Beyond the Iceberg Hypothesis: Opening the Black Box of Transport Costs

Guillaume Daudin* Jérôme Héricourt † Lise Patureau‡

July 22, 2016

July 2016

Abstract

Following Samuelson (1954), standard models of international trade have usually relied on modelling trade costs as an ad valorem tax equivalent. However, many common empirical facts support the existence of additive costs. This paper contributes to this debate. Precisely, we provide a quantitative assessment of the size and the importance of the additive component in international transport costs. Using SITC 3and 4 digit cif-fob unit values over 1974-2013 taken from US imports data, we estimate the two components of transport costs, by transport mode (air or ocean). We find that additive costs are 2.85% of fob unit values for ocean shipping (and ad-valorem ones 3.22%). These values are respectively equal to 1.9% and 2.5% for air transport. Further, we show that taking additive costs into account improves the fit of the modelling of transport costs. We also use the time dimension of our data to characterize the evolution of transport costs. After correcting for composition effects, we find that all types of transport costs have been roughly constant from 1974 to 1984 and then steadily decreased by 40% over the period 1984-2013. Yet, this steady decline hides shifts in the relative importance of additive and ad-valorem. While most of the early decline in air transport costs can be explained by the ad-valorem component, this component nearly doubled in the 2000s. These results therefore confirm the importance of the additive component in accounting for international transport costs.

JEL classification: F14, N70, R40

Keywords: Transport costs estimates, transport costs determinants, non-linear econometrics, period 1974-2013, additive transport costs

*Université Paris Dauphine, LEDa & PSL, Chercheur associé - Sciences Po (OFCE)

†Université de Lille - LEM-CNRS (UMR 9221), Université de Bretagne Occidentale-ICI (EA 2652) and CEPII

‡Université Paris Dauphine, LEDa & PSL

1 Introduction

Trade costs remain central in international economic analysis. In particular, they are considered as a major obstacle to international economic integration and international trade flows. According to the estimates by Jacks *et al.* (2008), trade cost declines explain around 55% of the pre-World War I trade boom and 33% of the post-World War II trade boom, while the abrupt rise in trade costs explains the inter-war trade collapse. After 1950, average trade costs fell by 16%, notably through the reduction of policy trade costs promoted through the GATT (WTO starting in 1995) multilateral agreements. Based on panel data, Novy (2013) finds that U.S. trade costs with major trading partners declined on average by about 40 percent between 1970 and 2000. Yet, several papers (mostly based on empirical estimates of the gravity equation) have shown that trade costs (typically captured through distance) still remain a major obstacle to trade (e.g. Head and Mayer, 2004 and Disdier and Head, 2008). Using data over 1989-2000, Anderson and Van Wincoop (2004) thus estimate that average international trade costs for industrialized countries put up to 74% markups over production costs. Defined as the costs associated with the exchange of goods across national borders, trade costs are usually split into transaction costs (information costs, contract enforcement costs, costs associated with the use of different currencies...), policy costs (tariff and non-tariff costs), time costs (time to ship goods) and transport costs *per se*. In this vein, Anderson and Van Wincoop (2004) obtain that the 74% markup made by international trade costs can be divided in 44% for border-related trade barriers and 21% for transportation costs. This last figure suggests that the share of transport costs in the consumer price of manufactured goods is substantial. Behar and Venables (2011) obtain that the elasticity of trade with respect to freight costs is sizeable, by around -3. If much of trade-policy barriers have been removed over the second half of the 20th century, these findings point out that the transport costs component of the overall trade costs remain large and deserve attention. This is accordingly the focus of the paper.

Following Samuelson (1954), standard models of international trade have usually relied on modelling trade costs as an *ad valorem* tax equivalent (ie, as a constant percentage of the producer price per unit traded, the "iceberg cost" hypothesis). However, many common empirical facts support the existence of additive costs. As documented by Irarrazabal *et al.* (2015), pricing structure in shipping, additive tariffs, distribution costs... often exhibit (at least partly) an additive structure. The structure (additive vs multiplicative) of transport costs is far from being anecdotal, as the literature has long emphasized its role in shaping the pattern of trade flows. The Alchian and Allen conjecture (Alchian and Allen, 1964), which points out that the relative price of two varieties of some good will depend on the level of trade costs, does rely on the existence of additive costs: The relative demand for more expensive/higher quality product goods should increase with trade cost ("shipping the good apples out"). Lashkaripour (2016) challenges this view though. He finds supporting evidence for the iceberg assumption by taking into account the fact that more expensive goods are systematically heavier and hence more costly to transport. One can yet be concerned by the generality of his results though. By nature, his study is restricted to goods that are enumerated by items in the statistics (that represent 60% of US imports for instance). Furthermore, while the positive correlation between weight and price seems reasonable for goods from the second industrial revolution like cars, it is dubious in the case of ITC goods which importance has been rising since 1994 (the end point of Lashkaripour's study).

Besides, a number of empirical papers provide a strong empirical support to the role of additive costs in international. Based on a firm-product-level database of French exporters, Martin (2012) finds that firms charge higher fob unit values on exports to more remote countries, in contradiction with the iceberg hypothesis. Hummels and Skiba (2004) estimate the elasticity of freight rates with respect to price is estimated to be well below unity. Also, their estimates imply that doubling freight costs increases average fob export prices by 80-141 percent, consistent with high quality goods being sold in markets with high freight costs. These findings deliver strong empirical support in favor of the Alchian-Allen conjecture. The existence of additive costs may also explain a large number of zeros in bilateral trade flows, and more generally, the granularity of trade flows. Relying on Spanish and US transaction-level trade data, Hornok and Koren (2015) find that additive trade costs of are associated with less frequent and larger shipments. With additive costs, exporters wait to fill completely a container before sending it abroad, to decrease as much as possible the number of shipments, thereby inducing more "lumpiness" in international trade.

Beyond the positive aspect of understanding trade patterns, several recent papers also point out the normative implications of additive trade costs. Sorensen (2014) extends Melitz (2003)'s seminal model of international trade by including additive trade costs, in addition to the iceberg component. A key analytical result is that the welfare gain from a reduction in trade barriers is higher for a decrease in additive costs than a decrease in multiplicative costs. Calibrating on Norwegian firm-level data for 2004, Irarrazabal *et al.* (2015) find that an additive import tariff reduces welfare and trade by more than an identically-sized multiplicative tariff. While these results suggest that important welfare gains can be achieved by reducing additive trade costs, not much can be done in quantifying such gains though, one potential reason being the lack of an empirical characterization of the additive component of trade costs.[1] One objective of the paper is to palliate this gap.

Our paper contributes to the literature by providing results on the size of transport costs over time, explicitly distinguishing between multiplicative and additive parts. Precisely, we quantitatively assess the size and the importance of the additive component in international transport costs. To do so, we update the detailed US customs, sector-level data from the US Imports of Merchandise used by Hummels (2007), to cover the period from 1974 to 2013. Closely related to our paper is the work by Irarrazabal *et al.* (2015), which develop a structural framework for inferring additive trade costs from firm-level trade data. Based on Norwegian exports in 2004, their results suggest that additive costs are about 14% of the median consumer price. However, while our data requires that we only consider transportation costs, our approach departs from theirs in several key aspects, as we develop below. One important difference is that we exploit exhaustive information about the imports flows of the US, over a large time span from 1974 to 2013. In this respect, our results deliver a broader view of the magnitude of additive costs in international trade over time. They can be summarized in three main points.

First, our theoretically agnostic approach provides a fairly simple framework for measuring both multiplicative and additive parts of transportation costs, which represents a valuable insight for calibrating related models.[2] We thus obtain that the mean values over 1974-2013 of iceberg costs are

[1] The one exception being Irarrazabal *et al.* (2015), upon which we come back later.

