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Exporting Costs and Multi-Product Shipments

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Abstract

In this paper, employing transaction level data for Russian imports, we explore the role of multi-product shipments in explaining shipping patterns across countries. First, we document that firms from more developed countries on average include a higher number of different products into a single shipment. We then show that such multi-product shipments can potentially explain why more developed countries tend to have a higher number of shipments per period with a lower average quantity and value. According to our proposed mechanism, multi-product shipments allow firms to split fixed costs per shipment across many products and, therefore, reduce total shipment costs. As a result, more developed countries tend to have lower fixed costs per shipment. Finally, we construct a simple partial equilibrium model that enables us to quantify the potential increases in trade volumes and welfare created by the multi-product shipment option.

Keywords: asymmetric trade costs, fixed costs per shipment, advanced countries.
JEL code: F10.

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1 Introduction

Recent studies argue that countries with different levels of development face different trade costs. For instance, Waugh (2010) and Tarasov (2012) find that less-developed countries tend to have higher variable and fixed costs of exporting. Blum, Claro, Dasgupta, and Horstmann (2019) consider a model of trade in the presence of inventory management and show that less developed countries have higher fixed costs per shipment and, as a result, lower aggregate trade volumes. Since the elimination or reduction of these asymmetries boosts exports of less-developed countries and, thereby, increases their income, it is important to understand deeper the micro-foundations behind these differences in export costs.

In this paper, employing transaction level data collected by the Federal Customs Service of Russian Federation, we document a number of empirical observations related to product shipments from many different countries to Russia. Similar to Blum et al. (2019), we find that countries with higher GDP per capita tend to make more frequent and smaller (in size) transactions. Our dataset also allows us to explore the empirical patterns related to multi-product shipments - when different products/varieties are combined in a single shipment. In particular, we show that firms from more developed countries include on average more different product varieties into a single shipment. Moreover, in the data we observe that in the sub-sample of single-product shipments only, there is no statistically significant relationship between per capita income and frequency and size of corresponding transactions.

In the paper, we explain the observed shipping patterns by the economy of scale related to the fixed costs of shipping a product: a higher number of different products within a shipment results in lower fixed costs of shipping per product. Such a mechanism can explain all the documented above shipping patterns. In particular, the literature argues (see, for instance, Hummels and Klenow, 2005) that more developed countries export more different product varieties: in our data set, Russian importers import on average more products from more developed countries. As a result, these countries have more possibilities of making multi-product shipments and, thereby, are supposed to use more multi-product shipments than single-product ones (as there is economy of scale in the shipping costs). Moreover, lower fixed costs per product for multi-product shipments lead to more frequent and smaller transactions (see Blum et al. (2019)). In other words, advanced countries have an advantage in international shipping stemming from their ability to make multi-product shipments, which contributes to higher levels of exports of these countries.

In our analysis, we focus on container shipments, which is the most important shipping category in international trade.[1] The dataset includes information on the identifier of the importer, product code, sending country, value and quantity of the product. There is also information on customs declarations: a declaration can include a single or multiple transactions/products with different codes. The declaration number can be used as the identifier of a distinct shipment. This in turn allows us to group

[1]Rua (2014) documents that the global share of containers in general cargo (i.e., excluding oil, fertilizers, ore, and grain) by volume reaches 70% by mid-2000s.

individual transactions into shipments. Since our empirical approach is closely related to that in Blum et al. (2019), we compare the descriptive statistics and some patterns implied by our dataset with those observed in the Chilean data, employed by Blum et al. (2019). We find no crucial differences between the characteristics of the datasets. In particular, in both datasets more developed countries tend to have a higher number of shipments per period with a lower average quantity and value, and a higher average per unit price.

To quantify the role of multi-product shipments in determining the shipment costs of a product, following Blum et al. (2019), we develop a simple partial equilibrium model of product shipping where fixed costs of shipping a product depend on the number of products included in the shipment. In our empirical analysis, we find a strong role for multi-product shipments in explaining shipping patterns across countries. Specifically, as in Blum et al. (2019), higher income countries tend to have lower shipping fixed costs. However, in our data, it is mostly due to multi-product shipments. In particular, if we assume that the number of products in each shipment is the same across all countries, the relationship between per capita income and fixed costs of shipping disappears.

Using our model, we then quantify the implications of multi-product shipments for trade volumes and welfare. Specifically, we perform two counterfactual experiments. First, we assume that for all transactions the number of products included in a corresponding shipment is equal to the weighted average number of products in the U.S. shipments. We find that in this case, the average rise in exports to Russia across countries is around 23%. Total exports to Russia in turn increase by 9.6%. Within our partial equilibrium model, the latter implies around 0.7% rise in the level of welfare in Russia. In the second experiment, we assume away the possibility of multi-product shipments. In other words, we consider a counterfactual economy where only single-product shipments can be made. Given these changes, the average decrease in exports to Russia is about 11%, the decrease in total exports is 8%, implying a 0.6% decrease in welfare. The latter number can be treated as the welfare gains from the possibility of multi-product shipping. It is worth mentioning that, since we consider a simple partial equilibrium model, the estimate of the welfare gains provides rather an idea about the lower bound of the corresponding welfare changes.

To our best knowledge, the only paper that discusses the role of multi-product shipments in the context of trade costs is Holmes and Singer (2018). This paper focuses on the importing patterns of US retail chains from China and shows that larger firms include a higher number of product varieties into shipping containers, which allows them to achieve a higher utilization of shipping containers and, thereby, to reduce trade costs. The paper employs a model of trade with indivisibilities to quantify these trade costs saving advantages. The present paper complements Holmes and Singer (2018) by studying cross country patterns of shipments rather than focusing on a single source country and a few importing firms in the retail sector. While Holmes and Singer (2018) show that large retailers take an advantage of multi-product shipments, we document that the same applies to exporters from more developed countries and relate it to the fixed cost of product shipping.

Our paper is related to the literature on the role of fixed costs per shipment. Alessandria, Kaboski, and Midrigan (2010) is one of the first papers that documents the importance of fixed costs per shipment and analyzes their implications for import dynamics. Specifically, they provide evidence that these costs amount to 20-percent tariff equivalent costs. Kropf and Saure (2014) develop this idea further and introduce fixed costs per shipment into a heterogeneous firm framework à la Melitz (2003) and calibrate it to transaction level data for Switzerland. Other studies that use transaction level data to explore the role of fixed costs per shipment include Hornok and Koren (2015) and Bekes, Fontagne, Murakozy, and Vicard (2017). None of these papers consider multi-product shipments.

It should be mentioned that papers analyzing the role of fixed costs in international trade belong to a broader literature that explores the role of transportation costs and their endogeneity for trade and welfare (see Behar and Venables, 2011 and Redding and Turner, 2015 for excellent surveys). Using an economic geography model, Behrens and Picard (2011) show that the prices for transporting differentiated goods increase in the degree of spatial specialization of the economy and that this channel dampens core-periphery patterns. While their model has a competitive transport sector, Hummels, Lugovskyy, and Skiba (2009) provide evidence that monopolistic market structure in the transport sector restricts trade. Brancaccio, Kalouptsidi, and Papageorgiou (2020) construct a spatial model of world trade with matching frictions and explore the quantitative role of the transportation sector.[2] Fajgelbaum and Schaal (2020) provide a framework to solve for the endogenous road infrastructure network and implements it to European countries. Heiland, Moxnes, Ulltveit-Moe, and Zi (2019) examine the structure of the shipping networks and estimate the effect of the expansion of the Panama Canal on global trade volumes. We complement this literature by considering the role of multi-product shipments in determining transportation costs.

