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

Guillaume Daudin
Université Paris-Dauphine, PSL & OFCE

Jérome Héricourt
Université de Lille I & CEPII

Lise Patureau
Université Paris-Dauphine, PSL

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Motivation

- Trade costs have a central role in international economic analysis
  - Declining over the second half of the 20^{th} century (Jacks et al., 2008, Novy, 2013)
  - But still significant: Average international trade costs = a 74% markup over production costs (Anderson & Van Wincoop, 2004)
- What exactly are "trade costs"?
  - Transaction costs, policy costs, time costs, and transport costs *per se*
- Transport costs are a sizeable share of international trade costs
  - Amount to $\simeq$ 30% of international trade costs $\Leftrightarrow$ A 21% markup over production costs

$\Rightarrow$ If much trade policy barriers have been removed, the transport cost component of trade costs remains sizeable

The paper: On international transport costs

Motivation (cont')

- Standard modeling of trade costs: As an ad-valorem tax-equivalent
  - As a constant percentage of the producer price per unit traded
  - $\Leftrightarrow$ Part of the "iceberg cost" hypothesis (Samuelson, 1954)
    - With p the import price, $\widetilde{p}$ the export price, q the quantity traded and $\tau > 1$ the trade cost
    - $\Rightarrow$ Multiplicative costs: $pq = \tau\widetilde{p}q$
- Yet... A debated question
- Would not trade costs rather exhibit an additive structure ?
  - Why would it be more costly to transport from Milan to Paris, a pair of Italian shoes at price €300 than a pair of Italian shoes at price €50?
  - Pricing shipping often includes an additive component
    - UPS: A \$125 fee charged for a 2 pound package from Oslo to NYC (Irrarazabal et al., 2015)
    - $\Rightarrow$ Additive costs: $pq = (t + \widetilde{p})q$

- Recent empirical evidence in support of the additive structure of trade costs
    - Irrarazabal et al. (2015), Hummels & Skiba (2004), Martin (2012)
- The structure (additive vs iceberg) of transport costs is not anecdotal
    - Additive costs play an important role in shaping the pattern of trade flows (Alchian & Allen, 1964)
    - Strong normative implications, notably w.r.t. the welfare gains of trade liberalization (Sorensen, 2014)

$\Rightarrow$ Transport costs are likely to display an additive component, but precisely... by how much?

One objective of the paper: Provide an answer to this question

Our paper in one question (and 3 answers)

- **Do additive transport costs matter?**
  - Provide an empirical decomposition of the structure of transport costs
  - Using the US imports database over 1974-2013 (air/vessel)

⇒ **Yes, they do**

(1) **In terms of size**: Additive costs are sizeable

- Additive cost: 1.8% and 2.9% of the export price, in air / vessel
- Roughly 50% of the overall transport costs

(2) **In terms of quality of fit**: With the additive component included,

- The estimated iceberg component is reduced by a factor of 2
- A substantially better "goodness-of-fit"

(3) **In accounting for the time trend of transport costs**

- The modelling of the additive component of transport costs is key
- Because it changes the result of excluding the trade composition effects when characterizing the time trend
    - The decrease in TC over time is mostly attributable to the decrease in the "pure" transport costs,
    - Rather than to trade composition effects
- A result in sharp contrast with Hummels (2007)

All our results: Provide new quantitative evidence about the importance of the additive component in international transport costs

Related literature: Two related strands

- Challenging the dominant role of iceberg costs in international trade
  - Hummels and Skiba (2004) (sectoral data), Martin (2012) (firm-level data)
  - The closest to us: Irarrazabal, Moxnes and Opromolla (2015)

  $\Rightarrow$ In support of the additive cost component assumption

  $\neq$ Our results: Quantitatively estimate the *value* of the additive costs

  - A broader view of the magnitude of additive costs

  $\Rightarrow$ Additive costs do matter quantitatively, throughout the period

- Studying the patterns of trade costs over time
  - Hummels (2007), Behar and Venables (2011)
  - What lies behind the decrease in transportation costs observed in the recent decades?
  - Hummels (2007): Mostly due to trade composition effects

  $\neq$ Our results: Trade composition effects only a minor role

  - Why such a difference?

