.026)		(0.091)		(0.038)
R^2	0.827	0.831	0.986	0.986	0.924	0.926	0.638	0.638
Adjusted R^2	0.805	0.809	0.984	0.984	0.914	0.916	0.591	0.592
Adjusted Within R^2	1.61e-05	0.0184	8.20e-05	0.0191	-1.28e-06	0.0289	-2.44e-06	0.00234
Observations	458,688	458,688	458,401	458,401	458,401	458,401	458,688	458,688

Table 4: Firm-level exports with transportation method

Left hand side variables are trade characteristics between the recipient j and Russian exporter i. Values (quantities) are calculated by aggregating daily cargo shipments from the exporter i to the recipient j. VARIETY.EXP(IMP) is defined as the total number of different goods shipped (received) by exporter (recipient) as per WTO 10-digit good code. N(IpE) is the size of the exporter's trading network, i.e., number of recipients the exporter i trades with. N(EpI) is the size of the recipient's trading network in Russia, i.e., number of Russian exporters the recipient i trades with. The transportation method is defined as the most frequently used by the exporting firm i. Railroad shipping is used as a reference. Double-clustered by exporter and recipient standard errors are reported in parentheses with significance levels indicated by * (10%), ** (5%), *** (1%).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Value		Value-per-Shipment		Weight		Weight-per-Shipment		# of Shipments	
log(DIST^2)	0.048**	-0.065**	0.106***	0.026	-0.046	-0.092***	0.012	-0.001	-0.057***	-0.090***
	(0.022)	(0.027)	(0.014)	(0.016)	(0.030)	(0.030)	(0.023)	(0.019)	(0.015)	(0.021)
Transportation method:										
AIR.TRANS	-1.642***	-1.538***	-1.342***	-1.268***	-5.169***	-3.031***	-4.874***	-2.767***	-0.300***	-0.277***
	(0.086)	(0.182)	(0.071)	(0.133)	(0.163)	(0.245)	(0.149)	(0.200)	(0.040)	(0.090)
AIR.TRANS×log(DIST^2)	0.019	0.098	-0.034	-0.014	0.082*	0.197*	0.029	0.088	0.053***	0.110***
	(0.032)	(0.083)	(0.026)	(0.064)	(0.047)	(0.103)	(0.041)	(0.085)	(0.017)	(0.040)
SHIP.TRANS	0.707***	0.411***	0.990***	0.548***	0.687***	0.422**	0.970***	0.560***	-0.285***	-0.156
	(0.086)	(0.155)	(0.079)	(0.107)	(0.115)	(0.166)	(0.109)	(0.118)	(0.051)	(0.108)
SHIP.TRANS×log(DIST^2)	-0.109***	-0.008	-0.200***	-0.142***	-0.064*	-0.018	-0.154***	-0.153***	0.090***	0.137***
	(0.029)	(0.054)	(0.024)	(0.038)	(0.038)	(0.058)	(0.033)	(0.041)	(0.019)	(0.035)
AUTO.TRANS	-0.532***	-0.491***	-0.455***	-0.483***	-1.082***	-0.673***	-1.004***	-0.664***	-0.076**	-0.012
	(0.056)	(0.075)	(0.045)	(0.046)	(0.088)	(0.089)	(0.076)	(0.063)	(0.031)	(0.051)
AUTO.TRANS×log(DIST^2)	-0.054**	0.006	-0.035**	0.019	-0.053	-0.014	-0.034	-0.000	-0.019	-0.015
	(0.023)	(0.030)	(0.016)	(0.019)	(0.033)	(0.034)	(0.026)	(0.023)	(0.016)	(0.023)
OTHER.TRANS	-0.806*	-0.695**	-0.625	-0.659***	-2.958***	-1.474***	-2.756***	-1.433***	-0.180*	-0.036
	(0.457)	(0.275)	(0.392)	(0.227)	(0.695)	(0.348)	(0.630)	(0.304)	(0.094)	(0.108)
OTHER.TRANS×log(DIST^2)	0.007	0.242	-0.004	0.175	0.071	0.289	0.057	0.230	0.009	0.057
	(0.114)	(0.148)	(0.099)	(0.126)	(0.194)	(0.178)	(0.180)	(0.156)	(0.032)	(0.062)

Continued

Table 4: Firms—*Continued*

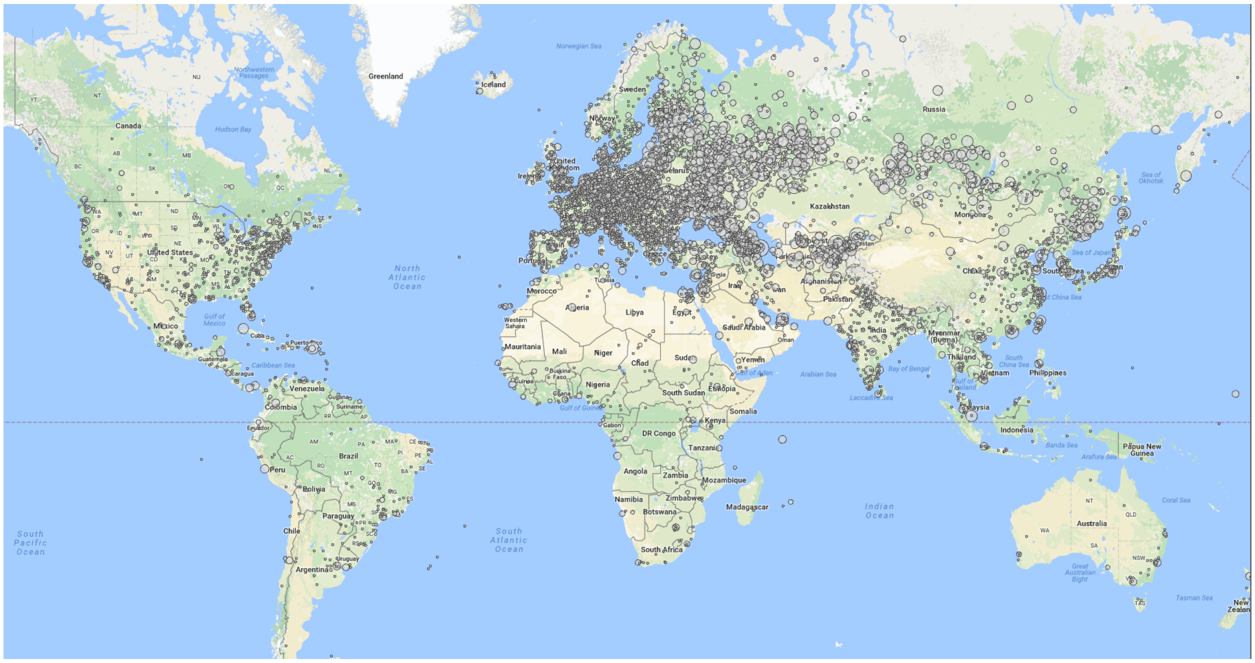
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Value		Value-per-Shipment		Weight		Weight-per-Shipment		Number of Shipments	
Recipient characteristics:										
log(N(EpI))	-0.027		0.003		0.078**		0.108***		-0.030**	
	(0.022)		(0.015)		(0.031)		(0.024)		(0.015)	
log(IMP.VARIETY)	0.312***		0.129***		0.177***		-0.006		0.182***	
	(0.019)		(0.013)		(0.026)		(0.020)		(0.011)	
Exporter characteristics:										
log(N(IpE))	-0.103***		-0.144***		0.012		-0.029		0.041***	
	(0.017)		(0.014)		(0.036)		(0.033)		(0.010)	
log(EXP.VARIETY)	-0.034*		-0.019		-0.099***		-0.084***		-0.015	
	(0.020)		(0.017)		(0.035)		(0.031)		(0.010)	
log(SALES)	0.243***		0.166***		0.216***		0.138***		0.078***	
	(0.011)		(0.009)		(0.016)		(0.015)		(0.004)	
log(ASSET.TRN)	-0.130***		-0.130***		-0.075***		-0.075***		-0.001	
	(0.016)		(0.014)		(0.025)		(0.022)		(0.008)	
Country FE	YES		YES		YES		YES		YES	
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Exporter FE		YES		YES		YES		YES		YES
Recipient FE		YES		YES		YES		YES		YES
R^2	0.373	0.894	0.461	0.942	0.674	0.958	0.736	0.979	0.180	0.801
Adjusted R^2	0.370	0.522	0.458	0.739	0.673	0.810	0.735	0.904	0.176	0.101
Adjusted Within R^2	0.182	0.0181	0.199	0.0465	0.312	0.0448	0.378	0.0986	0.0738	0.00349
Observations	64,156	64,159	64,156	64,159	64,061	64,064	64,061	64,064	64,156	64,159