Finally, our paper is related to the literature on multi-product firms (see, for instance, Eckel and Neary, 2010; Mayer, Melitz, and Ottaviano, 2014; Eckel, Iacovone, Javorcik, and Neary, 2015; Bernard, Redding, and Schott, 2011; Arkolakis, Muendler, and Ganapati, 2019. We providing some new evidence and intuition for the micro-foundations of potential advantage of multi-product firms in international shipping, which was not substantially explored before.

The rest of the paper is organized as follows. Section 2 describes the data set and presents some empirical patterns. In Section 3, we construct and estimate a partial equilibrium model of product shipping. In Section 4, we perform the counterfactual analysis. Section 5 concludes.

2 Data and Empirical Patterns

In this section, we describe the dataset we use in the analysis and report empirical patterns that link the frequency and quantity of country's exports with the average number of products that are included

[2] See also Asturias (2020) for the quantitative role of a oligopolistically competitive transportation sector in a Armington model, Wong (2020) for the effect of round trips between destinations and Ardelean and Lugovskyy (2021) for the role of information frictions in determining freight rates.

in a single shipment made by this country. We also compare some of our findings with those in Blum et al. (2019).

2.1 Data

In our empirical analysis, we use transaction level data for container shipments to Russia collected by the Russian Federal Customs Service. Container shipments is one of the most important shipping category in international trade. According to Rua (2014), the global share of containers in general cargo (i.e., excluding oil, fertilizers, ore, and grain) by volume reaches 70 percent by mid-2000s. Moreover, by considering container shipments, we are likely to exclude small individuals (a category that is excluded in Blum et al. (2019) as well) and trade in bulk goods that are shipped infrequently but in very large quantities.

The sample period is from February to July of 2014. The six-months period is shorter compared with the one-year period considered in Blum et al. (2019). However, the sample size is sufficient to meet our objective (as it covers both winter and summer months of the year, there are few concerns related to seasonal patterns). The dataset includes information on the identifier of the importer, product code, sending country, value, weight and quantity of the product. Importantly, there is data on custom declarations related the transactions: a declaration can include a single or multiple transactions/products with different codes. The declaration number can be used as the identifier of a distinct shipment. This in turn allows us to group individual transactions into shipments.

We present the descriptive statistics in Table 1. It is worth noting that there are substantial similarities between our sample and the one used in Blum et al. (2019). In our sample, we have about 20000 importers, 7000 distinct products codes, from 139 countries. All these numbers are only slightly above the values reported in Blum et al. (2019). The size of our sample is also close to that in Blum et al. (2019).

Compared to Blum et al. (2019), in our context, a shipment has a different meaning. They use the term shipment to refer to individual transactions. In reality, a shipment can include multiple transactions. In some cases, a shipment can consist of only a single transaction; we use the term single-product shipment to refer to such cases. However, a shipment frequently includes multiple transactions/products. As mentioned above, we can identify shipments using declaration numbers that are present in the dataset. For any declaration, the border-crossing date, clearance date, entry port, clearance customs house, sending company, sending country and receiving company are the same. Therefore, we can confidently rule out that a given company can accumulate many shipments and clear them at once. Even if such shipments were to be sent by the same company by the same route then border-crossing dates could not be the same.

This concept of multi-product shipments is also explored by Holmes and Singer (2018), who consider the importing patterns of US retail chains from China. In our dataset, the number of shipments is substantially smaller than the number of transactions: 405641 versus 2293576 (recall that every transaction is the part of a shipment). Among all shipments, single-product shipments represent about the half.[3] On average, a shipment includes 5 transactions/products. If we exclude exclude single-product shipments and consider only the subset of multi-product shipments then the average shipment includes about 10 transactions/products.

Table 1: Summary Statistics: Russian Import Data

Russian imports (RUR)	1.218×10^{13}
Number of importers	19,787
Number of HS ten-digit codes imported	7,060
Number of source countries	139
Number of transactions	2,293,576
Number of shipments	405,641
Number of single-product shipments	212,607
Average shipment value	5,310,040
Median shipment value	81,201.57

Values are reported in Russian rubles (RUR). During the period of study the average exchange rate was about 34 RUR per USD and had relatively stable dynamics.

In Panel A of Table 2, we present the distribution of imports with respect to firm size. As usual for trade datasets, the distribution is skewed. In particular, in our dataset, the ratio of the mean to the median is 39 (this ratio is 28 in Blum et al., 2019). In terms of the number of products purchased by importers, the difference between the median (4 products) and top 1 percent (180 products) is also somewhat larger in our sample. In the Chilean data, the corresponding values are 5 and 156, respectively. We also observe a large variation between the numbers of countries from which firms source. The median firm sources from one country, while the top 1 percent firms source from 11 countries. For instance, the corresponding numbers in the Chilean data are 1 and 21, respectively.

[3] In some cases, a multi-product shipment can include several transactions of the same HS10 good. For example, two iPhones of the same model with 32Gb and 64Gb memories are distinct products and have different prices, thus they are recorded separately.

Table 2: Distribution of Key Variables: Russian Imports

	Imports RUR (1)	Number of importers (2)	Number of HS10 codes (3)	Number of source countries (4)	Number of transactions (5)	Number of shipments (6)
Panel A. Distribution over importers: 19,787 firms						
P25	2.91×10^{6}	–	1	1	3	1
P50	1.57×10^{7}	–	4	1	10	4
P75	2.41×10^{8}	–	12	2	39	13
P90	9.62×10^{8}	–	36	4	145	40
P95	2.08×10^{9}	–	66	6	315	78
P99	8.71×10^{9}	–	180	11	1484	265
Mean	6.16×10^{8}	–	15.05	1.92	115.91	20.50
Panel B. Distribution over HS ten-digit products: 7,060 codes						
P25	6.00×10^{6}	3	–	2	6	–
P50	1.21×10^{8}	10	–	5	31	–
P75	9.19×10^{8}	36	–	11	183	–
P90	3.59×10^{9}	109	–	19	734	–
P95	7.46×10^{9}	193.5	–	25	1547.5	–
P99	2.33×10^{10}	488	–	34	4772	–
Mean	1.73×10^{9}	42.02	–	7.77	324.86	–
Panel C. Distribution over importer-HS ten-digit product pairs: 296,653 pairs						
P25	2.67×10^{4}	–	–	1	1	–
P50	2.68×10^{5}	–	–	1	2	–
P75	2.44×10^{6}	–	–	1	4	–
P90	2.57×10^{7}	–	–	2	11	–
P95	1.10×10^{8}	–	–	2	22	–
P99	7.12×10^{8}	–	–	3	105	–
Mean	4.11×10^{7}	–	–	1.15	7.73	–

In terms of the number of transactions, there are some differences between our sample and the Chilean. The number of transactions in our sample exceeds the Chilean numbers for almost all categories and differences get larger for top importers. This is most likely because of more detailed product codes and recording system in the Russian dataset. When we aggregate transactions at HS8 level then our figures for firms starting from 50 percentile do not exceed Chilean figures. In the last column of Panel A, we provide data on the number of shipments.

In Panel B, we present the distribution of imports across HS10 product codes. We again observe that the distribution is skewed. A given product is on average imported by 42 firms from 8 countries. Both figures are rather close to the ones reported in Blum et al. (2019). Finally, in Panel C we provide information on importer-product pairs. As can be seen, most importer-product pairs are sourced from one country. Only top 10 percent of importer-product pairs are sourced from more than one country. This pattern is similar to that described by Blum et al. (2019).