[2] Given their database and their methodology, Irarrazabal *et al.* (2015) can only identify the ratio of the additive to the multiplicative cost ($\frac{t_{ik}}{\tau_{ik}}$ in our terminology), that they interpret by expressing it in terms of the median fob price

equal to 2.5% and 3.2% in air and ocean respectively, whereas the additive component amounts to 1.8% and 2.9% of the fob price (in air and ocean). To our best knowledge, our paper is the first to provide such an extensive quantitative measure of both multiplicative and additive costs in total transport costs. Second, we provide an empirical assessment of what standard international trade models lose by skipping additive transport costs. Quantitatively, the omission of the additive term leads to overestimate the iceberg component by roughly a factor 2. On average over the whole period, biased estimate for iceberg is 5% for Air and 6% for Vessel, while unbiased estimate is respectively 2.5% and 3.2%. We also show that taking additive costs into account significantly improves the fit of the modelling of transport costs, through various measures of "goodness-of-fit", for both transport modes and years.

Third, we exploit the time dimension of our database to document the patterns of transport costs over time. Many argue that transport costs have substantially decreased with technological advance in transportation, infrastructure development and new communication technologies (seeLafourcade and Thisse, 2011). Glaeser and Kohlhase (2004) find that, over the twentieth century, the cost of moving goods have declined by over 90% in real terms. However, Hummels (2007) shows that the bulk of price declines in transportation comes from air transport, where average cost per ton-kilometer shipped dropped by 92% between 1955 and 2004. Concerning ocean shipping, which represents the major part of world trade value, decline in trade prices are much less obvious, a conclusion in accordance with the studies reviewed by Behar and Venables (2011). Our paper contributes to this debate. As pointed out by Hummels (2007), we confirm the importance of the composition effects by country of origin and by product in shaping the patterns of transportation costs over time. After excluding the composition effects, we find that all types of transport costs have been roughly constant from 1974 to 1984 and then steadily decreased by 40% over the period 1984-2013. Yet, this steady decline hides shifts in the relative importance of additive and ad-valorem. Air transport in particular exhibit contrasted trends. While most of the early decline in air transport costs can be explained by the ad-valorem part, this component nearly doubled in the 2000s, all along with a substantial decline in the per-unit cost. These results therefore confirm the importance of the additive component in accounting for international transport costs.

The paper is built as follows. 2 explains the data sources and the empirical methodology retained in the paper. Sections 3 and 4 report our results. In Section 3, we characterize the role of the additive component of transport costs. After reporting the mean values over the period (by transport mode), we show the improved performance in including additive trade costs in the measure of transport costs. This being established, Section 4 characterizes the trends in each component of transport costs (by transport mode) over the period 1974-2012. Section 5 concludes.

2 Data Sources and Empirical Methodology

2.1 A measure of Transportation Costs

As in Hummels (2007) (among others), our measure of transportation costs consists in exploiting the difference between commodity-level export and import prices. We first use values, quantities and

by country-product ($\tilde{\bar{p}}_{ik}$). By contrast, our estimation strategy enables us to uncover both values of the iceberg and the additive costs τ_{ik} and t_{ik} separately, in terms of the country-product fob price $\widetilde{p}_{ik}$.

freight costs to recover free-on-board (FOB) and cost-insurance-fret (CIF) prices, by goods, country of origin and transportation mode. More precisely, the (unit) FOB price is computed as the total customs value divided by the shipping weight; in other words, it is the price for the good net of transportation costs. The CIF price is then computed as the sum of the customs value and freight charges, once again divided by the shipping weight. Our dependant variable is finally computed as the ratio of the CIF price divided by the FOB price. Higher than 1, the variable provides therefore with a measure of transport costs as a proportion of the good's price, an *ad valorem* equivalent. The database we use to construct our measure of transport comes from US annual Imports of Merchandise provided by the Census bureau[3], spanning from 1974 to 2013. It is worth acknowledging that using this dataset encounters some limitations. First, our measure of the cif-fob price gap only covers transportation costs by nature, thereby being silent about the others dimensions of international trade costs, unlike Irarrazabal *et al.* (2015). Further, in terms of transport costs *per se*, this measure being based on freight costs, omits the other dimension of transport costs related to the time value of goods in transit. According to Anderson and Van Wincoop (2004)), the 21% markup over production costs coming from transport costs includes both directly measured freight costs and 9% tax equivalent of the time value of goods in transit. In this respect, it is true that using this dataset embraces a partial view of international transport barriers.

Yet, we believe that the results we get deliver valuable insights on this topic. Indeed, using this dataset has (at least) three main advantages. First, this dataset delivers a strong statistical reliability arising from a single, trustworthy customs origin. Based on customs declarations, this dataset inventories all imports (both values and quantities) by country of origin to the United states at the HS 10-digit level, with a concordance code to the SITC 5-digit coding system. In addition, the database reports information regarding freight expenditures and transportation mode (Ocean vessel and Air). The first will be crucial to compute transport costs (see below), the second will allow us enlightening substantial differences in the dynamics of transport costs across transportation mode. Second, using this dataset allows us to have the import price of the good (CIF price), next to the export price (FOB price). This is highly valuable, as we can estimate both the *levels* of the iceberg trade costs and of the additive trade costs. This differentiates us from Irarrazabal *et al.* (2015), which can only estimate the ratio of additive costs as a share of the median total consumer price. Third, this dataset having been used by Hummels (2007), this enables us to compare our results to his findings. Further, we extend the time coverage to the more recent period up to 2013, while Hummels (2007) stops in 2004. As we show in Section 4, covering the time period over the recent years delivers interesting insights regarding the trends in air shipping costs.

We make use sectorial price data at the 3-digit level, even if the data of transportation costs is available at a more disaggregated level. This is primarily due to technical reasons. As detailed below, the use of a nonlinear estimator triggers computational limitations that do not make them a likely option, especially when covering a long period of time. Yet, we ensure the robustness of these results by conducting the estimations at the 4-digit level (for some selected years).[4] Comparing different levels of aggregation is useful to check differences and the presence of biases precisely due to aggregation.

[3]More information available at: `http://www.census.gov/foreign-trade/reference/products/catalog/fl_imp.txt`

[4]The selected years for the 4-digit level estimations are: 1974, 1977, 1981, 1985, 1989, 1993, 1997, 2001, 2005, 2009, 2013.

Depending on the considered year, this leaves us with around 200 (3-digits) and 600-700 (4-digits) products, from approximately 200 countries of origin.