Table 5: Country level exports

Exports' from Russia to country i characteristics. F-to-F (C-to-C) indicates that the distance is measured as the average distance across all distances between recipients in country i and all Russian firms trading with them (capital of i and Moscow). NNHBR dummy takes the value of 1 if the country has a border with Russia and zero otherwise. Clustered by recipient standard errors are reported in parentheses with significance levels indicated by * (10%), ** (5%), *** (1%). Excludes countries with less than 6 cargo shipments from Russia to the country: Cayman Islands; Central African Republic; Comoros; Mayotte; El Salvador; Gambia; Guadeloupe; Jamaica; Malawi; Maldives; Monaco; Guinea-Bissau; East Timor; Saint Lucia; Western Sahara; US Virgin Islands; and Zambia.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Value		Number of Shipments		Value per Firm per Shipment		Number of Exporters per Country	
	F-to-F	C-to-C	F-to-F	C-to-C	F-to-F	C-to-C	F-to-F	C-to-C
$\log(\mathrm{DIST}^2)$	-1.152***	-0.866***	-0.892***	-0.706***	-0.225**	-0.139*	-0.705***	-0.573***
	(0.149)	(0.101)	(0.147)	(0.083)	(0.100)	(0.079)	(0.124)	(0.074)
log(GDP)	0.875***	0.738***	0.702***	0.592***	0.186***	0.161***	0.563***	0.474***
	(0.073)	(0.073)	(0.054)	(0.057)	(0.043)	(0.046)	(0.044)	(0.046)
NNHBR Dummy	0.835*	1.054**	2.100***	2.196***	-1.087***	-0.980***	1.636***	1.678***
	(0.498)	(0.462)	(0.491)	(0.444)	(0.284)	(0.268)	(0.432)	(0.379)
Constant	0.216	3.029	-9.233***	-6.877***	9.186***	9.577***	-7.932***	-5.980***
	(1.916)	(1.877)	(1.557)	(1.521)	(1.177)	(1.281)	(1.281)	(1.259)
Observations	181	179	181	179	181	179	181	179
R^2	0.561	0.570	0.611	0.630	0.111	0.105	0.602	0.627

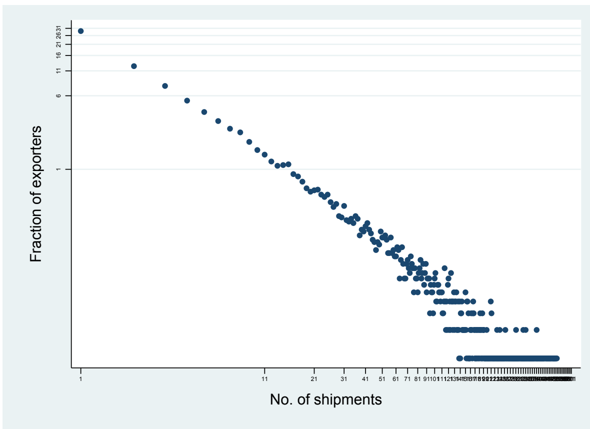
Panel A: World



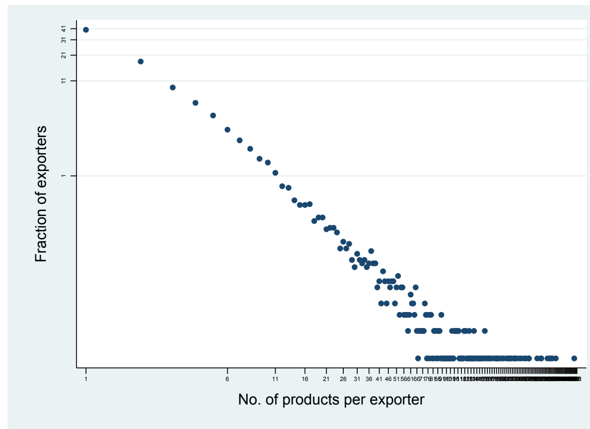
Panel B: Europe

Figure 1: Geography of Russian trade
The geography of Russian trade across the world (Panel A) and Europe (Panel B). Individual firms are shown as circles with the circle's size indicating the total trade value.

Panel A: Distribution of exporter shipments



Panel B: Distribution of exporter variety



Panel C: Degree distribution of exporter-recipient relation

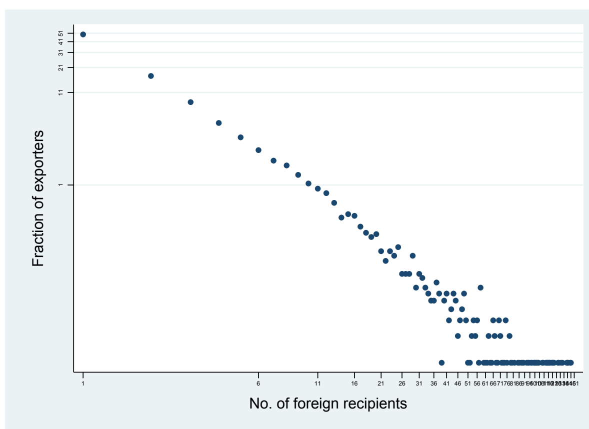
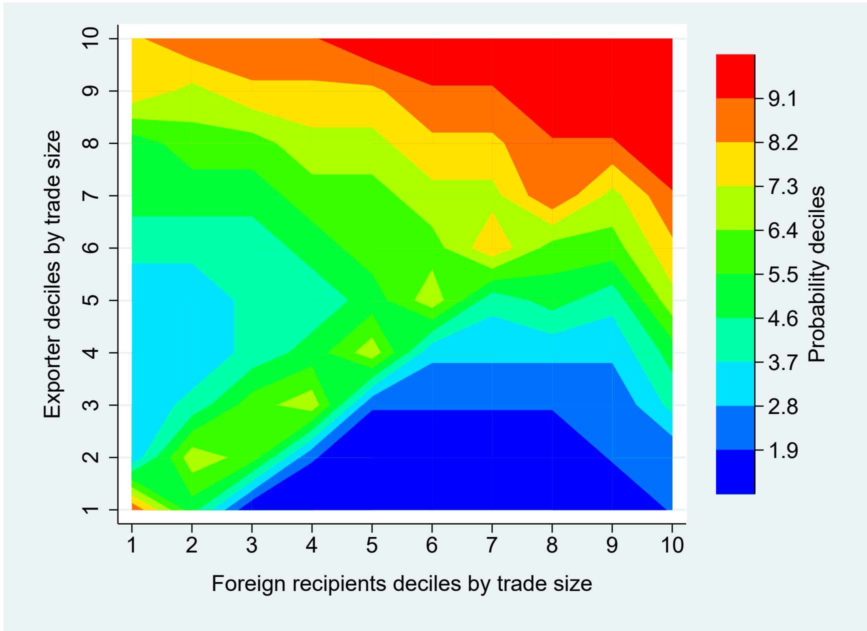