Note that sourcing from different countries for a given importer-product pair is important, as the identifying variation comes from importer-product pairs (see the estimation strategy described in Section 2.2). To this end, Table 3 classifies importer-pairs into groups, depending on the number of countries from which they are sourced, and presents some descriptive information. As mentioned before, almost 90 percent of importer-product pairs are sourced from one country, which is higher than the corresponding number in Blum et al. (2019). This can be partly due to the fact that we use more detail product codes. Nevertheless, single destination cases account only for 55 percent of imports by volume, which means that almost half of Russian importer-product pairs (measured by volume) are sourced from at least two countries. In our sample, an importer-product pair is imported at most from 15 countries.

Table 3: Characteristics of Importer-HS Ten-Digit Product Pairs

Number of source countries (1)	Number of importer-HS10 pairs (2)	Share of importer-HS10 pairs (3)	Share of imports (4)	HHI imports across countries (5)	Mean absolute deviation country per capita income (6)
1	263450	0.888	0.554	1	0
2	25142	0.085	0.195	0.724	9,304
3	5424	0.018	0.118	0.618	11,896
4	1672	0.006	0.061	0.56	13,256
5	544	0.002	0.026	0.525	13,670
6-10	411	0.001	0.045	0.498	14,758
11-15	10	0.000	0.002	0.539	11,456

Notes: Column 6 reports the mean absolute deviation from the mean per capita income of the countries the importer buys the product from.

To measure the concentration of importer-pairs across countries, in column 5 we report the Herfndahl-Hirschman Index (HHI). For importer-pairs sourced from up to 4 countries, our values are very close to the ones reported by Blum et al. (2019). We also can observe that the index decreases, as the number of countries increases. The only exception is the last line in Table 3 but this is likely due to the fact that we have few observations in that category. In the last column, we present the average absolute deviation of GDP per capita of countries from which an importer-product pair is imported.

2.2 Shipping Patterns across Countries

To exploit the information contained in the transaction level data, we adopt the decomposition approach used in Blum et al. (2019). Specifically, total imports V_{ihl} of product h in HS10 product category by firm l from country i can be written as

$$V_{ihl} = N_{ihl} \times \bar{s}_{ihl} = N_{ihl} \times \hat{p}_{ihl} \times \bar{q}_{ihl}, \tag{1}$$

where N_{ihl} is the total number of transactions, $\bar{s}_{ihl}$ the average value of a transaction, $\bar{q}_{ihl}$ the average quantity of a transaction, and $\hat{p}_{ihl}$ the weighted average per unit price. More specifically, these variables are defined as:

$$\bar{s}_{ihl} = \frac{1}{N_{ihl}} \times \sum_{k=1}^{N_{ihl}} \left(q_{ihl}(k) \times p_{ihl}(k)\right),$$

$$\bar{q}_{ihl} = \frac{\sum_{k=1}^{N_{ihl}} q_{ihl}(k)}{N_{ihl}}, \quad \hat{p}_{ihl} = \frac{\sum_{k=1}^{N_{ihl}} \left(q_{ihl}(k) \times p_{ihl}(k)\right)}{\sum_{k=1}^{N_{ihl}} q_{ihl}(k)}, \tag{2}$$

where k is a transaction index.

The main empirical specification we consider in this section is given by:

$$ln(z_{ihl}) = \delta_{hl} + \beta_1 ln(gdp_i) + \beta_2 ln(pcgdp_i) + \beta_3 ln(dist_i) + \beta_4 contig_i + \epsilon_{ihl}, \tag{3}$$

where gdp_i is the GDP of the exporting country i, $pcgdp_i$ is its per capita GDP, and $dist_i$ is the population weighted distance between exporter i and Russia, $contig_i$ is a dummy whether country i shares a border with Russia.[4] The specification also includes importer times HS10 digit product codes denoted by δ_{hl}. Country level variables are taken from the update CEPII Gravity database (Head, Mayer, and Ries, 2010).

The results of estimations are presented in Table 4. In columns 1 through 5, we replicate the results in Blum et al. (2019). As can be seen, the Russian data deliver the results that are very close both qualitatively and quantitatively to those derived for the Chilean data. This provides us confidence that the novel features we document below are not driven by special characteristics of the Russian data. Specifically, we find that more developed countries (proxied by GDP per capita) tend to make more frequent transactions, each transaction made by such countries is smaller and the average price is higher.

It is especially important to emphasize the relationships between GDP per capita with the number

[4] Note that Blum et al. (2019) do not include a contiguity dummy in their empirical analysis. However, in case of Russia, this dummy is an important control variable, as, unlike Chile, Russia shares a border with multiple countries, most of which were the part of the Soviet Union and there are still strong cultural, economic and migration ties. Moreover, as has been shown in the gravity literature, contiguity is a strong predictor of trade flows (see, for instance, Silva and Tenreyro, 2006). Finally, our results in Tables 4 and **??** are similar to those in the specification without the contiguity dummy.

Table 4: Country Characteristics and Shipping Patterns

	$ln(V_{ihl})$	$ln(N_{ihl})$	$ln(\bar{s}_{ihl})$	$ln(\bar{q}_{ihl})$	$ln(\hat{p}_{ihl})$	$ln(\bar{n}_{ihl})$
	(1)	(2)	(3)	(4)	(5)	(6)
GDP	0.177***	0.110***	0.066***	0.091***	0.029***	0.028***
	(0.018)	(0.008)	(0.014)	(0.015)	(0.009)	(0.005)
GDP per cap	-0.021	0.068***	-0.089***	-0.091***	0.063***	0.141***
	(0.032)	(0.014)	(0.024)	(0.027)	(0.016)	(0.009)
Distance	0.164**	-0.085***	0.249***	0.174***	-0.025	-0.165***
	(0.069)	(0.031)	(0.053)	(0.059)	(0.036)	(0.020)
Contiguity	0.426***	0.085***	0.341***	0.286***	-0.010	-0.051***
	(0.065)	(0.029)	(0.051)	(0.055)	(0.033)	(0.018)
R^2	0.929	0.860	0.944	0.943	0.938	0.967
N	343239	343420	343239	343402	343226	343420

Notes: OLS regressions of equation 3. All regressions include importer-by-HS 10 - level fixed effects. Robust standard errors are reported in parentheses. * (**) (***) indicates significance at the 10 (5) (1) percent level.

of transactions and the average quantity for a given product-importer pair. Our estimates are close to the ones obtained by Blum et al. (2019) both in terms of sign and value. For instance, our estimated coefficient representing the relationship between GDP per capita and the number of transactions is 0.068, while in Blum et al. (2019) it is 0.063. For the relationship between GDP per capita and quantity, we have -0.091 versus -0.287 in their study.

After assuring that the Russian data exhibit patterns that are very similar to those for the Chilean data in Blum et al. (2019), we explore another dimension of our dataset: multi-product shipments; which is not studied in Blum et al. (2019). As discussed before, shipping their products, firms can combine different product varieties into one shipment. In column 6 of Table 4, our dependent variable is the average number of different products/varieties that are included in a combined shipment made by an importer l from country i in HS10 product category h. We denote this variable by $\bar{n}_{ihl}$:

$$\bar{n}_{ihl} = \frac{1}{N_{ihl}} \times \sum_{k=1}^{N_{ihl}} n_{ihl}(k),$$

where $n_{ihl}(k)$ is the number of products (in HS10 category) included in the shipment corresponding to transaction k made by importer l from country i in HS10 product category h.