2.2 Empirical specification

The estimated equation Our purpose is to provide estimates over time of the sizes of multiplicative and additive costs among total transport costs. To do so, we start from the equation that expresses the price paid by the consumer (import, or cif) price p as a function of the producer (export, or fob) price $\widetilde{p}$ given both per-unit (t) and ad-valorem (τ) transport costs, according to:[5]

$$p = \tau\widetilde{p} + t \tag{1}$$

As usual in the literature, the so-called "iceberg" trade costs are denoted τ (with $\tau \geq 1$, $\tau = 1$ meaning no iceberg trade costs), while additive trade costs are labeled t (with $t \geq 0$, $t = 0$ implying no additive trade costs). We estimate this equation for each year over the period 1974-2013, and for each of the two transportation modes reported (air or vessel), on a sectoral-origin country basis.[6] Let us denote i the origin country, and k, the sector (or product). Transforming the above equation (1) as ratio, we thus get the following equation at the root of our estimation:

$$\frac{p_{ik}}{\widetilde{p}_{ik}} - 1 = \tau_{ik} - 1 + \frac{t_{ik}}{\widetilde{p}_{ik}}$$

Estimation Strategy We follow Irarrazabal *et al.* (2015) by considering that *1)* both multiplicative and additive costs are separable between the origin country (i) and the product (k) dimensions, and *2)* in a multiplicative way for the former and an additive way for the latter. In other words, τ_{ik} and t_{ik} from Equation (2.2) are written as:

$$\tau_{ik} = \tau_i \times \tau_k \tag{2}$$

$$t_{ik} = t_i + t_k \tag{3}$$

As a result, our underlying theoretical equation is specified as:

$$\frac{p_{ik}}{\widetilde{p}_{ik}} - 1 = \tau_i \times \tau_k - 1 + \frac{t_i + t_k}{\widetilde{p}_{ik}}$$

The ratio $\frac{p_{ik}}{\widetilde{p}_{ik}}$ has a "one-lower bond", since by construction, the cif price p cannot be lower than the fob price ($p > \widetilde{p}_{ik}$). Taking into account this constraint in the estimation requires to impose a multiplicative structure for the error term, according to:

$$\frac{p_{ik}}{\widetilde{p}_{ik}} - 1 = \left(\tau_i \times \tau_k - 1 + \frac{t_i + t_k}{\widetilde{p}_{ik}}\right) \times \varepsilon_{ik}$$

Taking in log, this finally drives us to estimate the following equation:

[5] This equation is similar to Irarrazabal *et al.* (2015) or Martin (2012), among others.

[6] We skip the year and transport-mode dimensions in the notations for reading convenience.

$$\ln\left(\frac{p_{ik}}{\widetilde{p}_{ik}}-1\right)=\ln\left(\tau_i\times\tau_k+\frac{t_i+t_k}{\widetilde{p}_{ik}}-1\right)+\epsilon_{ik} \tag{4}$$

where τ_i, τ_k, t_i and t_k are the parameters to be estimated, i.e., fixed effects specific to each origin country i and sector k, and $\epsilon_{ik}=\ln(\varepsilon_{ik})$.

The non-linearity of Equation (4) implies that estimations cannot be performed using standard linear estimators. Therefore, all estimates are performed using non-linear least squares. The basis of the method is to approximate the model by a linear one and to refine the parameters by successive iterations. The intuitive criterion for convergence is that the sum of squares does not decrease from one iteration to the next. In our case, due to computational limitations implied by the size of our dataset, we implement 100 iterations and set the convergence criterion for successive parameter estimates and for the residual sum of squares at 0.01. Finally, to eliminate the potential influence of outliers, we excluded observations in the 5 percent from the upper and lower tails of the distribution in the regression variables, and all our three measures of trade costs are bounded by 0 as minimal value. These cut-offs are aimed at eliminating reporting or coding errors.

Further, one key objective of the paper is to characterize the importance of additive costs relatively to iceberg costs. Put differently, what traditional models of international trade lose by ignoring additive costs? A natural way to answer this question is to perform estimations of equation (4) constraining t to be equal to zero, and compare the fitting properties and the explanatory power of the restricted and complete models. This is done by computing several standard diagnostic statistics (R^2 and statistics based on the likelihood function). Accordingly, for each year and transport mode, we estimate two equations, depending on additive transport costs being included (Equation (5)) or not (Equation (6)):

$$\ln\left(\frac{p_{ik}}{\widetilde{p}_{ik}}-1\right) = \ln\left(\tau_i\times\tau_k-1+\frac{t_i+t_k}{\widetilde{p}_{ik}}\right)+\epsilon_{ik} \tag{5}$$

$$\ln\left(\frac{p_{ik}}{\widetilde{p}_{ik}}-1\right) = \ln\left(\tau_i\times\tau_k-1\right)+\epsilon_{ik}^{nlI} \tag{6}$$

After estimating Equation (6), we can re-built a measure of each component $\widehat{\tau}_{ik}^{ice}=\widehat{\tau}_i\times\widehat{\tau}_k$ and $\widehat{t}_{ik}^{add}=\widehat{t}_i+\widehat{t}_k$, that is country-product specific, by year and transport mode. When assuming iceberg costs only (Equation (6)), we proceed similarly to get $\widehat{\tau}_{ik}^{nlI}=\widehat{\tau}_i\times\widehat{\tau}_k$.[7] Still following Irarrazabal *et al.* (2015), we take the average over the product-country dimension, using the values of each trade flow (ik-specific) over total yearly trade as a weighting scheme. We thus recover a "synthetic estimate" of each type of transport cost $\widehat{\tau}$ and $\widehat{t}$, for each year and transportation mode. These results are reported in Section 3.

[7]In this case, notice that the equation could be estimated relying on a non-linear form. To preserve comparability of the results, we keep the same non-linear estimation method in both cases though.

3 Decomposing Transport Costs: The importance of the additive component

The objective of this section is twofold. First, we quantify the magnitude of transport costs over time (by transport mode), distinguishing whether the additive component t_{ik} is included or not in the estimated equation (4). Second, we evaluate the importance of the per-unit component of in overall transport costs through the means of goodness-of-fit measures.

3.1 Decomposing transport costs over 1974-2013

Our first contribution to the literature is to provide estimates for the size of both the multiplicative and the additive components of transport costs. Table 1 reports a summary of our results. It displays the mean and median values of each type of trade costs (multiplicative estimated alone, estimated along with additive costs and the additive component), as well as the associated standard deviation, averaged over the period 1974-2013, for estimation driven both at the 3- and 4-digit sectorial level.[8,9]

Table 1: Transport costs estimates: Summary

Mean value over 1974-2013				
# digit	3 digits		4 digits (*)	
Mode	Vessel	Air (**)	Vessel	Air
With only Iceberg Trade Costs				
Mean	1.058	1.051	1.060	1.049
Median	1.051	1.042	1.052	1.037
Std	0.032	0.042	0.036	0.045
Min. value	1.003	1.001	1.003	1.000
Max. value	1.304	1.685	1.408	2.051
With Additive & Iceberg Trade Costs				
Iceberg term				
Mean	1.032	1.025	1.033	1.024
Median	1.028	1.018	1.028	1.016
Std	0.023	0.023	0.025	0.026
Min. value	1.001	1.000	1.000	1.000
Max. value	1.227	1.474	1.264	1.537
Additive term				
Mean	0.029	0.018	0.028	0.019
Median	0.019	0.007	0.017	0.008
Std	0.041	0.034	0.039	0.034
Min. value	0.000	0.000	0.000	0.000
Max. value	2.941	13.303	3.197	11.440
# obs.	29279	28207	29317	27680
# origin country	188	191	188	189
# products	230	211	666	567

Notes: Statistics are obtained weighting each observation by its value in transport (mode-dependent). Term A expressed in fraction of fob price. (*): Four 4-digit estimation: 0n selected years. (**): 1989 omitted in 3 digit estimation for Air.

Table 1 yields the following comments. First, the magnitude of overall transport costs is sizeable, either considering the average value over the period or even in the most recent years. Over 1974-2013,

[8] In Appendix , we report similar results for a sample of years, for both transport mode, at the 3 and 4-digit classification level. Results for all years are of course, available upon request to the authors.

[9] We present the results for Air at the 3-digit level removing the year 1989, as the estimation results reveal the presence of strong outliers that bias the estimates of transport costs upwards. Overall results (over the whole period) are not substantially affected if this year is included though. These results are available upon request to the authors.