Figure 2: Exporter trading activity

Distribution of exporter shipments for the whole year (Panel A), the variety of shipped goods measured as the average number of WTO 10-digit good codes used by the exporter (Panel B), and the degree distribution for exporter-recipient relations for the whole year (Panel C). We use a log-log scale

Panel A: Probability that exporter trades with recipient in size bin 1-10



Panel B: Number of shipments when exporter trades with recipient in size bin 1-10

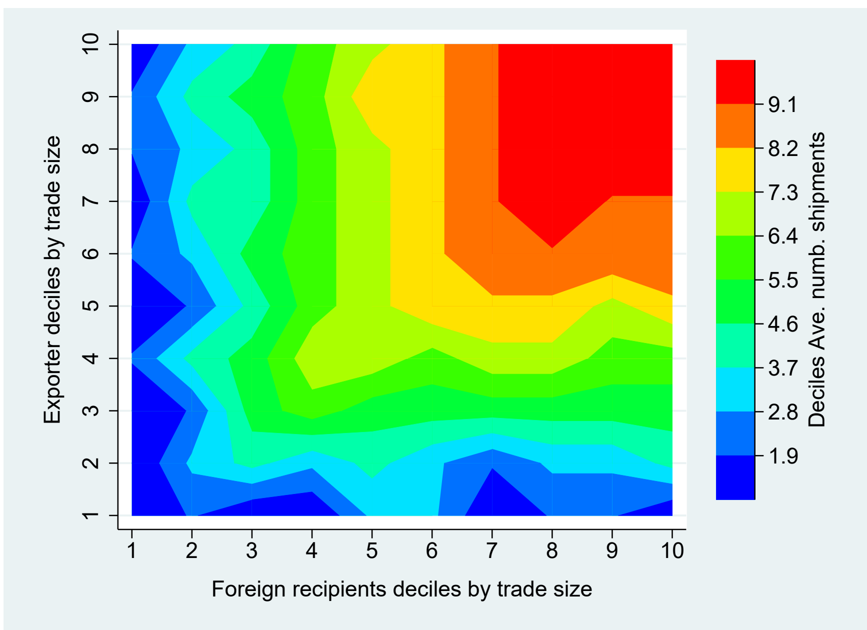
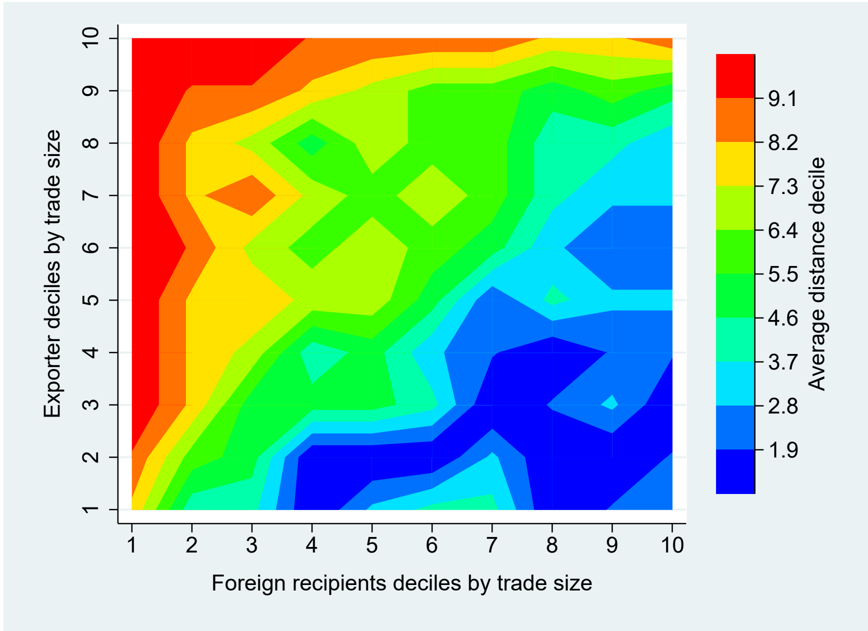


Figure 3: Exporter-recipient trading networks and exporters' shipment intensity

The figure illustrates the trading networks of each exporter and, respectively, recipient. Panel A depicts the trading activity in terms of the probability that an exporter trades with an recipient of given size over the entire sample period. Panel B depicts the corresponding trade intensity for each exporter measured using total number of shipments. On the horizontal (vertical) axis, we sort recipients (exporters) from low to high by their trading value over the sample period.

Panel A: Distance when exporter trades with recipient in size bin 1-10



Panel B: Distance when exporter trades with recipient in shipment number bin 1-10

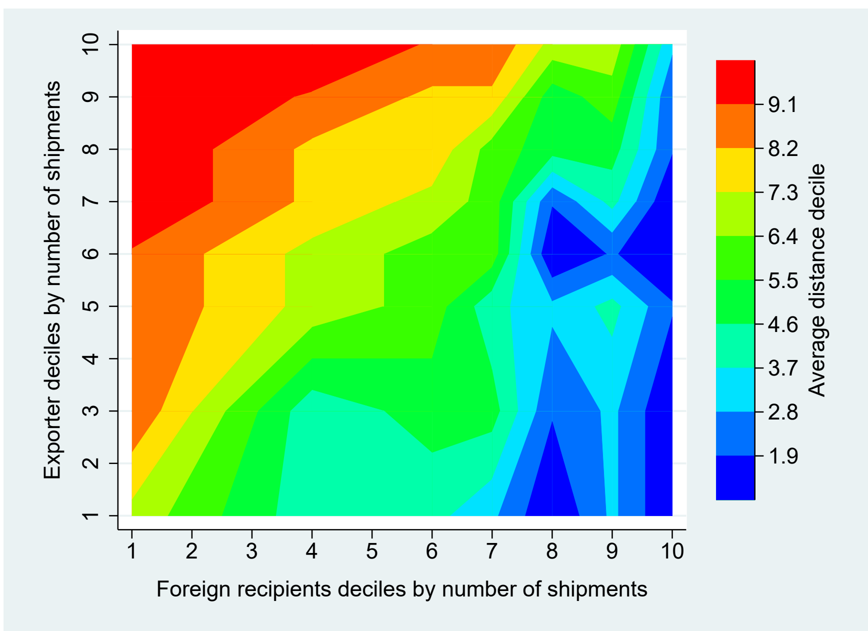


Figure 4: Exporter-recipient trading relations and average distance

The figure illustrates the average shipping distance specific to the exporter, recipient, and exporter-recipient relations. In Panel A we sort recipients (exporters) into ten bins from low to high by their trading value over the sample period. In Panel B we sort recipients (exporters) into ten bins from low to high by their number of shipments received (sent) over the sample period. Then for each exporter's size/shipment bin we calculate the average shipping distance between this bin and all recipient's bins.