  $\Rightarrow$ Key role of the modelling of the additive component

Plan of the talk

- Data Sources
- Empirical Methodology
- Results
- Conclusion

Data sources

- Our measure of international transport costs: The difference between the "export" price and the "import" price of US imports
- Database: US Imports of Merchandise database
  - The export (fas) price, $\widetilde{p}$: the price for one kg of merchandise at the country export point
  - The import (cif) price, p: the price for one kg of merchandise at the entry in the US
  - Yearly basis, from 1974 to 2013, SITC 5-digit classification level, by transport mode (air or vessel)

$\Rightarrow$ Our dependent variable: Based on the ratio $p/\widetilde{p}$

- The RHS is at the 3-digit classification level
  - Estimation at the 4-digit level on some selected years as robustness
  - Approximatively 200 sectors (3 digits), from around 200 countries
    - Around 600-700 sectors at the 4-digit level

More on our database

- Implications (and limitations)
  - Only cover international transport costs
  - Among transport costs, insurance + handling + quantitative freight costs (e.g. not those related to the time value of goods)
- A rich database to exploit
  - US imports, long time period: Broad view of international trade flows
  - A reliable database, already used by Hummels (2007), but on a shorter length of time
  - Have both the import and the export prices

  $\Rightarrow$ Allows the estimate the levels of both the ad-valorem and the additive transport costs

  $\neq$ Irarrazabal et al. (2015)

Empirical specification (1)

The equation at the root of the estimation

- Relate the import price p to the export price $\widetilde{p}$ given both additive (per-kg) costs t and ad-valorem costs τ:

$$p = \tau \widetilde{p} + t, \qquad \text{with} \quad \tau \geq 1, \quad t \geq 0$$

- From country i, for a product k (at the $k =$ 5-digit classification level, and for a given transport mode)

- Rewrite to get:

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

$\Rightarrow$ For each year over 1974-2013

- The equation is also mode (air or vessel) - specific

Empirical specification (2)

The estimation strategy

- Make some simplifying assumptions to get the estimated equation
- About the specification of both additive and multiplicative costs

  (1) Separability between the origin country i and the product k dimensions (ss in Irarrazabal et al., 2015)

  (2) All products k in a 3-digit sector s share the same structure of costs

  $\Leftrightarrow$ Write t_{ik} and τ_{ik} as:

$$\tau_{ik} = \tau_i \times \tau_{s(k)}, \qquad t_{ik} = t_i + t_{s(k)} \tag{2}$$

- About the specification of the error term

  - Given the constraint $\frac{p_{ik}}{\widetilde{p}_{ik}} - 1 > 0$, the error term should be always positive and multiplicative

  $\Rightarrow$ The equation of interest becomes:

$$\frac{p_{ik}}{\widetilde{p}_{ik}} - 1 = \left(\tau_i \times \tau_{s(k)} - 1 + \frac{t_i + t_{s(k)}}{\widetilde{p}_{ik}}\right) \times \exp(\epsilon_{ik})$$

  - With ϵ_{ik} following a normal law centered on 0

- Taking logs, we finally estimate the following equation

$$\ln\left(\frac{p_{ik}}{\widetilde{p}_{ik}} - 1\right) = \ln\left(\tau_i \times \tau_{s(k)} + \frac{t_i + t_{s(k)}}{\widetilde{p}_{ik}} - 1\right) + \epsilon_{ik} \tag{3}$$

  - τ_i, $\tau_{s(k)}$, t_i, $t_{s(k)}$ are the parameters (i.e., fixed effects) to be estimated

- A non-linear equation (due to the additive costs)

$\Rightarrow$ Estimation using non-linear squares

  - At the basis of the method: Approximate the model by a linear one and refine the parameters by successive iterations
  - The criterion for convergence: That the sum of the squares of the residuals does not increase from one iteration to the next

- Eliminate potential influence of outliers: Exclude the 5 percent of the upper and lower tails of the distribution

Empirical specification (3)

How to characterize the importance of additive costs relatively to ad-valorem?

- Estimate Equation (5) constraining $t = 0$

$\Rightarrow$ Estimate *two* models

(A) With additive costs excluded (only ad-valorem costs):

$$\ln\left(\frac{p_{ik}}{\widetilde{p}_{ik}} - 1\right) = \ln\left(\tau_i \times \tau_{s(k)} - 1\right) + \epsilon_{ik}^{ice} \quad (4)$$

(B) With additive costs included:

$$\ln\left(\frac{p_{ik}}{\widetilde{p}_{ik}} - 1\right) = \ln\left(\tau_i \times \tau_{s(k)} + \frac{t_i + t_{s(k)}}{\widetilde{p}_{ik}} - 1\right) + \epsilon_{ik} \quad (5)$$

- Under Model (B), $\simeq$ 800 fixed effects to estimate
- For each year over 1974-2013, by transport mode (air/vessel)

- After running the estimates, we re-built:
  - (A) With only iceberg costs (from Equation (4)):

$$\widehat{\tau}_{is}^{ice} = \widehat{\tau}_i \times \widehat{\tau}_s$$

  - (B) With additive costs included (from Equation (5)):

$$\widehat{\tau}_{is}^{adv} = \widehat{\tau}_i \times \widehat{\tau}_s, \qquad \widehat{t}_{is} = \widehat{t}_i + \widehat{t}_s$$

- Taking the weighted average over the sector-country dimension, we finally get, by year and transport mode:
  - With only iceberg costs: $\widehat{\tau}^{ice}$
  - When additive costs are included: $\widehat{\tau}^{adv}$, $\widehat{t}$