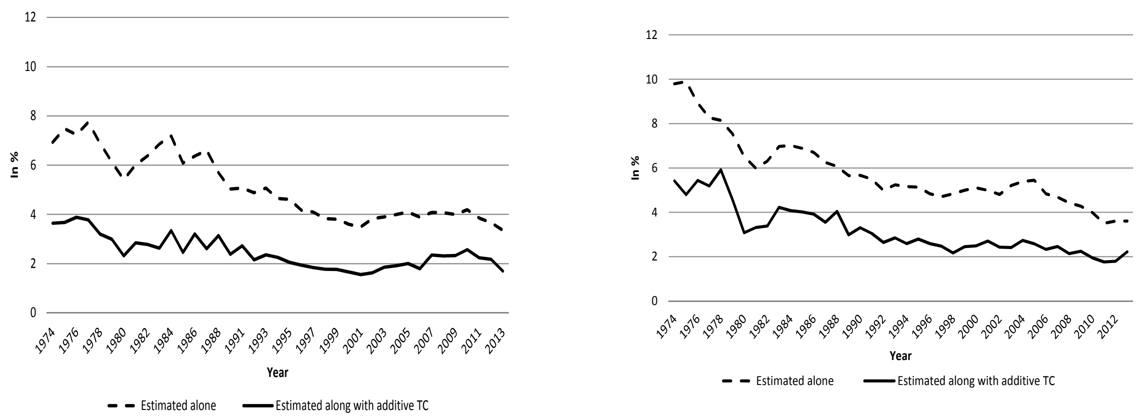
they correspond to a mean increase of the export price by 5.8% for ocean shipping, and by 5.1% for air shipping. Second, when decomposing transport costs into an additive and a multiplicative component, we find that the per-unit cost dimension is sizeable. Over the whole period, additive costs are 2.85% of fob unit values for ocean shipping - and ad-valorem ones being equal to 3.22%. These values are respectively equal to 1.9% and 2.5% for air transport. For both transport modes, the omission of the additive term seriously biases the multiplicative term upward. In quantitative terms, the omission of the additive term leads to overestimate the iceberg component by roughly a factor 2.

We investigate the robustness of this conclusion on a yearly basis. Figure 1 thus reports the mean value of the multiplicative component, estimated alone (Equation (6), dashed line) and along with the additive component (Equation (5, plain line), by transport mode.

Figure 1: Multiplicative Costs (3 digits

(a) Air

(b) Vessel



From Figure 1, we can infer that the sizeable magnitude of additive costs also holds on a yearly basis. For Air, the size of the bias seems to decrease over time, while it appears rather stationary for ocean shipping. Put it differently, this suggests that the share of the additive component in total transport costs has decreased over time for air transport. To get a better picture on this, we study the shares of both multiplicative and additive components in total costs, by transport mode and over time, based on Figure 2.

At this stage, two interesting comments can be made from Figure 2. First, the magnitude of transport costs is higher for ocean shipping than for air transport. This result also holds considering iceberg costs alone (Figure 1). Second, in both transport modes, the additive component appears of sizeable importance: As mean value over the period, it amounts to 48.2% of total transport costs in Vessel, and 42.3% in Air. We go on investigating this result further in the next subsection.[10]

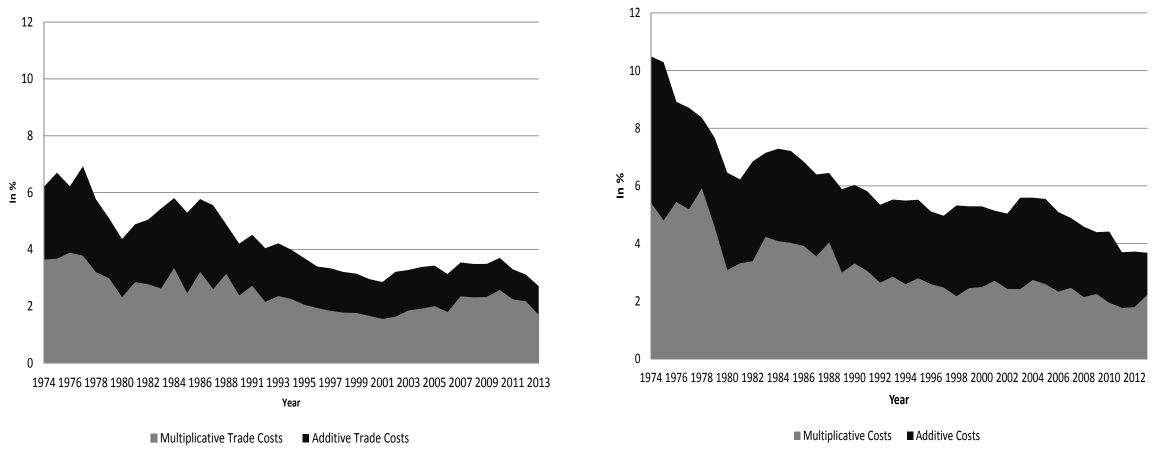
3.2 Assessing the importance of per-unit trade costs

In this section, we explore the performances of each type of model (with and without additive costs) in fitting the observed cif-fob prices gap, in order to deliver a more systematic diagnosis about the

[10]Figure 2 also delivers interesting results with respect to the time trends of transport costs. We come back to this aspect in Section 4.

Figure 2: Decomposing Transport costs (3 digits

(a) Air (b) Vessel



importance of additive costs. To do so, we rely on several standard measures of fit. The first indicator is through comparing R^2. However, its use is far from being straightforward when evaluating non-linear estimates.[11]. As a complement, we provide the Standard Error of Regression (SER), which represents the average distance that the observed values fall from the regression line. Smaller values are better because it indicates that the observations are closer to the fitted line. We also report the log-likelihood function, and two measures derived, the Akaike Information Criterion (AIC) and the log-likelihood (LL) ratio test. A decrease in the log-likelihood function points to a better quality-of-fit. However, the likelihood function systematically decreases with the number of parameters included; the AIC criterion allows for correcting this overfitting by including a penalty in the computation of the statistic, so that AIC stat $= 2 \times$ number of parameters $- 2 \times$ Likelihood. Once again, the preferred model is the one with the minimum AIC value. Finally, the log-likelihood ratio test statistic compares systematically the likelihood of the Unrestricted model (UR, including an additive term, i.e. Equation (5) and the Restricted one (R, i.e. Equation (6)). The null tested is that the two models are statistically equivalent.

Results are reported in Tables 2 and **??**, for Air and Vessel respectively, at the 3-digit level.[12]

Tables 2 and **??** lead to the same conclusion: The inclusion of the additive term leads to an improvement of the quality of fit, whatever the considered criterion or the transport mode. On average over the whole period, the R^2 doubles when per-unit costs are included for Air, and increases by 50% for Vessel. Similar qualitative conclusions arise from the comparisons of the standard errors of the regression (SER). Regarding the other criteria, improvements allowed by the inclusion of the additive term are roughly of the same extent across transport modes. Both AIC and Log-Likelihood statistics decrease with the inclusion of the additive term, and the log-likelihood test unambiguously rejects the null of statistical equivalence of the two models. These results holds whatever the considered year.

[11] R^2 is based on the underlying assumption that the adjusted model is a linear one. In a non-linear context, R-squared is therefore inappropriate, strictly speaking. However, if the error distribution is approximately normal, a standard metric like R-squared remains informative on the quality of adjustment.

[12] Due to our time coverage, we do not report the results for all years (at the 3-digit level). The results for all years are available upon request to the authors.