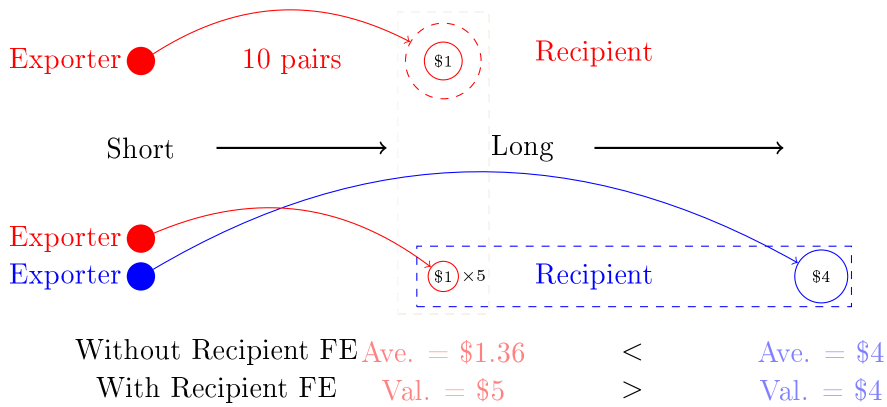
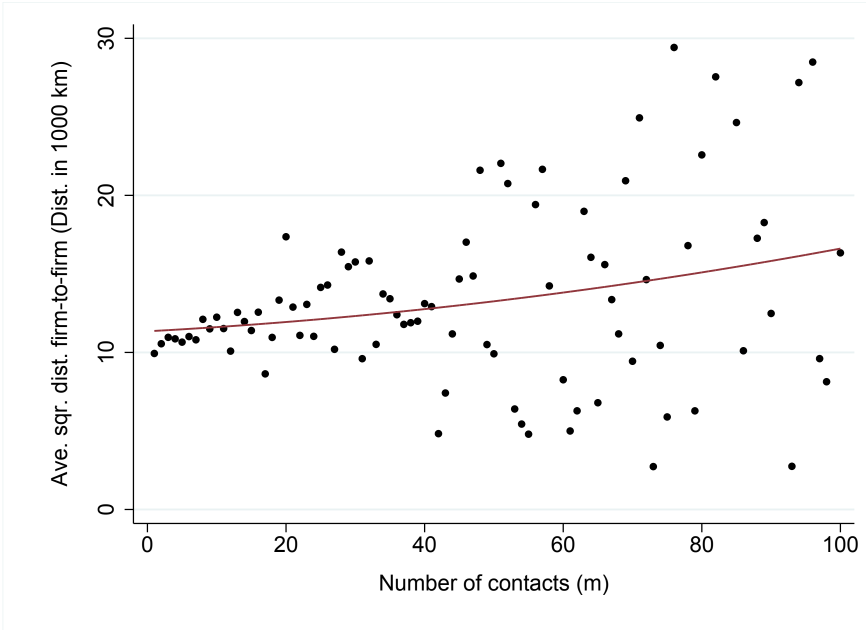


Figure 5: Effect of recipient fixed effects on distance elasticity
This example illustrates the effect of recipient fixed effects on distance elasticity. Consider 11 recipients, 12 exporters, and 1 good with 2 varieties (cheap at \$1 and expensive at \$4). Each of 10 recipients (red dashed circle) import only 1 unit of the cheap good from 10 nearby exporters (red). The 11th recipient (blue dashed box) imports 5 units of cheap good from a nearby exporter (red) and 1 unit of expensive good from the exporter located far away (blue). Without recipient FEs, the distance elasticity is proportional to the difference between the average values shipped far, \$4, and nearby, \$1.36, and it is positive since a lot of cheap units get shipped nearby. With recipient FEs, distance elasticity compares values across distances within recipients. In this case all identification comes from a single recipient receiving good both from afar and nearby. Since the total value of goods shipped from nearby is \$5 it is greater than the total value of goods shipped from afar, \$4. The example is consistent with the empirical observation that the number of shipments falls with distance both in aggregate and at the firm level. .

Panel A: Exporter to recipient



Panel B: Customs office to recipient

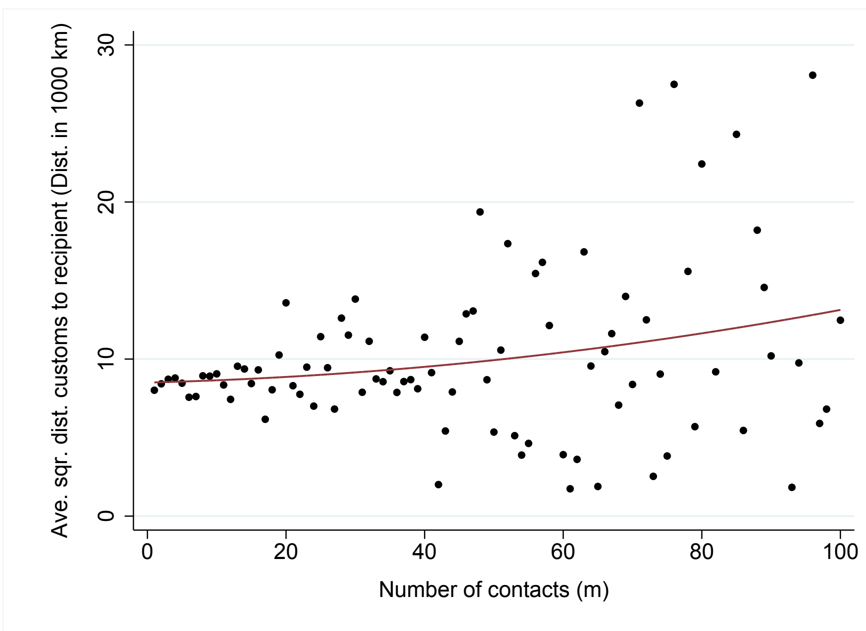


Figure 6: The geography of trade

Average squared distance from an exporter's contacts, among exporters with m contacts. Two different distances are used: Exporter to the recipient (Panel A) and from the customs office to the recipient (Panel B). This is Figure 2 in Chaney (2014).