As can be seen, there is a positive relationship between the level of GDP per capita and the number of different varieties of products included in a single shipment. In other words, more developed countries include on average a higher number of different varieties of products into a combined shipment. Specifically, our estimates imply that one percent increase in GDP per capita is associated with 0.14 percent increase in the number of products included in a shipment, which seems to be a relatively large effect.

Finally, to make sure that the results we document are not driven by the fact that we use HS10 level product codes, while Blum et al. (2019) use HS8, in Appendix Table 9, we aggregate transactions at HS8 level and run all specifications of Table 4 with the aggregated data. The estimated coefficients are very similar.

2.3 Multi-Product Shipments

The patterns reported in Table 4 imply that countries with higher per capita income ship more frequently with lower quantities and include a higher number of different products in a shipment. To understand more about the link between the above shipping patterns, we run the regressions in (3) on the sub-sample of importer-product pairs that were sent as single, without any accompanying products. If multi-product shipments are not related to shipping frequency and size, then we will observe the same shipping patterns in the restricted and unrestricted samples. Table 5 reports the results of these estimations. As can be seen, in this case, the relationship between per capita income and the frequency and size of transactions disappear - the corresponding estimates are not significant and, moreover, have the reverse signs. These findings suggest that a higher frequency and lower size of export shipments made by developed countries are highly related to multi-product shipping.

Table 5: Single-Product Shipments

	$ln(V_{ihl})$	$ln(N_{ihl})$	$ln(\bar{s}_{ihl})$	$ln(\bar{q}_{ihl})$	$ln(\hat{p}_{ihl})$
	(1)	(2)	(3)	(4)	(5)
GDP	0.101**	0.061***	0.039	0.034	0.014
	(0.049)	(0.023)	(0.038)	(0.025)	(0.033)
GDP per cap	-0.092	-0.040	-0.052	-0.035	-0.022
	(0.086)	(0.039)	(0.066)	(0.044)	(0.059)
Distance	0.230	0.047	0.182	0.061	0.117
	(0.173)	(0.079)	(0.135)	(0.083)	(0.118)
Contiguity	-0.105	-0.016	-0.090	0.045	-0.126
	(0.208)	(0.094)	(0.163)	(0.106)	(0.142)
R	0.926	0.875	0.937	0.971	0.936
N	37352	37361	37352	37355	37348

Notes: OLS regressions of equation 3. All regressions include importer-by-HS 10 - level fixed effects. Robust standard errors are reported in parentheses. * (**) (***) indicates significance at the 10 (5) (1) percent level.

This argument is also confirmed by the findings in Panel A of Table 6. In this panel, we include $\bar{n}_{ihl}$ as an explanatory variable in (3) with the objective of controlling for the role of multi-product shipments in explaining the frequency of shipments and other outcome variables. One can see that the average number of products is positively and significantly related with the number of transactions (column 2) and negatively related with quantity. At the same time, the relationship between per capita income and the shipping frequency becomes insignificant, while the relationship between per capita income and the size of a transaction is significant only at the 10-percent level and the size of the coefficient is half of the one in Table 4.

2.4 Shipping Costs and Shipping Patterns

The above empirical patterns imply that there is likely a common mechanism explaining some shipping patterns of advanced countries. Notice that the literature shows that richer countries tend to export on average a higher number of products to different destinations (see, for instance, Hummels

Table 6: Additional Controls

	$ln(V_{ihl})$	$ln(N_{ihl})$	$ln(\bar{s}_{ihl})$	$ln(\bar{q}_{ihl})$	$ln(\hat{p}_{ihl})$	$ln(\bar{n}_{ihl})$
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A						
GDP	0.176***	0.099***	0.077***	0.100***	0.026***	-
	(0.018)	(0.008)	(0.013)	(0.014)	(0.009)	-
GDP per cap	-0.022	0.010	-0.032	-0.049*	0.049***	-
	(0.032)	(0.014)	(0.024)	(0.027)	(0.016)	-
Distance	0.165**	-0.018	0.182***	0.125**	-0.009	-
	(0.069)	(0.030)	(0.053)	(0.059)	(0.036)	-
Contiguity	0.426***	0.106***	0.320***	0.271***	-0.005	-
	(0.065)	(0.028)	(0.050)	(0.054)	(0.032)	-
$ln(\bar{n}_{ihl})$	0.007	0.408***	-0.401***	-0.298***	0.097***	-
	(0.038)	(0.015)	(0.029)	(0.034)	(0.018)	-
R	0.929	0.870	0.945	0.943	0.938	-
N	343239	343420	343239	343402	343226	-
Panel B						
GDP	0.153***	0.106***	0.047***	0.099***	-	0.027***
	(0.016)	(0.008)	(0.012)	(0.014)	-	(0.005)
GDP per cap	-0.072**	0.057***	-0.129***	-0.074***	-	0.139***
	(0.029)	(0.014)	(0.022)	(0.027)	-	(0.009)
Distance	0.184***	-0.081***	0.265***	0.167***	-	-0.164***
	(0.062)	(0.031)	(0.048)	(0.058)	-	(0.020)
Contiguity	0.434***	0.087***	0.347***	0.283***	-	-0.051***
	(0.059)	(0.028)	(0.046)	(0.054)	-	(0.018)
$ln(\hat{p}_{ihl})$	0.812***	0.166***	0.646***	-0.277***	-	0.031***
	(0.020)	(0.009)	(0.017)	(0.018)	-	(0.006)
R	0.941	0.865	0.954	0.944	-	0.967
N	343226	343226	343226	343226	-	343226

Notes: OLS regressions of equation 3. All regressions include importer-by-HS 10 - level fixed effects. Robust standard errors are reported in parentheses. * (**) (***) indicates significance at the 10 (5) (1) percent level.

and Klenow, 2005). To examine this pattern in our data, we construct a product range measure for each country-importer pair and regress it on country characteristics. Specifically, our product range measure is the log of the number of different HS10 products shipped by a country-importer pair during the entire period denoted by $ln(Range_{il})$. Our estimation results are given by (the standard errors are in the brackets below):[5]

$$ln(Range_{il}) = \delta_l + \underset{(0.006)}{0.119} ln(gdp_i) + \underset{(0.009)}{0.058} ln(pcgdp_i) - \underset{(0.020)}{0.005} ln(dist_i) + \underset{(0.038)}{0.657} contig_i + \epsilon_{il}.$$

As can be seen, all else equal, Russian importers import on average more products from more developed countries.

Based on the above, we explain the observed shipping patterns by the economy of scale related the fixed costs of shipping a product: a higher number of different products within a shipment results in lower fixed costs of shipping per product. Such a mechanism can explain all the documented shipping patterns. Indeed, since richer countries have an opportunity to export more products (and, therefore,

[5] $R^2 = 0.67$ and $N = 37261$.

have more possibilities of making multi-product shipments) and, as argued, multi-product shipments allow for lower shipping costs, advanced countries are supposed to use multi-product shipments rather than single-product ones. Moreover, lower fixed costs of product shipping for multi-product shipments lead to more frequent and smaller shipments (see Blum et al. (2019)).

An alternative explanation for the frequency and size of shipments can be based on that advanced countries tend to export high-quality products (products with higher per unit values). Such products can have higher inventory costs, implying more frequent and smaller shipments. To check this explanation, we include the weighted average per unit price $\hat{p}_{ihl}$ in (3) as an explanatory variable. The results are reported in Panel B of Table 6. As can be inferred, per unit price is positively correlated with the frequency and negatively with the quantity, which supports the explanation. However, the corresponding relationships with per capita income barely changes, leaving the room for the explanation considered in the present paper. Moreover, it is not perfectly clear how exports of high-quality products can explain the prevalence of multi-product shipments made by rich countries.

