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

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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)

$\Rightarrow$ **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 importance of modelling the additive component of transport costs
- 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

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)

⇒ 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:

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

- For a product k, from country i (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 (at the $k = 5$-digit classification level)

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

Empirical specification (2)

- Make some simplifying assumptions ▸ More details
  - About the specification of both additive and multiplicative costs
    - Separability between the product and the country dimensions (as Irarrazabal et al., 2015)
    - All products k in a 3-digit sector (s) share the same structure of costs
  - About the specification of the error term
- Taking logs, we finally estimate the following equation:

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

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

⇒ Estimation using non-linear squares

Empirical specification (3)

How to characterize the importance of additive costs relatively to iceberg?

- Estimate Equation (3) constraining $t = 0$

$\Rightarrow$ Estimate *two* models

(A) With only ad-valorem costs:

$$\ln\left(\frac{p_{ik}}{\widetilde{p}_{ik}} - 1\right) = \ln\left(\tau_i \times \tau_{s(k)} - 1\right) + \epsilon_{ik}^{ice} \tag{2}$$

(B) With additive costs included:

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

* 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 (2)):

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

  - (B) With additive costs included (from Equation (3)):

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

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

Do additive costs matter? Our answers

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

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

Result 1: Size of additive transport costs ▸ More on this

- **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
  - 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)

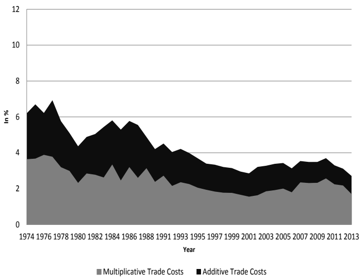
$\Rightarrow$ A systematically better goodness of fit when including the additive component

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

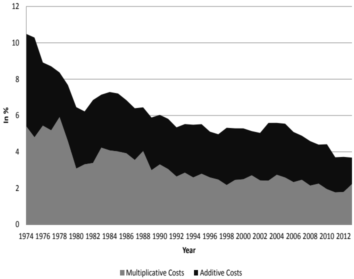
Result 3: Characterizing the time trend of TC

- 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

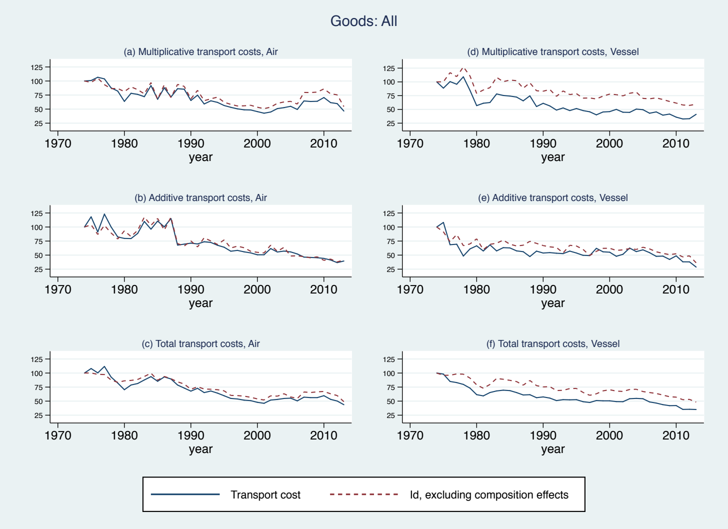
⇒ Necessary to eliminate the composition effects of trade flows, to isolate the evolution of transport costs *per se*

⇒ What we do, in accordance with Hummels (2007)

- Some insights on our methodology More details Comparison with Hummels (2007)
  - Start with estimates of additive/multiplicative transport costs
  - Extract the "pure" TC component by the mean of a time fixed-effect
  - Build a unified measure of "total" transport costs (agglomerate the two components), also both fitted and unfitted

Time trends in transport costs: Results

- Transport costs over time (with and without composition effects)



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Time trends in transport costs: Comments