Table 2: Air: Measures of Goodness-of-fit (3 digits)

Year	1974	1980	1990	2000	2010	2013	Mean stat(*)
R^2							
Term I only	0.30	0.27	0.25	0.32	0.42	0.34	**0.31**
Terms A & I	0.59	0.65	0.63	0.64	0.51	0.46	0.60
SER							
Term I only	0.79	0.86	0.81	0.84	0.86	0.92	0.85
Terms A & I	0.67	0.71	0.67	0.70	0.79	0.85	0.73
AIC criteria							
Term I only	35674.98	41170.98	60715.58	87492.55	102297.66	88191.87	70498.1
Terms A & I	31387.29	35738.39	52098.91	74954.88	95887.05	80873.72	62285.0
Log-likelihood							
Term I only	-17530.5	-20253.5	-29977.8	-43341.3	-50746.8	-43692.9	-34888.6
Terms A & I	-15125.6	-17263.2	-25393.5	-36788.4	-47277.5	-39751.9	-30508.3
Test LL							
2*(ll(UR) -ll(R))	4809.7	5980.6	9168.7	13105.7	6938.6	7882.1	8760.69
nb of restrictions	355	369	393	426	426	427	402
p-value(d)	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: SER = Standard Error of regression; AIC = Akaike Information Criterion. R^2 between the log of predicted ratio and the log of the observed ratio. The number of restrictions is equal to the number of parameters estimated, i.e., the number of partner countries plus the number of products. (*): The mean statistics calculated as the average value over all years.

Table 3: Vessel: Measures of Goodness-of-fit (3 digits)

Year	1974	1980	1990	2000	2010	2013	Mean stat(*)
R^2							
Term I only	0.450	0,415	0.456	0.401	0,350	0.339	0.39
Terms A & I	0.612	0.575	0.590	0.571	0.491	0.462	0.56
SER							
Term I only	0.58	0.62	0.59	0.65	0.74	0.76	0.66
Terms A & I	0.48	0.53	0.51	0.55	0.66	0.68	0.57
AIC criteria							
Term I only	33328.8	33010.3	51142.6	71365.9	84789.9	88191.9	57848.6
Terms A & I	27331.5	28067.3	43664.7	60475.9	76161.3	80873.7	49682.3
Log-likelihood							
Term I only	-16287.4	-16129.1	-25169.3	-35263.9	-41998.9	-43692.9	-28534.3
Terms A & I	-12985.8	-13353.7	-21171.4	-29491.0	-37418.7	-39751.9	-24151.3
Test LL							
2*(ll(UR) -ll(R))	6603.28	5550.96	7995.88	11545.98	9160.56	7882.15	8766.0
nb of restrictions =q	393	395	411	436	424	427	417
p-value(d)	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: SER = Standard Error of regression; AIC = Akaike Information Criterion. R^2 between the log of predicted ratio and the log of the observed ratio. The number of restrictions is equal to the number of parameters estimated, i.e., the number of partner countries plus the number of products. (*): The mean statistics calculated as the average value over all years.

Going deeper into the examination of the levels of these goodness-of-fit statistics reveals interesting differences. First, multiplicative costs have more explanative power in the Vessel sector, where they account for 39% of the variance of the CIF/FOB ratio, versus 31% for the Air sector (considering the mean values of the R^2 across transport modes). As well, the standard error of the regression based only on the iceberg term is consistently lower for Vessel than for Air.

Second, the dynamics over time also reveals that the quality of fit decreases strongly after 2000, for both transport modes. For Air, the additive term explains less and less variance over time: In 2000, the inclusion of the additive term allows adding more than 30% of explanatory power, and decreases the standard error of the regression by 14 percentage points; in 2010 and 2013, it is hardly more than 10% for the R^2, and 7 percentage points for the SER. The picture is quite different for Vessel. In this case, the inclusion of the additive term increases the R^2 by a percentage very similar whatever the considered year (between 12 and 18%); a similar conclusion can be drawn for the SER, which decreases by 8-11 percentage points across the years when additive costs are included. Rather, the deteriorating performance of the model in terms of goodness-of-fit from 2000 mainly comes from the decreasing performance of the iceberg term.

For comparison purposes, we provide a similar goodness-of-fit exercise at the 4-digit product level (4-digits), reported in in Appendix C, Tables 8 and 9. If anything, the quality of fitting appears slightly higher when estimations are based on the 4-digit classification. This is especially true for the model restricting trade cost to their iceberg dimension, whatever the transport mode considered. When the additive part is taken into account however, the difference in goodness of fit between the 3- and the 4-digit classification level becomes very small, whatever the considered criterion. In other words, if using a more disaggregated classification unsurprisingly adds some statistical precision, this is not with an extent that would disqualify the use of slightly more aggregated data. Further, the same conclusion emerges regarding the significant role of the additive components in fitting international transport costs, that established at the 3-digit level.

4 Decomposing Transport Costs: Characterizing the trends

In this section, we investigate the role of the additive component in total transport costs by exploring the time dimension of our data. As first step, we come back to Figure 2, which displays the respective shares of additive and iceberg components in transport costs over time (by transport mode). Let us consider first the trend in overall transport costs (ie, considering the upper line in Figure 2). Two main comments can be made. First, both air and ocean shipping exhibit a downward trend in overall transport costs. Second, starting from 1974, the decrease appears more important for sea than air transportation: Transportation costs are divided by 3 for the ocean shipping, versus by 2 for air transport. That said, it may be the case the oil shock inflated transportation costs that specific year. If we start the analysis from 1980, the decrease is roughly 1.5-2 percentage points for Air, and 2-3 percentage points for Vessel (depending if we consider mean or median estimates). These results are consistent with Hummels (2007). If we now consider the respective shares of additive and multiplicative components, we observe that the share of additive costs in air transport costs has declined between 1974 and 2013, in particular starting in 1988 (panel (a) of Figure 2). By contrast, this share has been roughly constant throughout the period in ocean shipping (panel (b)).

Before making any definite statement about this though, it is worth emphasizing that the evolution of transport costs depends both on the evolution of per product and per partner costs and on the evolution of the composition of trade. Put it simply, total transport costs may have decreased over time either the country either trades with countries with which trade is cheaper, or trades products which are cheaper to transport, independently of any change in tranport costs *per se*. As argued by Hummels (2007), it is hence necessary to eliminate the composition effects of trade flows to isolate the evolution of per product- and per partner- transport costs. In this aim, we estimate the following equation for the multiplicative cost, based on the iceberg cost series obtained when estimated alone ($\widehat{\tau}_{ikt}^{nlI}$ and the iceberg cost series estimated along with additive costs ($\widehat{\tau}_{ikt}^{ice}$:[13,14]

$$\begin{aligned}
\widehat{\tau}_{ikt} &= \delta \times \exp\left(\sum_{i\neq \text{AFG}} \alpha_i.\mathbb{1}_i\right).\exp\left(\sum_{k\neq 011} \beta_k.\mathbb{1}_k\right).\exp\left(\sum_{t\neq 1974} \gamma_t.\mathbb{1}_t\right).\exp\left(\epsilon_{ikt}\right) \\
\Leftrightarrow \ln(\tau_{ikt}) &= \delta + \sum_{i\neq \text{AFG}} \alpha_i.\mathbb{1}_i + \sum_{k\neq 011} \beta_k.\mathbb{1}_k + \sum_{t\neq 1974} \gamma_t.\mathbb{1}_t + \epsilon_{ikt} \qquad (7)
\end{aligned}$$

As for the additive cost, we estimate the following equation, based on the additive cost series $\widehat{t}_{ikt}$ previously obtained:

$$\begin{aligned}
\widehat{t}_{ikt} &= \left(\prod_{i\neq \text{ARG}} \alpha_i.\mathbb{1}_i + \prod_{k\neq 011} \beta_k.\mathbb{1}_k\right).\exp\left(\sum_{t\neq 1974} \gamma_t.\mathbb{1}_t\right).\exp\left(\epsilon_{ikt}\right) \\
\Leftrightarrow \ln(t_{ijt}) &= \ln\left(\prod_{i\neq \text{ARG}} \alpha_i.\mathbb{1}_i + \prod_{k\neq 011} \beta_k.\mathbb{1}_k\right) + \sum_{t\neq 1974} \gamma_t.\mathbb{1}_t + \epsilon_{ijt} \qquad (8)
\end{aligned}$$

Notice that Equations (7) and (7) preserve our specification of the multiplicative and additive costs of Equations (2) and (3). That is, we consider that the multiplicative cost is the product of the country of origin and the good dimension, while the additive cost is the sum of the two dimensions. In the three estimations (iceberg costs alone, iceberg costs estimated along with additive, and the additive component), we consider Argentina, the sector 011 and the first year of our dataset 1974, as references for the country-, product and -year dummies. As before, both equations are estimated using the non-linear least square procedure (by transport mode).