Finally, it is worth noting that, in this paper, we do not provide micro-foundations for the link between country's development level and the number of products the country can potentially export. At the same time, the positive relationship between economic development and export diversification has been discussed extensively (see Hesse, 2008). It can be related to a higher technological level or the presence of a higher number of multi-product firms in advanced countries. In the next section, we develop a simple structural model of multi-product shipments to understand their quantitative role.

3 A Partial Equilibrium Shipping Model

In this section, we construct a simple partial equilibrium model of product shipping where fixed costs of shipping a product depend on the number of products included in the shipment. In building the model, we follow Blum et al. (2019) and consider a continuous-time, finite-horizon world with uniform deterministic over time demand for any product. Specifically, we denote by x_{ijh} demand in country j at any time $t \in [0, 1]$ for product h produced in country i.[6]

We assume that country i (or the distributor of its products) holds an inventory for product h in country j of size $m_{ijh}(t)$ at period t. The inventory depreciation rate is δ (same for all countries and products). Hence, the change in the inventory size at time t, if there are no shipments at this period, can be written as follows:

$$\frac{dm_{ijh}(t)}{dt} = -x_{ijh} - \delta m_{ijh}(t), \tag{4}$$

where the first term represents demand at period t, while the second one stands for the inventory depreciation.

[6] Note that models on inventory management with stochastic demand cannot be usually solved in a closed form (see Alessandria et al., 2010).

A representative producer (we assume that firms within each country are homogeneous) of product h in country i faces the following trade-off when shipping to country j. On the one hand, shipping is costly implying incentives for the producer to hold a bigger inventory. On the other hand, a bigger inventory leads to greater losses because of depreciation. Note also that uniform deterministic demand implies that the optimal shipping strategy includes shipments of equal size that are made when the size of the inventory goes to zero (see Arrow, Harris, and Marschak, 1951 and Blum et al., 2019). This in turn means that shipments are made at equal intervals. Hence, taking into account the above trade-off, the producer decides on the number of shipments of product h, n_{ijh}, and their size, s_{ijh}.

Consider a certain interval between two shipments, $[t_0, t_1]$. On this interval, the size of the inventory is given by (we solve the differentiation equation in (4)):

$$m_{ijh}(t) = \frac{-x_{ijh}}{\delta} + Ce^{-\delta t},$$

where C is a certain constant. Taking into account that $m_{ijh}(t_0) = s_{ijh}$, $m_{ijh}(t_1) = 0$, and $t_1 - t_0 = 1/n_{ijh}$, we derive that

$$s_{ijh} = \frac{x_{ijh}}{\delta} \left(e^{\delta / n_{ijh}} - 1 \right). \tag{5}$$

The latter equation describes the shipment size of product h given the demand x_{ijh} and the shipment frequency n_{ijh}.

Hence, the representative producer of product h solves the following optimization problem:

$$min_{\{n_{ijh}, s_{ijh}\}} n_{ijh} \left(K_{ijh} + c_{ijh} s_{ijh} \right) \tag{6}$$

subject to (5). In the above, K_{ijh} is the fixed cost of shipping product h from i to j, while c_{ijh} is the cost of each inventory unit that includes variable transportation and production costs (see Blum et al., 2019). In other words, the producer minimizes the total cost of distributing product h in country j by choosing the frequency and size of shipments. The optimal number of shipments then solves

$$\frac{1}{n_{ijh}} e^{\delta / n_{ijh}} + \frac{1}{\delta} \left(1 - e^{\delta / n_{ijh}} \right) = \frac{K_{ijh}}{c_{ijh} x_{ijh}}. \tag{7}$$

It is straightforward to see that a rise in the ratio $K_{ijh}/c_{ijh}x_{ijh}$ reduces the number of shipments of product h. Specifically, a lower fixed cost of shipping or higher demand for the product naturally leads to more frequent shipments.

3.1 Estimation Strategy

In this section, we estimate the fixed costs of shipping taking into account the possibility of multi-product shipments. In doing this, we follow the estimation strategy in Blum et al. (2019), but assume that K_{ijh} can depend on the total number of products included in this shipment.

Note that the total cost of distributing product h in country j given the optimal choice of n_{ijh} can be written as follows:

$$D_{ijh} = n_{ijh}\left(K_{ijh} + c_{ijh}s_{ijh}\right) = c_{ijh}x_{ijh}e^{\delta/n_{ijh}}.$$

The "traditional" part of this cost is represented by $c_{ijh}x_{ijh}$. However, since the product melts due to inventory management, this cost is multiplied by $e^{\delta/n_{ijh}} > 1$. In other words, we have

$$D_{ijh} = c_{ijh}x_{ijh} + \left(e^{\delta/n_{ijh}} - 1\right)c_{ijh}x_{ijh},$$

where the second term is because of inventory depreciation: if $\delta = 0$, the term disappears.

As in Blum et al. (2019), we assume that the representative producer of product h maximizes its profits taking the market aggregates shipping costs as given:

$$max_{p_{ijh}}\left\{p_{ijh}x_{ijh} - D_{ijh}\right\}$$

where p_{ijh} is the price of the product in market j. Note that we do not restrict the producer to be a multi-product firm (we do not model this explicitly, as it is not necessary for our empirical analysis). In this case, we assume away the cannibalization effects that can arise in a framework with multi-product firms (see Eckel and Neary, 2010 and Mayer et al., 2014). Assuming isoelastic demand x_{ijh} with the elasticity of substitution σ and taking into account (5) and (7), it is straightforward to derive that the optimal price is given by

$$p_{ijh} = \frac{\sigma}{\sigma-1}c_{ijh}\frac{e^{\delta/n_{ijh}} - 1}{\delta/n_{ijh}} = \frac{\sigma}{\sigma-1}c_{ijh} + \frac{\sigma}{\sigma-1}c_{ijh}\left(\frac{e^{\delta/n_{ijh}} - 1}{\delta/n_{ijh}} - 1\right). \tag{8}$$

In the above, as was discussed, the second component stands for a rise in the price caused by inventory depreciation. It is equal to zero, if there is no inventory depreciation.

Under an assumption of a perfectly competitive distribution sector in each country (here we again follow Blum et al., 2019), a producer of product h in country i sold in country j eventually receives a FOB price given by

$$\tau_{ijh}p_{ijh}^{FOB} = p_{ijh} - c_{ijh}\left(\frac{e^{\delta/n_{ijh}} - 1}{\delta/n_{ijh}} - 1\right),$$

where τ_{ijh} is the variable transportation cost of product h from i to j. In other words, the FOB price is equal to p_{ijh} net of the marginal cost associated with inventory management normalized by τ_{ijh}. We have

$$p_{ijh}^{FOB} = \frac{c_{ijh}}{\tau_{ijh}}\left(\frac{1}{\sigma-1}\frac{e^{\delta/n_{ijh}} - 1}{\delta/n_{ijh}} + 1\right). \tag{9}$$

The next step in the estimation procedure is to notice that the total value of exports to j of a firm producing product h in i is given by

$$v_{ijh} = \tau_{ijh} p_{ijh}^{FOB} n_{ijh} s_{ijh}. \tag{10}$$

Taking into account (5) and (9), we derive

$$c_{ijh} x_{ijh} = \frac{v_{ijh}}{n_{ijh} \left(\frac{1}{\sigma-1} \frac{e^{\delta/n_{ijh}}-1}{\delta/n_{ijh}} + 1 \right) \frac{e^{\delta/n_{ijh}}-1}{\delta}}.$$