- A strong reduction of transport costs over the period (1974-2013)
  - Consistent with the literature, see Lafourcade & Thisse (2011)
  - Roughly same order of magnitude for both the ad-valorem and the additive component
- **Trade composition effects: A minor role in accounting for the time trend of TC**
  - Not much evidence of a difference between the “raw” and the “pure” TC components
- In Air transport
  - The 50% decrease is mainly attributable to the reduction of “pure” transport costs, for both components
- Composition effects (slightly) more pronounced in maritime transport
  - The 60% decrease is roughly 50% decrease of “pure” TC, 10% decrease from composition effects
  - But for the multiplicative component only

Time trends in transport costs: The role of additive costs

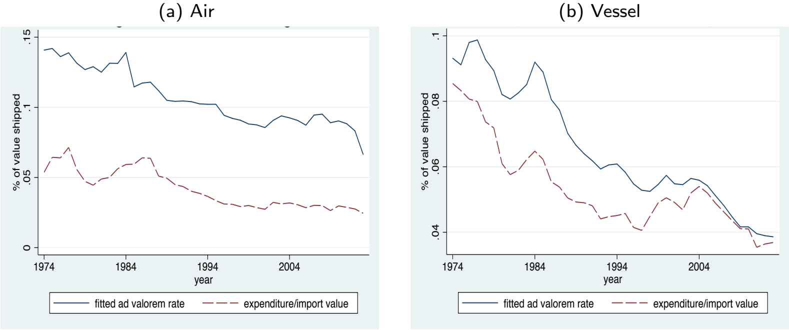
- A result in sharp contrast with Hummels (2007)
  - According to whom pure transport costs have decreased much more than the unfitted ones (over 1974-2004)
  - Suggesting an important role to trade composition effects
- Not the case here.

$\Rightarrow$ **Where does the difference come from?**

- **From the treatment of the additive component of transport costs**
  - Assuming (as we do, $\neq$ Hummels (2007)) a varying share of the additive component over time, product and country partner is key
  - What if we relax this assumption?

▶ Assuming (as Hummels, 2007) a constant share of the additive component over time/country partner/product

⇒ Transport cost changes decompose as:



⇒ Suggest a much more important role to trade composition effects...

▶ Than they actually do, see ▸ Figure 2

⇒ The (appropriate) modeling of additive costs, of key importance in understanding the time trends of international transport costs

Conclusion: Main findings

Our paper: Empirical evidence about the role of the additive component in international transport costs

- Provide a quantitative evaluation of both the additive and the ad-valorem components
  - Based on the US imports flows from 1974 to 2013
  - Additive cost: amount to 2.8% of the export price in ocean shipping, 1.8% in air transport
  - Iceberg cost: 3.2% and 2.5% for air and ocean respectively
- The importance of taking into account additive transport costs
  - Additive costs are sizeable quantitatively
  - A better fit of the model when they are taken into account
  - A key role in the understanding of the time trend of transport costs

Conclusion : What to do next?

Two main possible extensions

- On the empirical side: Go deeper in the structural determinants of transport costs
  - Identify the respective roles of handling costs, insurance and freight costs at the root of the import-export prices gap
- On the theoretical side: Use our results to explore the role of additive costs
  - In shaping international trade flows (trade theory)
  - In affecting the international transmission of business cycles (business cycle theory)

Appendix

More on the empirical specification

The estimation strategy

- Two assumptions (as in Irrarazabal et al., 2015)
  - Both iceberg and additive costs are separable between the origin country i and the product k dimensions
  - Separability in a multiplicative manner for ad-valorem costs and additive manner for per-kg costs

$$\tau_{ik} = \tau_i \times \tau_k \quad \text{and} \quad t_{ik} = t_i + t_k$$

- Additional assumption: All products in a 3-digit sector (s) share the same structure of costs

$\Leftrightarrow$ Write $t_{is(k)}$ and $\tau_{is(k)}$ as:

$$\tau_{is(k)} = \tau_i \times \tau_{s(k)}, \qquad t_{is(k)} = t_i + t_{s(k)} \tag{4}$$

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

$\Rightarrow$ The equation of interest (1) becomes:

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

- Taking logs, we finally estimate the following equation

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

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

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More on the estimation method

- Non-linear least square estimation method: Some insights
  - 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

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Decomposing transport costs: Summary

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Mean value over 1974-2013				
# digit	3 digits		4 digits (*)	
Mode	Vessel	Air (**)	Vessel	Air
With only Ad-Valorem 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 & Ad-Valorem Trade Costs				
Ad-valorem 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. The additive term is expressed in fraction of fab price. (*): Four 4-digit estimation: 0n selected years. (**): 1989 omitted in 3 digit estimation for air.