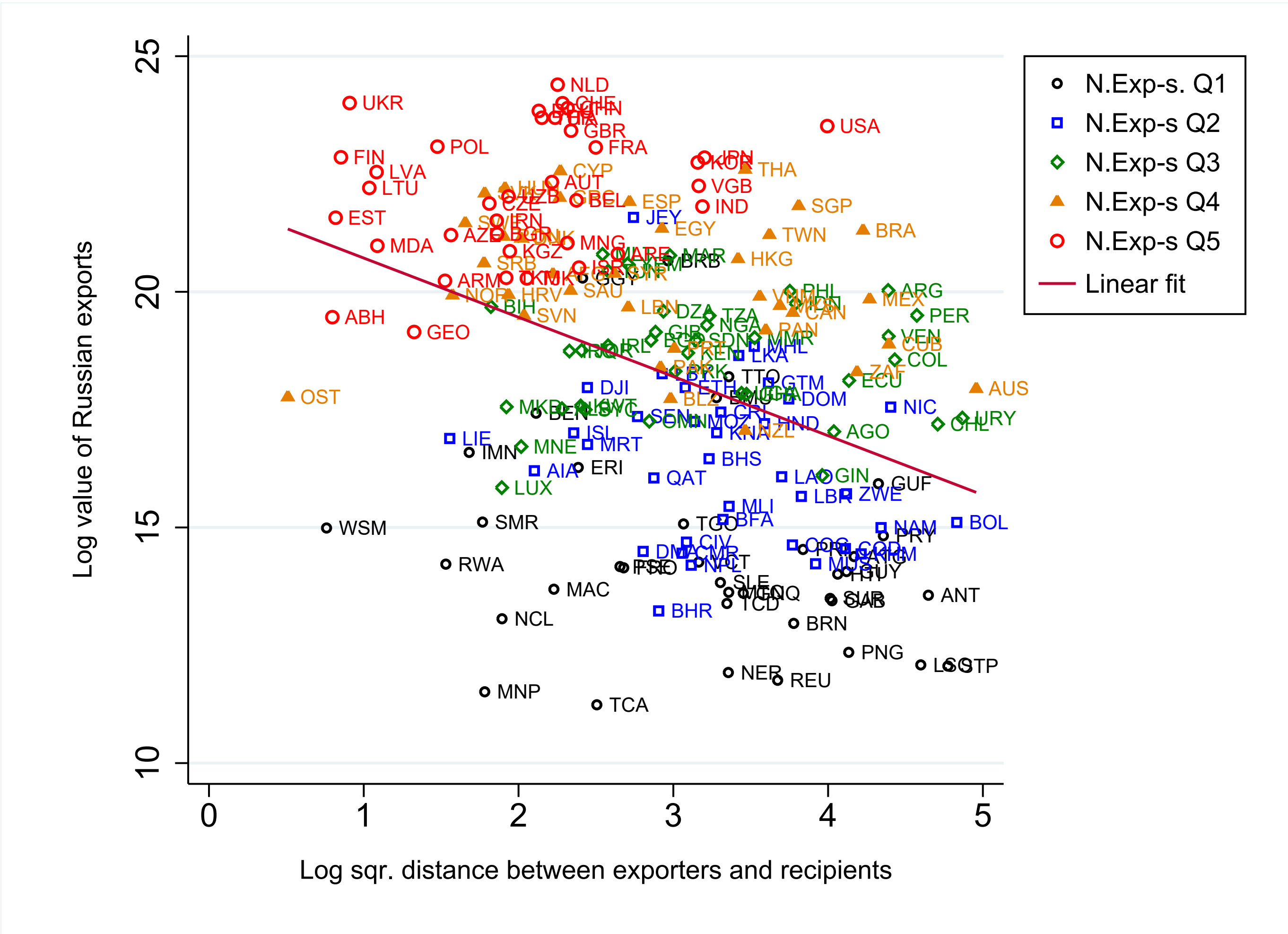
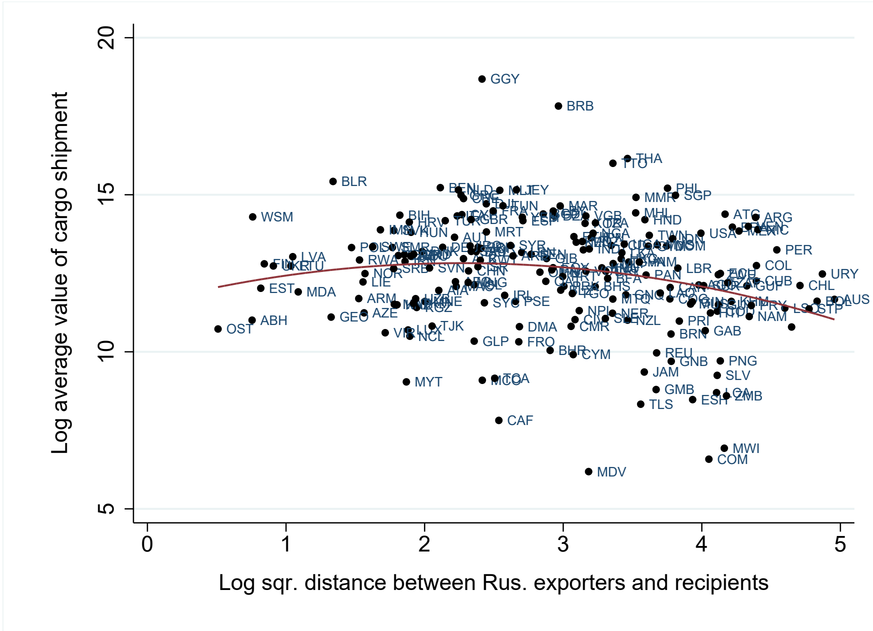


Figure 7: Country-to-country gravity conditional on the number of exporters
This figure illustrates the relation between the value of exports and the average squared distance between Russia and the country of destination. All observations are sorted into the five bins using the number of exporters from Russia to country i. Red color indicates the largest number and black color indicates the smallest number. Distance is measured as the average across all distances between recipients in country i and all Russian firms trading with them. The solid line represents fitted values from the OLS regression of the log value of Russian imports for each country importing from Russia on the log average distance between the importing country and Russia.