Substituting the latter into (7), we have

$$\frac{\frac{\delta}{n_{ijh}} e^{\delta/n_{ijh}} + 1 - e^{\delta/n_{ijh}}}{\frac{n_{ijh}}{\delta} \left(\frac{1}{\sigma-1} \frac{e^{\delta/n_{ijh}}-1}{\delta/n_{ijh}} + 1 \right) \left(e^{\delta/n_{ijh}} - 1 \right)} = \frac{\delta K_{ijh}}{v_{ijh}}.$$

Then, linearizing the left-hand side of the latter with respect to δ/n_{ijh} around zero (given the number of shipments in the data, δ/n_{ijh} is sufficiently small), we derive

$$ln(v_{ijh}) - 2ln(n_{ijh}) = const + ln(K_{ijh}) - ln(\delta). \tag{11}$$

In the context of the data set we employ, in the above we substitute the importing country index j for an importer (located in Russia) index l. To control for variations in carrying costs in as flexible a way as possible, we follow Blum et al. (2019) and assume that the value of δ can vary across an exporting country (i), a product (h), and an importer (l). In particular, we assume that $ln(\delta_{ihl}) = ln(\delta_{HS2}) + \epsilon_{ihl}$, where δ_{HS2} is an HS two-digit product fixed effect and ϵ_{ihl} is an unobserved export country, HS product (within HS two-digit category), importer effect.

Finally, in the previous section, we discuss the relevance of multi-product shipments for the fixed cost of shipping a product. Taking this into account, we assume that

$$K_{ihl} = \frac{\widetilde{K}_i}{(\bar{n}_{ihl})^{\kappa}},$$

where κ represents the role of the number of products in a multi-product shipment in determining the fixed cost of shipping a product. Specifically, if $\kappa > 0$, a higher number of products implies a lower fixed cost of shipping per product - there is a scale effect. $\widetilde{K}_i$ stands for the potential variation of the fixed cost across exporters. If we assume away the role of multi-product shipments, our specification will coincide with that in Blum et al. (2019) who consider exporter specific fixed costs of shipping.

Note that, in our partial equilibrium model, we do not endogenize the choice of the number of products included in a shipment. We also do not provide micro-foundations for the link between K_{ihl} and $\bar{n}_{ihl}$. One of the explanations for such a relationship can be a well known fact that the cost of handling half-full and full containers does not differ much (see Alessandria et al., 2010), which in turn potentially implies a lower cost per product of handling full containers, if full containers contain more different products. Financing and insurance also involve some costs. A letter of credit is frequently used in international trade to reduce risks related with the failure of delivery. Typically, these costs include a fixed cost component that does not depend on the number of products in a shipment, implying the discussed link between K_{ihl} and $\bar{n}_{ihl}$.

With all the above reasoning, we obtain the following estimating equation:

$$ln(v_{ihl}) - 2ln(n_{ihl}) = ln(\widetilde{K}_i) - \kappa ln(\bar{n}_{ihl}) - ln(\delta_{HS2}) + \epsilon_{ihl}. \tag{12}$$

In the next subsection, we discuss the results and provide some robustness checks.

3.2 Results

We first report the results for the empirical model in (12). The estimate of κ is 1.35 with a high level of significance, implying a strong role of the number of products in determining the fixed costs of shipping a product. At the same time, it is worth mentioning that it is intuitive to expect κ being less than unity, meaning a concave relationship between K_{ihl} and $\bar{n}_{ihl}$. A possible explanation for such a large estimate of κ is that the HS2 level fixed effects are not sufficient to capture shipping patters across different product categories. Indeed, when we include more detailed level fixed effects in (12), the estimate of κ falls. Estimating (12) with HS6 or HS8 level fixed effects delivers the estimates of κ being lower than unity. Specifically, including HS8 level fixed effects results in the estimate of κ being 0.96, which still means the strong role of the number of products included in a shipment. To compare our findings with those in Blum et al. (2019), we continue considering the model with the HS2 level fixed effects as a benchmark.

Next, we consider the estimate of $\widetilde{K}_i$ and its correlation with country characteristics. As was mentioned, the only difference between our empirical model and that in Blum et al. (2019) is the structural relationship between K_{ihl} and $\bar{n}_{ihl}$ we impose. Therefore, we first report the correlations for $\widetilde{K}_i$ estimated when $\kappa = 0$: that is, when there is no link between the fixed costs and the number of products. We denote this estimate by $\widetilde{K}_i^{Blum}$. As can be seen from column 1 in Table 7, there is a negative correlation between country's per capita income and $\widetilde{K}_i^{Blum}$, meaning that higher income countries have lower fixed costs of shipping a product. This is consistent with the results in Blum et al. (2019), however the coefficient is not significant at conventional levels. In column 2 we report the correlations for the benchmark case: that is, "controlling" for the number of products included in a combined shipment. The correlation between $\widetilde{K}_i$ and per capita income appears to be positive rather than negative and statistically significant at a 10-percent level. This implies a potentially strong, important role of multi-product shipments in explaining shipping patterns across countries. In column 3, we use the estimates of $\widetilde{K}_i$ and κ to calculate $K_{ihl} = \widetilde{K}_i / (\bar{n}_{ihl})^{\kappa}$ and then aggregate K_{ihl} at the country level - we denote this new measure by K_i. In other words, we construct some measure of the fixed costs of shipping a product on the country level taking into account the role of multi-product shipments. Non-surprisingly, this measure is negatively correlated with GDP per capita - higher income countries tend to have lower fixed costs of shipping. However, in our data, it is due to multi-product shipments. Finally, the last three columns in Table 7 report the correlations when the contiguity dummy is taken into account. As can be inferred, the results are very similar.

Table 7: Country Characteristics and Shipping Costs

	$ln(\widetilde{K}_i^{Blum})$	$ln(\widetilde{K}_i)$	$ln(K_i)$	$ln(\widetilde{K}_i^{Blum})$	$ln(\widetilde{K}_i)$	$ln(K_i)$
	(1)	(2)	(3)	(4)	(5)	(6)
GDP	-0.085	-0.017	-0.102	-0.085	-0.017	-0.102
	(0.072)	(0.042)	(0.082)	(0.072)	(0.042)	(0.082)
GDP per cap	-0.063	0.110*	-0.157	-0.063	0.111*	-0.155
	(0.101)	(0.060)	(0.115)	(0.102)	(0.060)	(0.116)
Distance	0.292	0.091	0.571**	0.268	0.070	0.509**
	(0.200)	(0.118)	(0.228)	(0.219)	(0.129)	(0.249)
Contiguity				-0.130	-0.111	-0.338
				(0.474)	(0.280)	(0.540)
R-Adj.	0.055	0.032	0.125	0.056	0.033	0.128
N	127	127	127	127	127	127

Notes: OLS regressions of equation 12. Standard errors are reported in parentheses. * (**) (***) indicates significance at the 10 (5) (1) percent level.

We noted earlier, that estimate of κ are below unity when we include HS6 level or more detailed fixed effects. For this reason, in Table 8 we report the same correlations between the fixed costs and country characteristics obtained from estimating equation 12 with HS8 fixed effects. As can be seen, the results are not much different from those in Table 7. In particular, we observe that $\widetilde{K}_i^{Blum}$ and K_i are negatively correlated with GDP per capita with the latter being significant at a 5-percent level. While when we take into account the presence of multi-product shipments (columns 2 and 5), the estimated coefficients of interest become positive, although they are not significant.