Size of transport costs: Comparison with the literature (1)

- 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 more precise and exhaustive estimation of international transport costs

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Size of transport costs: Comparison with the literature (2)

- Size of additive transport costs: Comparison with Irarrazabal et al. (2015)
  - Irarrazabal et al. (2015): Estimate the trade costs ratio $t/\tau = 14\%$ of the export price $\widetilde{p}$
  - In 2004, our estimates lead to $t/\tau = 7.7\% \times \widetilde{p}$ (Air), $t/\tau = 1.5\% \times \widetilde{p}$ (Ocean)

  $\Rightarrow$ Much lower !
- But, our work: Estimate transport costs, not trade costs
  - According to AVW, transport costs $\simeq$ 15% of trade costs
  - Simple calculus thus implies that our estimates amount to 62% (Air) and 53% (Vessel) of Irarrazabal & al.'s estimates

$\Rightarrow$ Additive transport costs represent between 1/2 and 2/3 of total additive trade costs

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More on Result 2: Goodness of fit comparison

- Air, 3 digit - level, selected years

Year	1980	1990	2000	2010	2013	Mean stat
R^2						
Term I only	0.27	0.25	0.32	0.42	0.34	0.31
Terms A & I	0.65	0.63	0.64	0.51	0.46	0.60
SER						
Term I only	0.86	0.81	0.84	0.86	0.92	0.85
Terms A & I	0.71	0.67	0.70	0.79	0.85	0.73
AIC criteria						
Term I only	41171.0	60715.6	87492.6	102297.6	88191.9	70498.1
Terms A & I	35738.4	52098.9	74954.9	95887.1	80873.7	62285.0
Log-likelihood						
Term I only	-20253.5	-29977.8	-43341.3	-50746.8	-43692.9	-34888.6
Terms A & I	-17263.2	-25393.5	-36788.4	-47277.5	-39751.9	-30508.3
LL ratio	5980.6	9168.7	13105.7	6938.6	7882.1	8760.69
nb of restrictions	369	393	426	426	427	402
p-value	0.00	0.00	0.00	0.00	0.00	0.00

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Goodness of fit comparison (cont')

- Vessel, 3 digit - level, selected years

Year	1980	1990	2000	2010	2013	Mean stat
R^2						
Term I only	0.415	0.456	0.401	0.350	0.339	0.39
Terms A & I	0.575	0.590	0.571	0.491	0.462	0.56
SER						
Term I only	0.62	0.59	0.65	0.74	0.76	0.66
Terms A & I	0.53	0.51	0.55	0.66	0.68	0.57
AIC criteria						
Term I only	33010.3	51142.6	71365.9	84789.9	88191.9	57848.6
Terms A & I	28067.3	43664.7	60475.9	76161.3	80873.7	49682.3
Log-likelihood						
Term I only	-16129.1	-25169.3	-35263.9	-41998.9	-43692.9	-28534.3
Terms A & I	-13353.7	-21171.4	-29491.0	-37418.7	-39751.9	-24151.3
LL ratio	5550.96	7995.88	11545.98	9160.56	7882.15	8766.0
nb of restrictions	395	411	436	424	427	417
p-value	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. For the LL ratio test, 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.