Question, and answers

- Do additive costs matter?
- How we answer (yes) to this question

Result 1: Size of additive transport costs

- Estimate the values of both the ad-valorem and the additive components
  - Average values over 1974-2013, in percent of the export price ▸ More details

Mean value over 1974-2013				
# digit	3 digits		4 digits (*)	
Mode	Vessel	Air (**)	Vessel	Air
Model (A) - With only Ad-Valorem Transport Costs ($\widehat{\tau}^{ice}$, in %)				
Mean	5.8	5.1	6.0	4.9
Median	5.1	4.2	5.2	3.7
Model (B) - With Additive & Ad-Valorem Transport Costs				
Ad-valorem term ($\widehat{\tau}^{adv}$, *in %*)				
Mean	3.2	2.5	3.3	2.4
Median	2.8	1.8	2.8	1.6
Additive term ($\widehat{t}/\widetilde{p}$, *in %*)				
Mean	2.9	1.8	2.8	1.9
Median	1.9	0.7	1.7	0.8
Data ($p/\widetilde{p}$, *in %*)				
Mean	5.3	5.0	5.6	3.9
Median	4.3	2.0	4.4	1.9
# obs.	29279	28207	29317	27680
# origin country	188	191	188	189
# products	230	211	666	567

Interpretation

- **Size of overall transport costs**
  - Add $\simeq$ a 5% margin over the export price
  - Lower than the 21% markup taken from Anderson & Van Wincoop (2004) (AWM), but
    - AVW decompose the 21% markup in 9% of time costs and 11% in pure freight costs
    - Their 11% markup: A "rough" estimate, based on Hummels (2001) with 1994 data
    - Our data are only for the US, which presumably has lower trade costs

$\Rightarrow$ Our work: A precise estimation of international transport costs

  - Going deeper into the structure of international transport costs

- **International transport costs: A sizeable additive component**
  - 48.2% of total costs in average for vessel, 42.3% for air
  - A result that holds throughout the period See Figure 1
  - Omitting the additive term substantially biases the iceberg component upwards (Table 1)
    - The ad-valorem cost is reduced by a factor of 2 when additive transport costs are included in the estimation
    - From 5.8% to 3.2% in maritime transport (mean value over the period)
    - From 5.1% to 2.5% in Air transport
- Opening the black box of transport costs More on this
  - Iceberg cost: 2.5% and 3.2% of the export price in Air & Vessel resp.
  - Additive cost: 1.8% and 2.9% of the export price

$\Rightarrow$ Valuable insights for related papers more theoretically-oriented, in need for calibration

Result 2: Quality of fit

- **A better quality of fit with the additive component included**
  - Compare the goodness-of-fit of Model (B) (with additive TC) vs Model (A) (without additive TC)
  - Various measures of goodness of fit
    - The R^2 (the larger the value, the better the fit)
    - Standard Error of Regression (SER) (the smaller the value, the better the fit)
    - The Akaike Information Criterion (the lower AIC, the better the fit)
    - The log-likelihood ratio test (H_0: both models are equivalent)

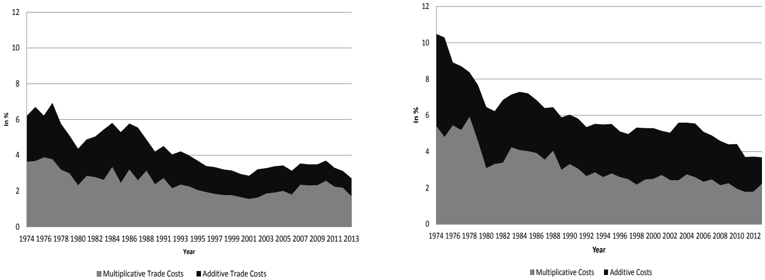
$\Rightarrow$ A systematically better goodness of fit when including the additive component

  - See the results
  - Even when taking into account the additional degrees of freedom

Result 3: Characterizing the time trend of TC

- Exploit the time-dimension of our database Go back to Result 1

(a) Air (b) Vessel



  - Lower overall transport costs in Air than in Vessel
  - Downward trend for both modes since 1974
    - A 50% decrease in Air, a 60% decrease in Vessel over the period

Time trends in transport costs & composition effects

- Does it mean a decrease in transport costs *per se*? Not necessarily
- The change in overall transport costs over time:
  - Depend on the evolution of per product- per partner costs,
  - But also on the composition of trade flows
    - ⋆ Over time, import more goods that are cheaper to transport, and/or from countries with which it is cheaper to trade

$\Rightarrow$ Necessary to eliminate the composition effects of trade flows, to isolate the evolution of transport costs *per se*

$\Rightarrow$ What we do, in accordance with Hummels (2007)