Table 8: Country Characteristics and Shipping Costs (with HS8 FE)

	$ln(\widetilde{K}_i^{Blum})$	$ln(\widetilde{K}_i)$	$ln(K_i)$	$ln(\widetilde{K}_i^{Blum})$	$ln(\widetilde{K}_i)$	$ln(K_i)$
	(1)	(2)	(3)	(4)	(5)	(6)
GDP	0.005	0.045	-0.125	0.005	0.045	-0.126
	(0.059)	(0.045)	(0.094)	(0.060)	(0.045)	(0.094)
GDP per cap	-0.115	0.051	-0.295**	-0.115	0.051	-0.294**
	(0.084)	(0.064)	(0.133)	(0.084)	(0.064)	(0.133)
Distance	0.173	0.025	0.691***	0.161	0.030	0.633**
	(0.166)	(0.126)	(0.262)	(0.182)	(0.138)	(0.287)
Contiguity				-0.067	0.024	-0.311
				(0.394)	(0.299)	(0.621)
R-Adj.	0.037	0.029	0.181	0.037	0.029	0.182
N	126	126	126	126	126	126

Notes: OLS regressions of equation 12 with HS8 level fixed effects. Standard errors are reported in parentheses. * (**) (***) indicates significance at the 10 (5) (1) percent level.

4 Counterfactual Analysis

In this section, we perform counterfactual analysis to explore quantitatively the role of multi-product shipping for trade volumes and consumer welfare. In particular, we examine how changes in K_{ijh} affect outcomes in our partial equilibrium model.

Note that by substituting (5) and (9) into (10), we derive that

$$v_{ijh} = c_{ijh} x_{ijh} \left(\frac{1}{\sigma - 1} \frac{e^{\delta/n_{ijh}} - 1}{\delta/n_{ijh}} + 1 \right) \frac{e^{\delta/n_{ijh}} - 1}{\delta/n_{ijh}}. \tag{13}$$

We then assume that demand x_{ijh} takes the following form:

$$x_{ijh} = \frac{B_{ijh}}{\left(p_{ijh}\right)^{\sigma}} \tag{14}$$

where B_{ijh} is a parameter representing the market size in j for product h produced in i. Considering the effects of changes in K_{ijh} within our partial equilibrium framework, we assume that c_{ijh} are B_{ijh} are not affected and remain the same. As a result, if the costs K_{ijh} change to K'_{ijh}, taking into account the expression for p_{ijh} in (8), we have

$$\frac{v'_{ijh}}{v_{ijh}} = \frac{\left(\frac{1}{\sigma-1} \frac{e^{\delta/n'_{ijh}}-1}{\delta/n'_{ijh}} + 1 \right) \left(\frac{e^{\delta/n'_{ijh}}-1}{\delta/n'_{ijh}} \right)^{1-\sigma}}{\left(\frac{1}{\sigma-1} \frac{e^{\delta/n_{ijh}}-1}{\delta/n_{ijh}} + 1 \right) \left(\frac{e^{\delta/n_{ijh}}-1}{\delta/n_{ijh}} \right)^{1-\sigma}}, \tag{15}$$

where n'_{ijh} is the number of shipments corresponding to K'_{ijh}. To find n'_{ijh}, we substitute (14) and (8) into the left-hand side in (7) deriving

$$\left(\frac{1}{n_{ijh}} e^{\delta/n_{ijh}} + \frac{1}{\delta} \left(1 - e^{\delta/n_{ijh}} \right) \right) \left(\frac{e^{\delta/n_{ijh}} - 1}{\delta/n_{ijh}} \right)^{-\sigma} = \left(\frac{\sigma}{\sigma - 1} \right)^{\sigma} \frac{K_{ijh} c_{ijh}^{\sigma-1}}{B_{ijh}}.$$

As a result, we have

$$\frac{K'_{ijh}}{K_{ijh}} = \frac{\left(\frac{1}{n'_{ijh}} e^{\delta/n'_{ijh}} + \frac{1}{\delta} \left(1 - e^{\delta/n'_{ijh}} \right) \right) \left(\frac{e^{\delta/n'_{ijh}}-1}{\delta/n'_{ijh}} \right)^{-\sigma}}{\left(\frac{1}{n_{ijh}} e^{\delta/n_{ijh}} + \frac{1}{\delta} \left(1 - e^{\delta/n_{ijh}} \right) \right) \left(\frac{e^{\delta/n_{ijh}}-1}{\delta/n_{ijh}} \right)^{-\sigma}}. \tag{16}$$

Hence, if we know changes in K_{ijh}, then given δ and σ we can find the new values of n'_{ijh} predicted by our model using (16). This in turn allows us finding the corresponding changes in the trade values given by (15). It is worth noting that the above approach to quantifying changes in trade volumes is based on the partial equilibrium framework (in particular, we ignore the effects of K_{ijh} on c_{ijh} and B_{ijh}) and, thereby, rather provides a lower bound for the considered changes.

4.1 Experiments

In the first counterfactual experiment, for all i, h, l we set $\bar{n}_{ihl}$ to the weighted average number of products in the U.S. shipments denoted by $\bar{n}_{US}$. In particular,

$$\bar{n}_{US} = \sum_h \sum_l \frac{V_{US,hl}}{V_{US}} \bar{n}_{US,hl}$$

where $V_{US,hl}$ is the total imports from the U.S. of product h by firm l and

$$V_{US} = \sum_h \sum_l V_{US,hl}.$$

In our sample, $\bar{n}_{US}$ appears to be equal to 23, implying that

$$\frac{K'_{ihl}}{K_{ihl}} = \left(\frac{\bar{n}_{ihl}}{\bar{n}_{US}}\right)^{\kappa} = \left(\frac{\bar{n}_{ihl}}{23}\right)^{\kappa}.$$

For κ, we take the estimate under HS8 level fixed effects in (12) that is equal to 0.96. Following Blum et al. (2019), we set δ to 0.3. Finally, the elasticity of substitution σ is set to 6 (see, for instance, Costinot and Rodriguez-Clare 2014).

Given the considered change in K_{ijh}, we find the counterfactual trade values v'_{ihl} and aggregate them at the country level. Specifically, we find that the average change in the export values to Russia across countries is equal to 23%. Overall, the total Russian imports increase by 9.6%. This outcome seems to be intuitive, as countries that gain most are the ones that have the lowest levels of exports, implying that the average across countries exceeds the total import growth. The main beneficiaries of the experiment turn out to be countries with low levels of trade: Comoros, El Salvador, Puerto Rico; which experience export growths of 86%. On the other extreme, countries that are located closer and have strong commercial ties with Russia (such as, for instance, Czech Republic and Slovakia) do not experience any gains. Figure 1 plots the relationship between the initial level of exports to Russia (in log Russian rubles) against the predicted change in exports. As can be seen, countries with a lower level of initial exports exhibit a higher change in the export volumes caused by the considered change in the fixed cost of shipping.[7]

To get an idea of welfare implications behind the above counterfactual experiment for Russia, we employ the formula for welfare changes in Arkolakis, Costinot, and Rodriguez-Clare (2012). Specifically,

$$\frac{W'}{W} = \left(\frac{\lambda'}{\lambda}\right)^{-\frac{1}{\varepsilon}}, \tag{17}$$

where W'/W represents the change in the welfare given some changes in trade costs, λ'/λ stands for the change in the share of expenditure on domestic manufacturing goods, and ε is the trade elasticity. In our

[7] We also regress the change in the exports on country characteristics. We find a negative and statistically significant relationship with country total income: for smaller countries, the change in exports is greater. The relationship with per capita income is positive, but not significant.