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Goodness of fit: Comments

- **Result 2**: Including the additive component improves the fit of the model, whatever the considered criterion or the transport mode
  - On average over the period, the R^2 doubles for air transport, increases by 50% for vessel (also on a yearly basis)
- A decrease in the quality of fit strongly after 2000, for both transport modes
- Contrasted results between air and ocean transports
  - Ad-valorem costs have more explanative power in ocean shipping than in air transport
    - On average, account for 39% of the variance of the cif-fas ratio, vs 31% in Air
  - But their explanatory power seems to have decreased over time
    - For vessel: A roughly constant contribution of the additive component to the goodness of fit over time

  $\neq$ For Air: The decreasing role of the explanatory power of the additive component over the recent years (consistent with Figure 1)

$\Rightarrow$ Go deeper in the analysis of the time-trends

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Composition effects: Our strategy

- Start with our estimates of add. & adv. transport costs (TC)
  - That vary over time (t)/product (k) /origin country (i) (by transport mode): $\widehat{\tau}_{ikt}, \widehat{t}_{ikt}$

$\Rightarrow$ Decompose the estimated TC component in three parts:
  - Country dimension (Term (a)), product dimension (Term (b)) and the "pure TC time trend" (Term (c)).

- For the ad-valorem component, we estimate the following equation:

$$\ln(\widehat{\tau}_{ikt}) = \delta + \underbrace{\sum_{i \neq ARG} \alpha_i.\mathbb{1}_i}_{(a)} + \underbrace{\sum_{s(k) \neq 011} \beta_{s(k)}.\mathbb{1}_{s(k)}}_{(b)} + \underbrace{\sum_{t \neq 1974} \gamma_t.\mathbb{1}_t}_{(c)} + \epsilon_{ikt} \quad (5)$$

- For the additive component:

$$\ln(\widehat{t}_{ikt}) = \ln\left(\delta + \underbrace{\sum_{i \neq ARG} \alpha_i.\mathbb{1}_i}_{(a)} + \underbrace{\sum_{s(k)} \beta_{s(k)}.\mathbb{1}_{s(k)}}_{(b)}\right) + \underbrace{\sum_{t \neq 1974} \gamma_t.\mathbb{1}_t}_{(c)} + \epsilon_{ikt} \quad (6)$$

  - With $\mathbb{1}_i$, $\mathbb{1}_{s(k)}$ and $\mathbb{1}_t$ country-, sector- and time- fixed effects

- Isolate the change in the time dimension of each TC component
  - From the ad-valorem component estimation (Equation (5)), build the variable Γ_t ($\forall\ t \geq 1974$):

$$\Gamma_t^{adv} = \frac{\bar{\tau}_{1974}.\exp(\gamma_t) - 1}{\bar{\tau}_{1974} - 1}$$

    - with $\bar{\tau}_{1974} = \exp(\delta + \sum_i \alpha_i + \sum_k \beta_k)$ the mean TC in 1974
  - For the additive cost, build the variable ($\forall\ t > 1974$)

$$\Gamma_t^{add} = 100 \exp(\gamma_t)$$

- The Γ_t^{add} and Γ_t^{adv} series:
  - How TC components have changed over time if we stick the composition of trade flows by product/ country partner to the one observed in 1974
  - Interpretation in percentage changes, with an initial value of 100 for $t = 1974$
  - As indices, measures easily comparable

- Rebuild a measure of "total" transport costs
  - As the sum of the two components (additive and ad-valorem)
  - On both the "raw" (unfitted) measures and the "pure" (fitted) measures
- For the unfitted measure, build (by transport mode)

$$\widehat{tc}_t^{raw} = \widehat{\tau}_t^{adv} - 1 + \widehat{t}_t$$

  - with $\widehat{\tau}_t^{adv}$ and $\widehat{t}_t$ estimated by year (see before)
  - From this, we build:

$$\Gamma_t^{tc,raw} = 100 \frac{\widehat{tc}_t^{raw} - 1}{\widehat{tc}_{1974}^{raw} - 1}$$

- For the fitted measure, start directly from the two indices just obtained, Γ_t^{add} and Γ_t^{adv}:

$$\Gamma_t^{tc,pure} = \omega_x \Gamma_t^{add} + (1 - \omega_x)\Gamma_t^{adv}$$

  - With $x = air,\ vessel$ and ω_x the relative weight of the additive TC component in total cost in 1974
  - Precisely, $\omega_{air} = 0.423$ and $\omega_{vessel} = 0.482$