Panel A: Valuer per shipment



Panel B: Number of shipments

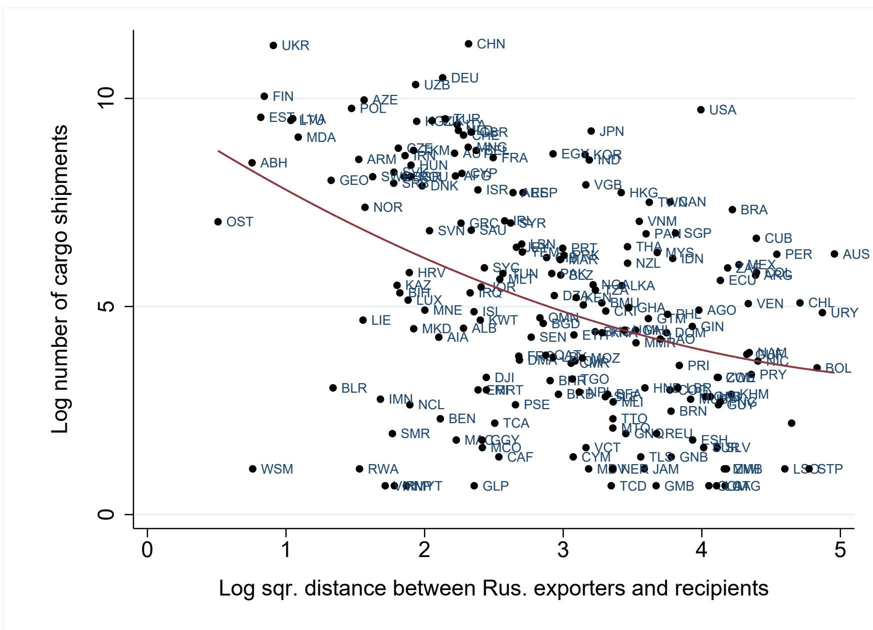
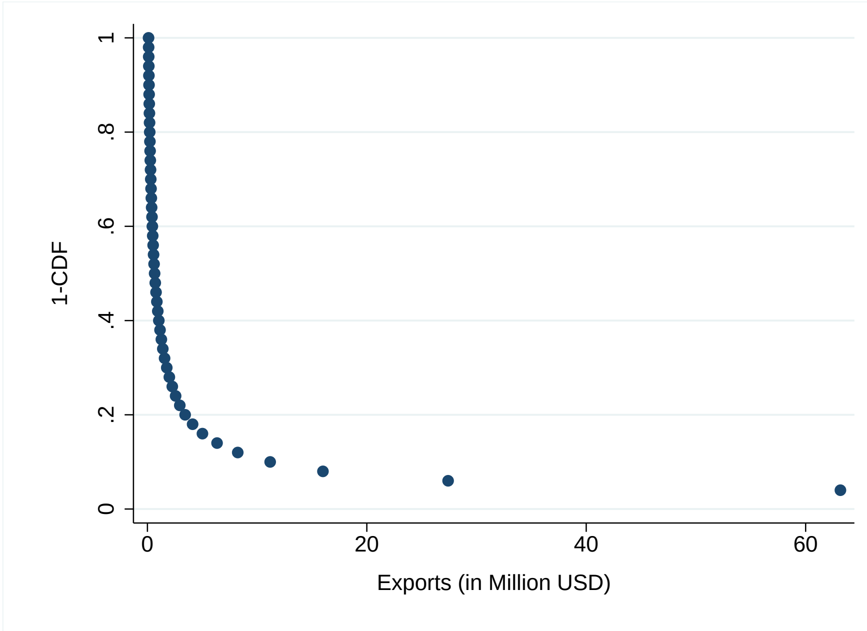


Figure 8: Value per cargo shipment a function of distance: Country-to-country

This figure illustrates the relation between the value per cargo shipment (Panel A), the number of cargo shipments (Panel B) and the average squared distance between Russia and the country of destination. Distance is measured as the average across all distances between recipients in country i and all Russian firms trading with them. The total number of shipments is calculated by adding up the daily shipments from all Russian exporters to all recipients in country j. A daily shipment from the exporter i to recipient j is defined as the total number of custom forms filed on that day by the exporter i as going to the recipient j. The solid line represents fitted values from the OLS regression of the log value per cargo shipment (number of shipments) of Russian imports for each country importing from Russia on the log of the average distance between the importing country and Russia.

Panel A: CDF versus K



Panel B: log(1-CDF) versus K^{α}

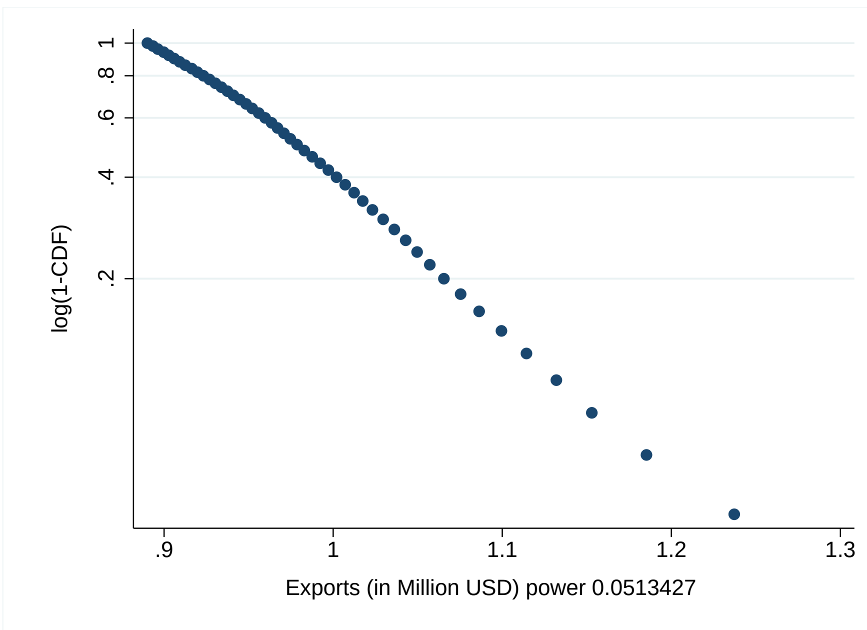
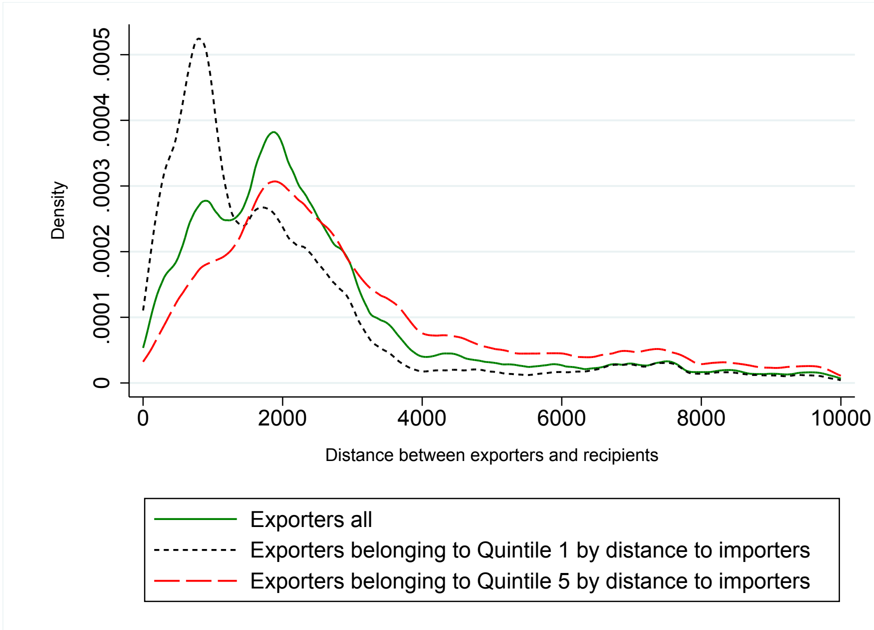


Figure 9: Russian exporting firms' size distribution

All Russian firms that export more than 100,000 USD in 2011 are ordered in increasing value of exports, and placed into 50 bins of equal log-size. Panel A shows fraction of firms larger than firms in bin b, as a function of the average size of exports among firms in bin b. Panel B is a visual guide for the distribution $1 - F(K) \propto exp(-K^{\alpha})$, which is a Weibull distribution, with $\alpha \approx 0.0511$. The size distribution of Russian firms is close to the exponential rather than Pareto.