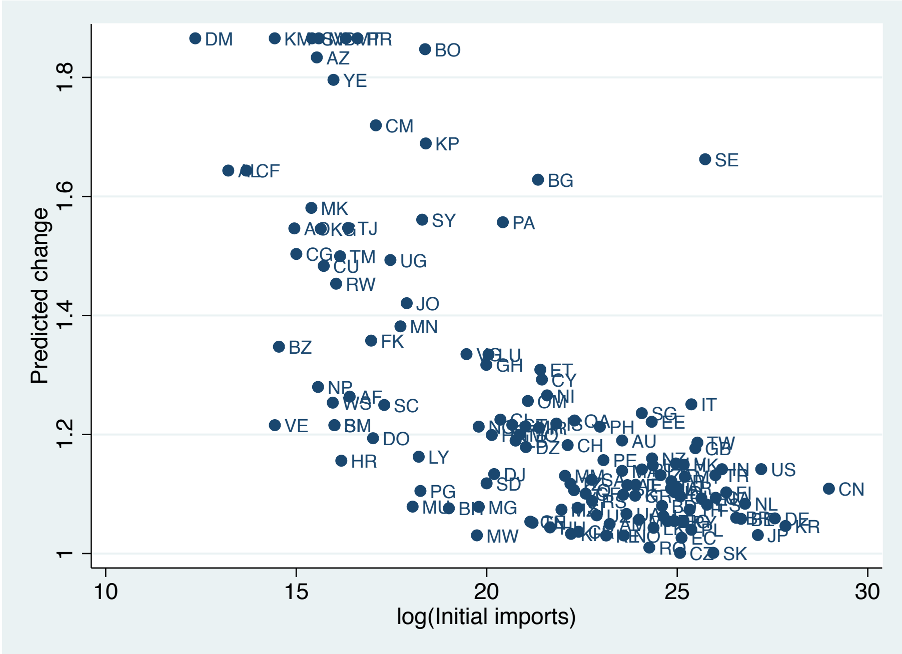

Figure 1: Initial import volumes (in log Russian rubles) and predicted growth.

quantitative analysis, as we consider a partial equilibrium framework, we ignore the effect of changes in the value of imports on the aggregate level of expenditure in Russia. In other words, we consider only the direct effect of higher imports on λ. In particular, let us define by λ^{-} the share of expenditure on manufacturing imports in Russia: $\lambda + \lambda^{-} = 1$. According to our experiment, λ^{-} rises by 9.6%. This means that $\lambda' + 1.096\lambda^{-} = 1$, implying that $\lambda' = 1 - 1.096(1 - \lambda)$. Here, as was mentioned, we ignore changes in the total expenditure that can potentially affect the shares. As a result,

$$\frac{W'}{W} = \left(\frac{1 - 1.096(1 - \lambda)}{\lambda}\right)^{-\frac{1}{\varepsilon}}. \tag{18}$$

We compute the initial value of λ using the World Input Output Database (WIOD) constructed by Timmer, Dietzenbacher, Los, Stehrer, and de Vries (2015). We obtain a value of 0.73. For the trade elasticity, we take a value of 5. This implies a 0.7% rise in the welfare. As was discussed, it is rather the lower bound for the welfare change caused by our experiment. In particular, we ignore the general equilibrium effects and other ingredients (such us the presence of multiple sectors, intermediate inputs, etc.) that can affect the magnitude of the welfare changes. Moreover, in our partial equilibrium model we do not endogenize entry decisions at the product level. To illustrate the intuition, we consider an example with two goods that face the same demand but are produced by two different firms. The first firm exports many different products, which are in relatively high demand in the destination, while the second firm produces only one good. In this context, we can have an outcome where the first firm starts exporting the product because of the low per product fixed costs of shipping. Meanwhile, the second firm forgoes exporting its good, because that single good is supposed to bear the entire fixed costs.

To understand more about the quantitative role of multi-product shipments for welfare, we consider an experiment, where we assume away the possibility of multi-product shipments. In other words, we set K'_{ihl} to $\widetilde{K}_i$, implying that

$$\frac{K'_{ihl}}{K_{ihl}} = (\bar{n}_{ihl})^{\kappa}.$$

The values of the other parameters remain the same. In this case, we find that the average decrease in export values to Russia across countries is equal to 11%. Overall, total Russian imports decrease by 8%. Among the most affected countries, there are Belize, Turkmenistan, Sweden, Norway. For these countries, exports to Russia decrease by around 50-70%. For a number of countries (with mostly single-product shipments), export values obviously do not substantially change. Among these countries, there are Cameroon, Guatemala, Yemen. To compute the corresponding welfare change in Russia, we use the same approach as in the previous counterfactual experiment. As total Russian imports decrease by 8%, the welfare decreases by around 0.6%. This number can be treated as the welfare gains for Russia from the possibility of multi-product shipping.

5 Concluding Remarks

In this paper, we explore a potential source of cross-country differences in fixed costs of product shipping that are in turn an important ingredient of cross-country differences in trade patterns. In particular, we relate the fixed costs to the number of products included in a single shipment: in other words, we take into account multi-product shipments. We show that firms from more developed countries tend to include more different products into a single shipment. We then estimate a simple partial equilibrium model of product shipping imposing a structural relationship between the fixed costs of shipping a single product and the number of other products in this shipment. We find that more developed countries tend to have lower fixed costs of product shipping. In our data, it is mostly due to multi-product shipments, which suggests an important role of multi-product shipments in explaining shipping patterns across countries. We also find that the welfare gains from multi-product shipments are not negligible. In particular, if we assume away the possibility of multi-product shipments to Russia, its welfare will decrease by around 0.6%, which is rather the lower bound for the corresponding welfare changes. A fruitful extension of this paper could be a general equilibrium model of trade where the link between fixed costs of shipping and the number of products in a shipment is endogenous. This could shed some more light on the structure of shipping costs and lead to counterfactual analysis with interesting policy implications. Another important dimension which requires more exploration is understanding the link between the level of economic development and multi-product firms. As our results suggest there is a positive relationship between the two. However, we do not explore the mechanism and do not provide micro-foundations. We leave this question for our future work.

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Appendix

Table 9: Country Characteristics and Shipping Patterns (HS8)

	$ln(V_{ihl})$	$ln(N_{ihl})$	$ln(\bar{s}_{ihl})$	$ln(\bar{q}_{ihl})$	$ln(\hat{p}_{ihl})$	$ln(\bar{n}_{ihl})$
	(1)	(2)	(3)	(4)	(5)	(6)
GDP	0.178***	0.111***	0.066***	0.091***	0.029***	0.025***
	(0.018)	(0.008)	(0.014)	(0.015)	(0.009)	(0.004)
GDP per cap	-0.022	0.069***	-0.091***	-0.095***	0.065***	0.122***
	(0.032)	(0.014)	(0.025)	(0.027)	(0.016)	(0.008)
Distance	0.178***	-0.076**	0.254***	0.177***	-0.021	-0.121***
	(0.069)	(0.031)	(0.053)	(0.059)	(0.036)	(0.018)
Contiguity	0.432***	0.085***	0.346***	0.292***	-0.007	-0.039**
	(0.066)	(0.029)	(0.051)	(0.055)	(0.033)	(0.016)
R	0.928	0.860	0.944	0.942	0.938	0.970
N	339496	339677	339496	339659	339483	339677

Notes: OLS regressions of equation 3. All regressions include importer-by-HS 8 -level fixed effects. Robust standard errors are reported in parentheses. * (**) (***) indicates significance at the 10 (5) (1) percent level.

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