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Composition effects: Comparing with Hummels (2007) (1)

Reformulating Hummels's (2007) method

- Start from the observed cif-fas price gap $TC_{ikt} = \frac{p_{ikt} - \widetilde{p}_{ikt}}{\widetilde{p}_{ikt}}$ (by transport mode)
- **The unfitted TC measure**, TC_t: Take the mean yearly value by weighting each flow by its (relative) total value
- To get the fitted TC measure, start from the regression

$$\ln TC_{ikt} = \delta + \beta \ln \frac{1}{\widetilde{p}_{ikt}} + \sum_{i,k} \alpha_{ik}.\mathbb{1}_{ik} + \sum_{t} \gamma_t.\mathbb{1}_t + \epsilon_{ikt} \tag{7}$$

- Take the predict of the regression $\rightarrow \widehat{TC}_{ikt}$
- **The fitted TC measure**, $\widehat{TC}_t$: The unweighed average in the product/origin country dimension
- To be compared to the unfitted ad-valorem rate TC_t (by transport mode)

Five differences with our method

1. Hummels (2007) obtains the fitted ad-valorem rate in one step (the LHS is the observed price gap) while we use a 2-step approach (extract the fitted TC from the *estimated* unfitted ad-valorem rate) - but a slight difference
2. Hummels (2007) does not purge its measure of the fitted ad-valorem rate by the country-sector fixed effect - but only a scale effect
3. We separate the country-product fixed effects in two components (country / product), due to the number of fixed effects to estimate in the non-linear setting - robustness analysis to this point (in progress)
4. We differ in the weighting scheme to obtain the yearly value of the fitted TC measure.
   - Hummels (2007): The unweighed average value over the i, k dimension
   - $\neq$ We weight each flow by its relative value in total trade flows observed in 1974
   - Not much of a difference provided the weighting scheme in value is constant over time
   - Robustness to the alternative weighting scheme (apply Hummels's (2007) method) in progress

5. Last difference - the major one !

- Coming back to Hummels's (2007) equation (7), rewritten as:

$$\ln TC_{ikt} \equiv \ln \left(\frac{p_{ikt} - \widetilde{p}_{ikt}}{\widetilde{p}_{ikt}} \right) = \Delta_{ikt} - \beta \ln \widetilde{p}_{ikt} \tag{8}$$

  - with $\Delta_{ikt} \equiv \delta + \sum_{i,k} \alpha_{ik}.\mathbb{1}_{ik} + \sum_t \gamma_t.\mathbb{1}_t + \epsilon_{ikt}$

- Encompasses the two extreme cases of only ad-valorem costs / only additive costs
- Only multiplicative costs under $\beta = 0$
  - In which case Equation (8) rewrites as:

$$\ln \left(\frac{p_{ikt} - \widetilde{p}_{ikt}}{\widetilde{p}_{ikt}} \right) = \Delta_{ikt} \quad \leftrightarrow \quad p_{ikt} = \underbrace{[\exp(\Delta_{ikt}) + 1]}_{\tau_{ikt}} \times \widetilde{p}_{ikt}$$

- Only additive costs under $\beta = 1$
  - In which case Equation (8) rewrites as:

$$\ln (p_{ikt} - \widetilde{p}_{ikt}) = \Delta_{ikt} \quad \leftrightarrow \quad p_{ikt} = \widetilde{p}_{ikt} + \underbrace{[\exp(\Delta_{ikt}) + 1]}_{t_{ikt}}$$

- As noted by Hummels & Skiba (2004), $0 < \beta < 1$ is the elasticity of freight costs to the export price
- Measures the relative weight of the additive component in international transport costs
  - The higher β close to 1, the larger the share of additive costs
- By estimating Equation (7) **with a constant** β, Hummels (2007) assumes a constant share of additive costs over time/country partner/product
- A key difference with our method
  - Our strategy to obtain the transport costs measures explicitly allows for an additive component that varies in the 3 dimensions
- A key importance in the decomposition of time trends of transport costs (between the role of trade composition effects and the "pure" transport costs dimension)

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