In this exercise, we are interested in isolating the change in the time dimension of the each transport cost component. From the estimation of Equation (7) (on both $\widehat{tau}_{ikt}$ and $\widehat{\tau}_{ikt}^{nlI}$), we built the variable Γ_t, for each year $t \geq 1974$, according to:

$$\Gamma_t = 100.\frac{\bar{\tau}_{1974}.\exp(\gamma_t) - 1}{\bar{\tau}_{1974} - 1} \qquad (9)$$

As for the additive cost, we built the variable $\Gamma_t^{add} = 100.\exp(\gamma_t)$, with the reference year being

[13]We thus estimate Equation (7) twice, depending on the type of iceberg cost series considered ($\widehat{\tau}_{ikt}^{nlI}$ or $\widehat{\tau}_{ikt}^{ice}$), even if it is denoted $\widehat{\tau}_{ikt}$ for sake of notational simplicity. For the same reason, we do not distinguish the coefficients associated to the fixed effects between Equations (7) and (8), even if they are specific to the type of transport costs considered (e.g., the series of γ_t differs from one estimation to the other).

[14]We use the transport costs series obtained at the 3-digit classification level.

1974 in all cases (ie, with $\gamma_{1974} = 0$). As a result, the series for Γ_t (with an initial value of 100 for $t = 1974$) have a straightforward interpretation in percentage changes.

We first report the changes over time of the transport costs, estimated iceberg alone, in Figure 3, by transport mode (Panel (a) for Air and Panel (b) for Vessel).

Figure 3: Total transport costs (estimated iceberg alone), composition effects excluded

Figure 3 drives the following comments. First, whatever the transport mode considered,[15] they have been roughly constant from 1974 to 1984. This stands in sharp contrast with Figures 1 and 2, which rather conveyed the view that transport costs fall immediately started in 1974. Combining these results therefore indicates that the reduction of transport costs between 1974 and 1984 is rather attributable to changes in the composition of trade patterns (either in the country or the product dimension, or both) of the US, rather than a decrease in transport costs *per se*. In line with Hummels (2007), this confirms the importance of excluding these composition effects before assessing the time trends of transport costs. Second, after excluding the composition effects, we find that all types of transport costs have steadily decreased by 40% over the period 1984-2013. Further, if we only assume iceberg costs (Figure 3), we infer that the decrease is stronger for air transport than for air shipping over the period 1984-2005, in accordance with the findings of Hummels (2007) and Behar and Venables (2011). Yet, going deeper in the decomposition between the additive and the multiplicative components substantially modifies the picture.

In Figure 4, we report the sum of the multiplicative and the additive costs (re-scaled to start from the reference value 100), for each transport mode.

In line with Figure 3, Figure 4 reports that transport costs have been roughly constant over 1974-1984 in both modes, decreasing afterwards. Yet, another result emerges, that conversely stands in sharp contrast. There is now not much difference in the reduction of transport costs between air transport and ocean shipping, and both display very similar trends. Taking into account the additive component therefore substantially modifies the analysis of the dynamics of transport costs over time. In Figure 5, we investigate this result further, by reporting the changes in both the additive and multiplicative components of transport costs, by transport model.

Again, the decomposition between both components of transport costs brings valuable insights.

[15] Note that this is also true for all type of transport costs, additive and iceberg, as reported in Figure 5, as we come back later on.

Figure 4: Total transport costs (additive & multiplicative combined), composition effects excluded

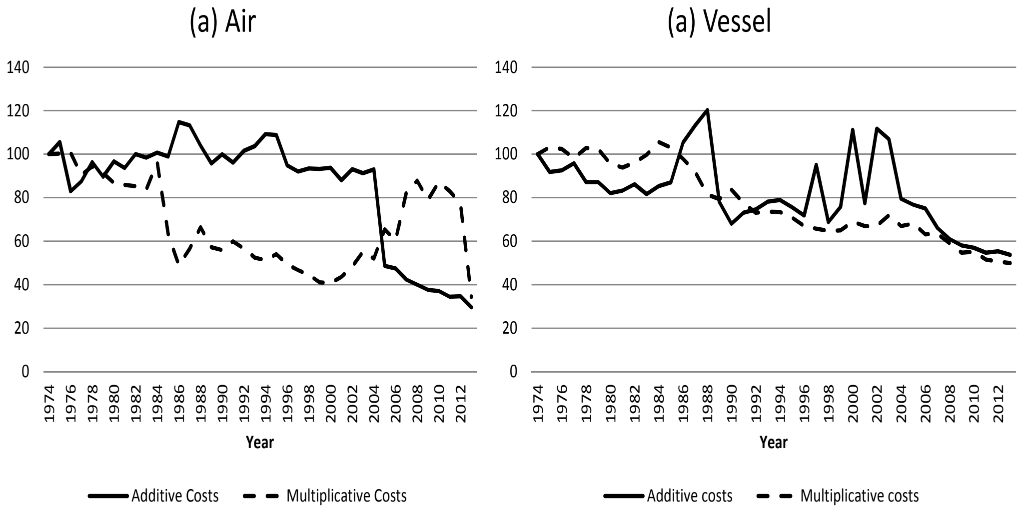
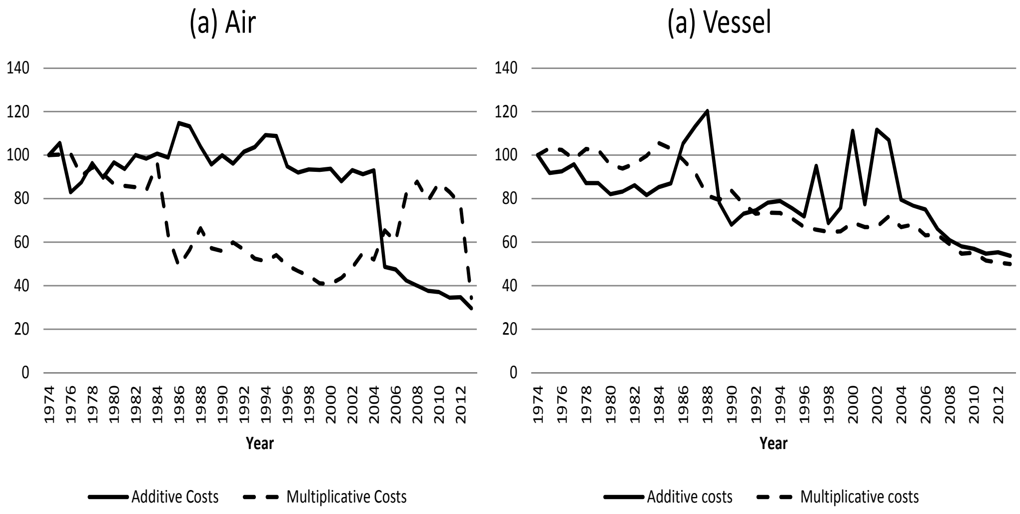


Figure 5: Decomposing transport costs over time, composition effects excluded



Comparing Figure 5 with Figure 4 (or Figure 3) indicates that the steady decline of overall transport costs hides shifts in the relative importance of additive and ad-valorem. Air transport in particular exhibit contrasted trends. While most of the early decline in air transport costs can be explained by the ad-valorem part, this component nearly doubled in the 2000s, all along with a substantial decline in the per-unit cost. These results therefore confirm the importance of the additive component in accounting for international transport costs.