Panel A: Quintiles



Panel B: Deciles

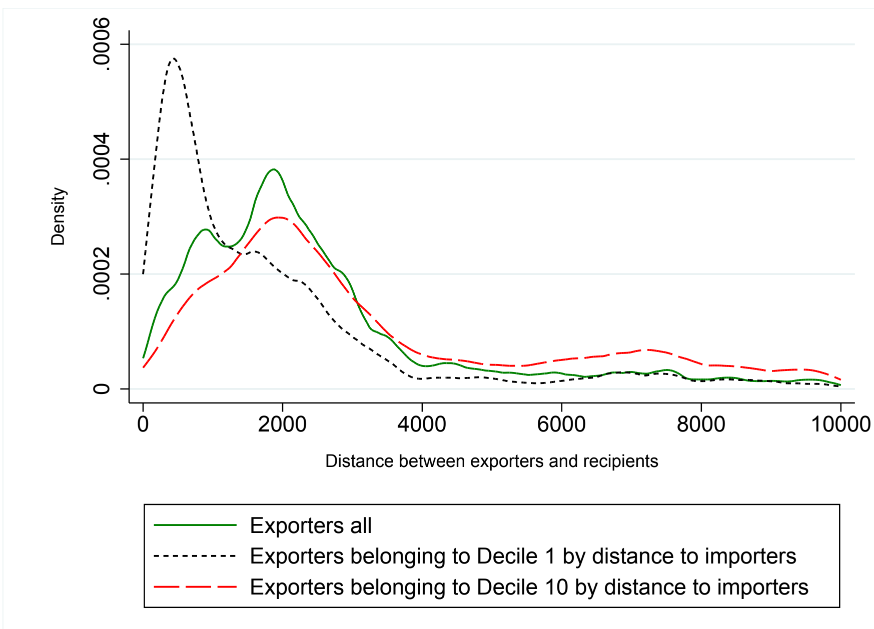


Figure 10: Exporter-recipient pairwise distance density

The figure illustrates that firms exporting over longer distances do not self-select and do not ship exclusively over these longer distances. All exporter-recipient pairs are sorted at the firm-to-firm level into either quintiles (Panel A) or deciles (Panel B) by distance. A special identifier is then created for all exporters in either top or bottom deciles (quintiles). For example if an exporting firm has a decile 10 identifier then at least one of its shipping destinations is very far (belongs to decile 10 by distance). Next, we plot densities for all firms and separately for firms in both top and bottom deciles (quintiles). The plot indicates that firms in the 10th decile (5th quintile) have vast majority of their recipients at a medium distance away and that their density function is close to the density function of the full sample. Firms belonging to the first decile (quintile) predominantly ship over sort distances thus indicating a self-selection among them.

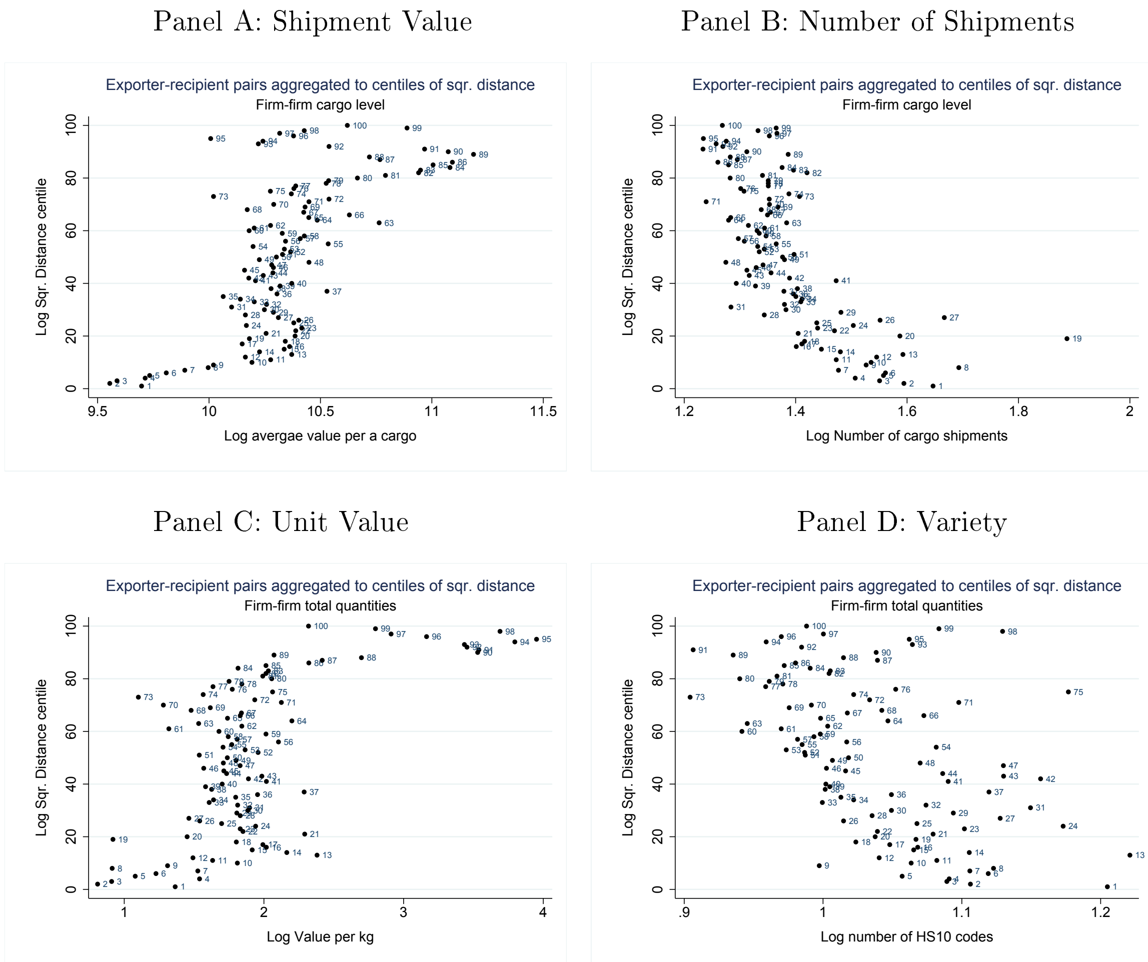


Figure 11: Shipment-Level Trade Characteristics as a Function of Distance

Value per shipment (Panel A), number of shipments (Panel B), unit value measured as value per kilogram (Panel C), and variety as functions of distance for recipient-exporter pairs. All exporter-recipient pairs are sorted at the firm-to-firm level into distance centiles.