5 Conclusion

This paper empirically studies the magnitude of additive (or per-unit) costs in international transport costs, by exploiting the differences between the import and the export prices. Using SITC 3 and 4- digit cif-fob unit values taken from the US import database over 1974-2013, we estimate the two components of transport costs, by transport mode (air or ocean). Our results may be summarized in three main findings. First, we obtain that additive costs are 2.8% of fob unit values for ocean shipping (and ad-valorem ones 3.2%). These values are respectively equal to 1.8% and 2.5% for air transport. Second, we show that taking additive costs into account improves the fit of the modelling of transport costs. All goodness-of-fit measures point out to this conclusion, which holds for both transport modes and all years considered. Third, we also use the time dimension of our data to characterize the evolution of transport costs. After correcting for composition effects, we find that all types of transport costs have been roughly constant from 1974 to 1984 and then steadily decreased by 40% over the period 1984-2013. Yet, this steady decline hides shifts in the relative importance of additive and ad-valorem. While most of the early decline in air transport costs can be explained by the ad-valorem component, this component nearly doubled in the 2000s. Further, the inclusion of additive costs yields to the conclusion that overall trade costs are decreased in air transport and ocean shipping roughly the same path and the same magnitude of order. This last result stands in contrast with related studies (Hummels, 2007 (that omit the role of additive costs), which rather obtain a larger decrease in air transport costs, relative to ocean shipping costs. Behar and Venables, 2011). In all three aspects, our results point the importance of the additive component in accounting for international transport costs.

Our results could be extended in two main ways. On the empirical side, one may want to ge deeper in the "structural" determinants of trade costs, i.e. identify the respective roles of handling costs, insurance and freight at the root of the gap between export and import prices. On the theoretical side, our results can be used to explore the role of additive costs in shaping international trade flows (in an international trade theory perspective) as well as regarding the international transmission of business cycles. This is left for further research.

References

Alchian, A. A. and Allen, W. R. (1964), *University Economics*, Belmont, CA: Wadsworth Publishing Company.

Anderson, J. and Van Wincoop, E. (2004), "Trade Costs", *Journal of Economic Literature*, vol. 42 n° 3: pp. 691–751.

Behar, A. and Venables, A. J. (2011), "Transport costs and International Trade", in A. de Palma, E. Q. R. V., R. Lindsey (editor), *A Handbook of Transport Economics*, Cheltenham: Edward Elgar Publishing Ltd.

Disdier, A.-C. and Head, K. (2008), "The Puzzling Persistence of the Distance Effect on Bilateral Trade", *The Review of Economics and Statistics*, vol. 90 n° 1: pp. 37–48.

Glaeser, E. L. and Kohlhase, J. E. (2004), "Cities, regions and the decline of transport costs", *Papers in Regional Science*, vol. 83: pp. 197–228.

Head, K. and Mayer, T. (2004), "The empirics of agglomeration and trade", in J.V. Henderson, J. T. (editor), *Handbook of Regional ad Urban Economics, Volume IV*, Amsterdam: North-Holland.

Hornok, C. and Koren, M. (2015), "Per-Shipment Costs and the Lumpiness of International Trade", *Review of Economics and Statistics*, vol. 97 n° 2: pp. 525–530.

Hummels, D. (2007), "Transportation Costs and International Trade in the Second Era of Globalization", *Journal of Economic Perspectives*, vol. 21 n° 3: pp. 131–154.

Hummels, D. and Skiba, S. (2004), "Shipping the Good Apples Out? An Empirical Confirmation of the Alchian-Allen Conjecture", *Journal of Political Economy*, vol. 112.

Irarrazabal, A., Moxnes, A. and Opromolla, L. D. (2015), "The Tip of the Iceberg: A Quantitative Framework for Estimating Trade Costs", *The Review of Economics and Statistics*, vol. 97 n° 4: pp. 777–792.

Jacks, D. S., Meissner, C. M. and Novy, D. (2008), "Trade Costs, 1870-2000", *American Economic Review, Papers and Proceedings*, vol. 98 n° 2: pp. 529–534.

Lafourcade, M. and Thisse, J.-F. (2011), "New Economic Geography: the Role of Transport Costs", in A. de Palma, E. Q. R. V., R. Lindsey (editor), *A Handbook of Transport Economics*, Cheltenham: Edward Elgar Publishing Ltd.

Lashkaripour, A. (2016), "Worth its Weight in Gold: Product Weight, Trade Costs, and Trade Patterns", .

Martin, J. (2012), "Markups, Quality, and Transport Costs", *European Economic Review*, vol. 56: pp. 777–791.

Melitz, M. (2003), "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity", *Econometrica*, vol. 71 n° 6: pp. 1695–1725.

Novy, D. (2013), "Gravity Redux: Measuring International Trade Costs with Panel Data", *Economic Inquiry*, vol. 51 n^{o} 1: pp. 101–121.

Samuelson, P. (1954), "The Transfer Problem and Transport Costs, II: Analysis of Effects of Trade Impediments", *Economic Journal*, vol. 64: p. 264289.

Sorensen, A. (2014), "Additive versus multiplicative trade costs and the gains from trade", *Canadian Journal of Economics*, vol. 47 n^{o} 3: pp. 1032–1046.

A Data Appendix

A.1 Fob-cif prices

The Customs value is the value of imports as appraised by the U.S. Customs and Border Protection in accordance with the legal requirements of the Tariff Act of 1930, as amended. This value is generally defined as the price actually paid or payable for merchandise when sold for exportation to the United States, excluding U.S. import duties, freight, insurance, and other charges incurred in bringing the merchandise to the United States. The term "price actually paid or payable" means the total payment (whether direct or indirect, and exclusive of any costs, charges, or expenses incurred for transportation, insurance, and related services incident to the international shipment of the merchandise from the country of exportation to the place of importation in the United States) made, or to be made, for imported merchandise by the buyer to, or for the benefit, of the seller. In the case of transactions between related parties, the relationship between buyer and seller should not influence the Customs value.

In those instances where assistance was furnished to a foreign manufacturer for use in producing an article which is imported into the United States, the value of the assistance is required to be included in the value reported for the merchandise. Such "assists" include both tangible and intangible assistance, such as machinery, tools, dies and molds, blue prints, copyrights, research and development, and engineering and consulting services. If the value of these "assists" is identified and separately reported, it is subtracted from the value during statistical processing. However, where it is not possible to isolate the value of "assists", they are included. In these cases the unit values may be increased due to the inclusion of such "assists". Import Charges

The import charges represent the aggregate cost of all freight, insurance, and other charges (excluding U.S. import duties) incurred in bringing the merchandise from alongside the carrier at the port of exportation in the country of exportation and placing it alongside the carrier at the first port of entry in the United States. In the case of overland shipments originating in Canada or Mexico, such costs include freight, insurance, and all other charges, costs and expenses incurred in bringing the merchandise from the point of origin (where the merchandise begins its journey to the United States) in Canada or Mexico to the first port of entry. C.I.F. Import Value

The C.I.F. (cost, insurance, and freight) value represents the landed value of the merchandise at the first port of arrival in the United States. It is computed by adding "Import Charges" to the "Customs Value" (see definitions above) and therefore excludes U.S. import duties.