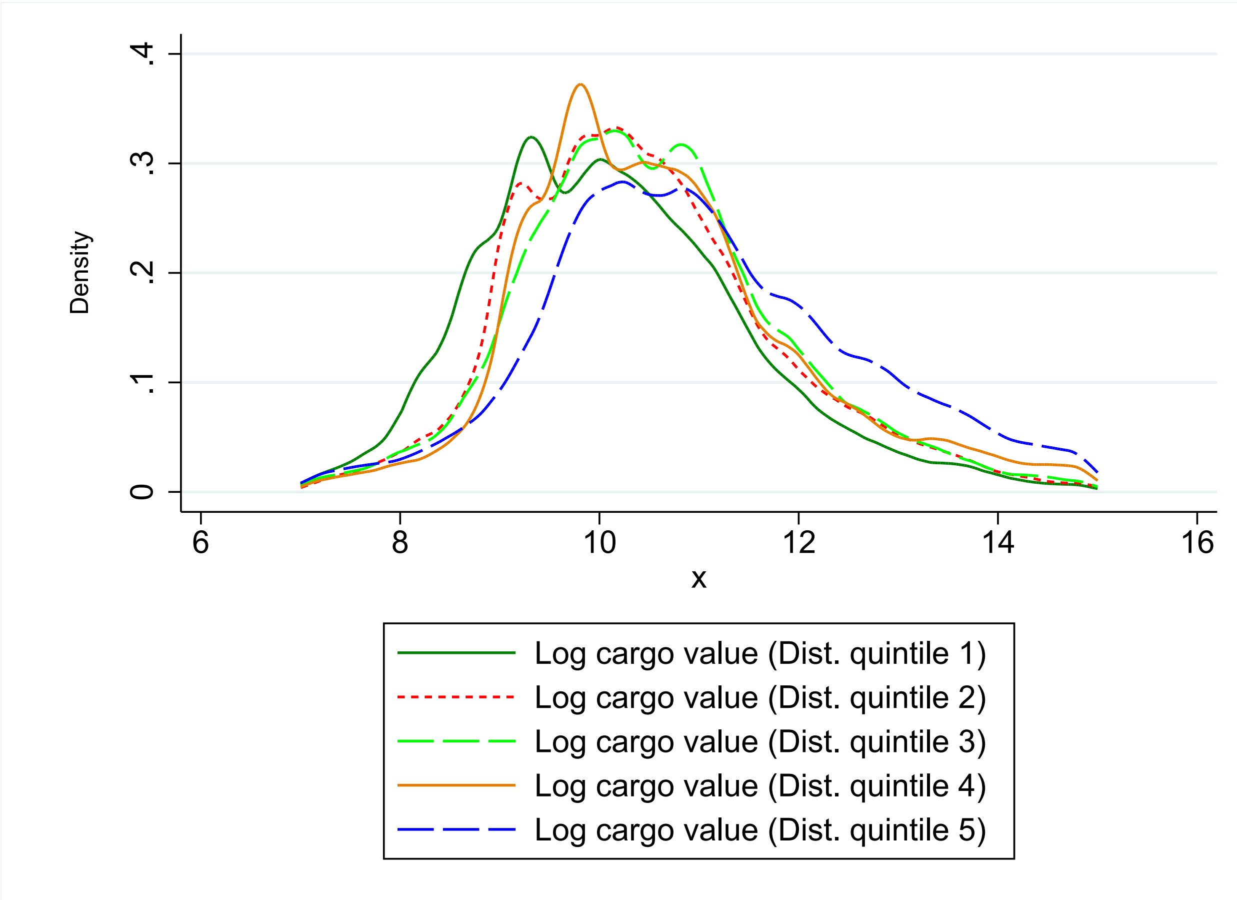
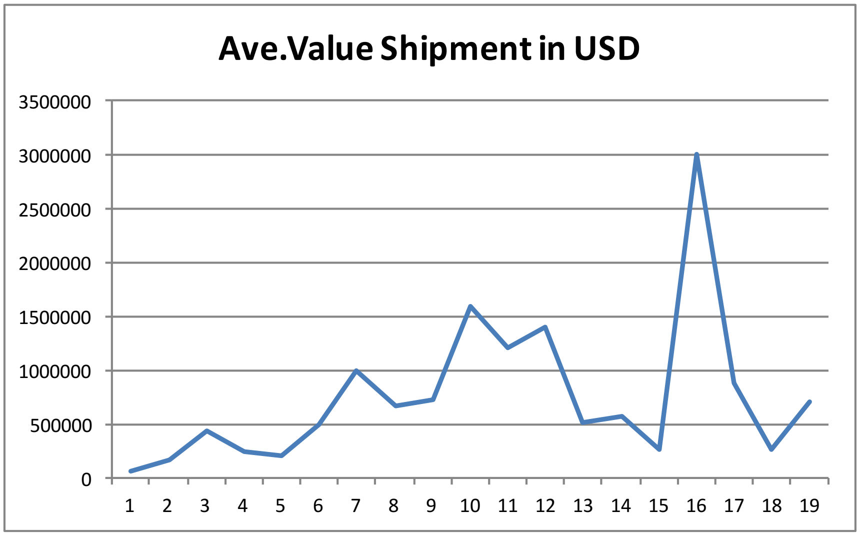


Figure 12: Conditional on distance distribution of value per shipment
All shipments are sorted into quintiles based on distance with 118,147 shipments per quintile. We then plot the distribution of log value per shipment for each quintile. Table below reports summary statistics.

Decile	Distance (km)			Value (1,000 US$)		
	Min	Mean	Max	Median	Mean	Max
1	1.23	523.78	876.99	22.98	272.07	$1.6 \cdot e^6$
2	876.99	1197.83	1551.51	30.28	191.53	$1.7 \cdot e^5$
3	1551.57	1850.95	2154.53	34.86	525.08	$7.1 \cdot e^5$
4	2154.58	2583.30	3150.33	35.42	779.72	$6.6 \cdot e^5$
5	3150.35	5865.75	18747.17	55.32	$1.3 \cdot e^3$	$6.9 \cdot e^5$

Panel A: Value Per Shipment



Panel B: Number of Shipments

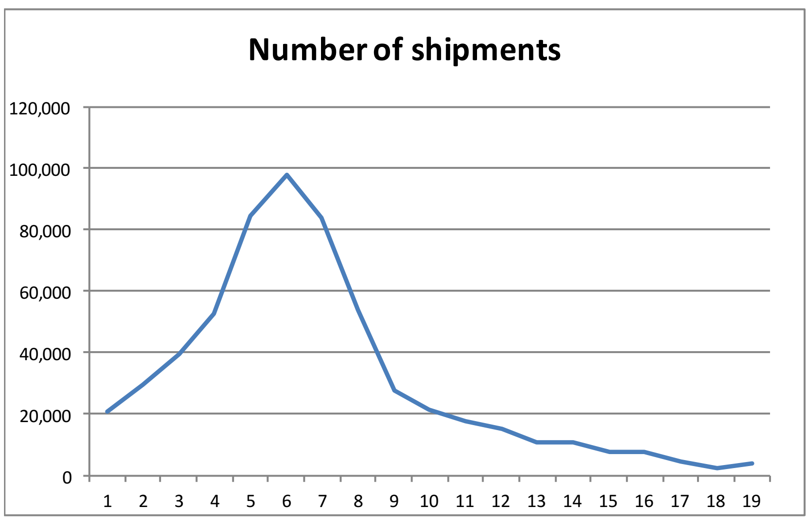


Figure 13: Exporter-recipient pairwise distance density

The figure plots the value per shipment (Panel A) and the number of shipments (Panel B) as a function of distance. All shipments are split into 19 distance bins. The bins are selected as follows. First four bins are for shipments shipped up to 250kms, 500kms, 750kms, and 1000kms. Next six bins are for shipments shipped up to 1,500kms, 2,000kms, 2,500kms, 3,000kms, 3,500kms, and 4,000kms. Next six bins are for shipments shipped up to 5,000kms, 6,000kms, 7,000kms, 8,000kms, 9,000kms, and 10,000kms. The last three bins are for shipments shipped up to 12,000kms, 15,000kms, and anywhere further than 15,000kms. The value per shipments is calculated by averaging shipment values per bin.