B Some detailed results

In this section, we report the estimates for international transport costs, by transport mode on a yearly basis, when either additive costs are included in the estimation (Equation (5)) or not (Equation (6)). For sake of space saving, we only report the results for a sample of years. Tables 6 and 7 display the results for the 4-digit product-level estimation.

Table 4: Air: Dynamics of Trade Costs over Time, 3 digits (selected years)

Year	1974	1980	1990	2000	2010	2013
With only Iceberg Trade Costs						
Mean	1.069	1.054	1.050	1.036	1.042	1.034
Median	1.054	1.038	1.044	1.025	1.034	1.029
Standard Error	0.052	0.049	0.039	0.033	0.037	0.024
With Additive & Iceberg Trade Costs						
Additive term						
Mean	0.026	0.020	0.018	0.013	0.011	0.010
Median	0.011	0.005	0.008	0.005	0.004	0.005
Standard Error	0.040	0.041	0.033	0.028	0.024	0.020
Iceberg term						
Mean	1.036	1.023	1.024	1.017	1.026	1.017
Median	1.027	1.016	1.016	1.012	1.022	1.017
Standard Error	0.032	0.025	0.021	0.016	0.023	0.012
# observations	14955	16118	24958	35027	40279	39351

Notes: Statistics are obtained weighting each observation by its value in transport (mode-dependent). Additive term expressed in fraction of fob price.

Table 5: Vessel: Dynamics of Trade Costs over Time (3 digits), selected years

Year	1974	1980	1990	2000	2010	2013
With only Iceberg Trade Costs						
Mean	1.098	1.065	1.057	1.051	1.040	1.036
Median	1.096	1.055	1.046	1.049	1.036	1.033
Standard Error	0.053	0.040	0.032	0.028	0.020	0.018
With Additive & Iceberg Trade Costs						
Additive term						
Mean	0.051	0.034	0.027	0.028	0.025	0.015
Median	0.029	0.023	0.017	0.022	0.019	0.008
Standard Error	0.085	0.046	0.040	0.043	0.025	0.020
Iceberg term						
Mean	1.054	1.031	1.033	1.025	1.019	1.022
Median	1.049	1.024	1.028	1.021	1.018	1.018
Standard Error	0.041	0.023	0.022	0.021	0.018	0.018
# obs	19007	17356	28383	36090	37748	38473

Notes: Statistics are obtained weighting each observation by its value in transport (mode-dependent). Additive term expressed in fraction of fob price.

Table 6: Air: Dynamics of Trade Costs over Time, 4-digit

Year	1974	1981	1989	2001	2009	2013
With only Iceberg Trade Costs						
Mean	1.066	1.058	1.052	1.033	1.037	1.032
Median	1.052	1.044	1.041	1.021	1.027	1.026
Standard Error	0.056	0.054	0.046	0.040	0.036	0.025
With Additive & Iceberg Trade Costs						
Iceberg term						
Mean	1.035	1.026	1.031	1.015	1.021	1.016
Median	1.025	1.017	1.019	1.010	1.017	1.014
Standard Error	0.036	0.028	0.030	0.021	0.024	0.015
Additive term						
Mean	0.026	0.021	0.017	0.012	0.012	0.010
Median	0.012	0.006	0.006	0.005	0.004	0.004
Standard Error	0.039	0.042	0.033	0.027	0.029	0.019
# obs	14944	16844	25307	35005	38475	39460

Notes:Statistics are obtained weighting each observation by its value in transport (mode-dependent). Additive term expressed in fraction of fob price.

Table 7: Vessel: Dynamics of Trade Costs over Time, 4-digit

Year	1974	1981	1989	2001	2009	2013
With only Iceberg Trade Costs						
Mean	1.098	1.061	1.058	1.051	1.042	1.036
Median	1.094	1.051	1.048	1.045	1.038	1.031
Standard Error	0.060	0.038	0.036	0.030	0.023	0.020
With Additive & Iceberg Trade Costs						
Iceberg term						
Mean	1.054	1.034	1.028	1.028	1.024	1.021
Median	1.049	1.030	1.024	1.025	1.026	1.018
Standard Error	0.043	0.026	0.025	0.021	0.016	0.013
Iceberg term						
Mean	0.046	0.026	0.031	0.024	0.021	0.015
Median	0.029	0.013	0.019	0.015	0.013	0.008
Standard Error	0.068	0.044	0.037	0.035	0.031	0.023
# obs	19196	17916	29387	36677	37643	38820

Notes: Statistics are obtained weighting each observation by its value in transport (mode-dependent). Additive term expressed in fraction of fob price.

C Robustness checks

In this section, we report the goodness-of-fit exercise conducted by transport mode, for selected years at the 4-digit product classification level. The results are reported in Tables 8 (for Air) and 9 (for Vessel), for a sample of some years.

Table 8: Air: Measures of Goodness-of-fit, 4-digits

	Year						
	1974	1981	1989	2001	2009	2013	**Mean stat**
R2							
Term I only	0.48	0.49	0.50	0.50	0.45	0.35	**0.47**
Terms A & I	0.63	0.66	0.65	0.66	0.54	0.45	**0.63**
SER							
Term I only					0.88	0.93	**0.89**
Terms A & I					0.80	0.86	**0.79**
Log-likelihood							
Term I only	-17505.55	-21813.46	-30960.56	-44067.62	-49375.57	-53197.87	**-34744.40**
Terms A& I	-14895.81	-18589.91	-26553.53	-37297.93	-45747.57	-49899.14	**-30243.95**
AIC criteria							
Term I only	36243.10	44966.91	63417.12	89747.24	100317.13	107963.73	**70940.07**
Terms A & I	31873.63	39495.82	55777.05	77439.85	94059.14	102224.28	**62955.73**
Test LL							
$2\times$(ll(UR) -ll(R))	5219.47	6447.09	8814.06	13539.39	7255.99	6597.45	**9000.89**
# restrictions	640	698	778	833	824	818	**755.73**
p-value	0.000	0.000	0.000	0.000	0.000	0.000	

Notes: R^2 between the log of predicted ratio and the log of the observed ratio. The number # of restrictions is equal to the number of parameters estimated, i.e., the number of partner countries plus the number of products.

Table 9: Vessel: Measures of Goodness-of-fit, 4-digits

	Year						
	1974	1981	1989	2001	2009	2013	**Mean stat**
$\mathbf{R^2}$							
Term I only	0.50	0.45	0.47	0.41	0.37	0.35	**0.44**
Terms A & I	0.66	0.62	0.62	0.58	0.51	0.46	**0.59**
SER							
Term I only					0.79	0.82	**0.77**
Terms A & I					0.69	0.75	**0.68**
Log-likelihood							
Term I only	-16460.10	-16951.61	-26771.44	-39008.34	-43888.90	-47161.62	**-29883.62**
Terms A& I	-12743.65	-13546.92	-21752.77	-33280.96	-39078.86	-43399.22	**-25303.92**
AIC criteria							
Term I only	34464.19	35491.21	55272.87	79800.67	89459.80	95987.23	**61425.60**
Terms A & I	28271.29	29877.84	46595.55	69743.91	81155.73	89692.44	**53573.29**
Test LL							
2×(ll(UR) -ll(R))	12385.80	11226.75	17354.65	20113.52	16608.16	12589.59	15704.63
# restrictions	797	814	881	910	886	874	860
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: R^2 between the log of predicted ratio and the log of the observed ratio. The number # of restrictions is equal to the number of parameters estimated, i.e., the number of partner countries plus the number of products.