Heterogeneity and the Distance Puzzle

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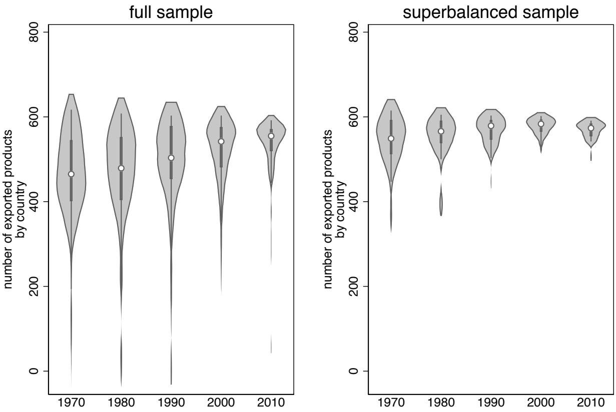
Introduction: the paradox of distance

- The distance effect is increasing or stable through time in gravity models: Disdier & Head, (2008), Head & Mayer (2013)...
  - This seems counter-intuitive ("Death of distance")
- Various answers in the literature (see Head & Mayer (2013)):
  - Problem with the log-linear estimation strategy?
    - Not taking zeros into account + heteroskedasticity
    - $\Rightarrow$ PPML estimates (Santo Silva & Tenreyro (2006), , Bosquet & Boulhol (2015))
  - Composition effect (Larch et al. (2016))
  - Relative evolution of short-distance trade costs compared to long-distance trade costs (Buch & al. (2004), Krautheim (2012))
  - Input-output linkage (Daudin et al. (2011))
  - Network : the distance coefficient does not depend on trade costs (Chaney (2018))

How do we contribute?

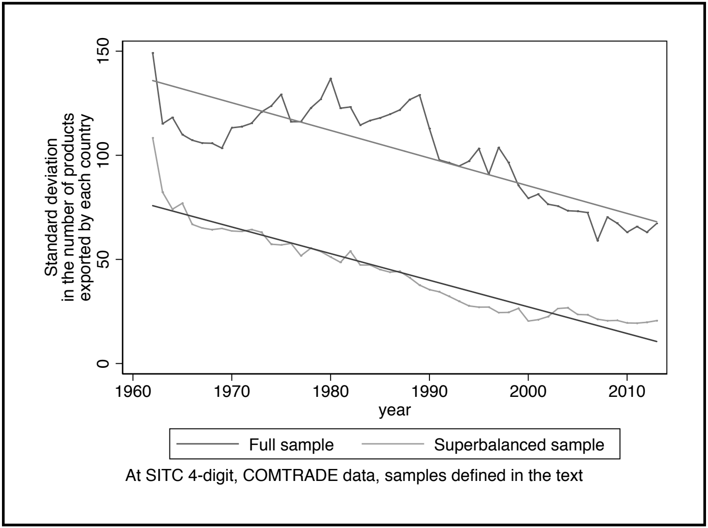
- Every theoretical fundation of the gravity equation delivers a relationship betwee the distance elasticity and a degree of structural heterogeneity in some model-specific structural dimension
  - "Trade elasticity" (Arkolakis et al. (2012))
- The distance coefficient is the product of:
  1. The elasticity of distance to trade costs
  2. The elasticity of trade to trade costs
- Empirical evidence on the historical evolution of structural heterogeneity is notoriously scarce
  - The only other try we know of is Berthelon & Freund (2008) from the late 1980s to early 2000s
- We document over 1962-2013 how the increasing substituability of the bundles shipped out by each country (Armington framework) contributes to the paradox

Dispersion of the number of products exported by each country



At SITC 4-digit, COMTRADE data, samples defined in the text

Standard deviation in the number of products exported by each country



Overview

The distance puzzle in our data
- Benchmark estimation
- Composition and sample effects

Interpreting the distance coefficient
- What does the trade elasticity actually measures?
- What do we know about the evolution of the trade elasticity?

Evolution of the Armington trade elasticity
- Benchmark estimation
- Endogeneity

Conclusion

Summary of results

- Robustness of distance puzzle in 1962-2013: increase in distance coefficient
  - +5% controlling for estimation strategy
  - +31% controlling for composition and sample effects
- Evolution of heterogeneity parameter:
  - ??% increase in 1963-2013 (??% in 1970-2013)
  - this estimate is likely to be a lower bound
- Elasticity of trade costs to distance has not increased
  - ???% decrease in 1963-2013
  - ??% decrease in 1970-2013
- Which dimension of increased country similarity?
  - Result obtained within the Armington framework
  - Increased substitutability of traded product bundles

Roadmap

The distance puzzle in our data

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- Composition and sample effects

Interpreting the distance coefficient

- What does the trade elasticity actually measures?
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Evolution of the Armington trade elasticity

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Conclusion

Estimation procedure (1)

- run gravity equations (obviously)
  - COMTRADE data, 1962-2009 STIC 4 digits (1962-2009)
  - cross section, no panel
  - focus on evolution of distance elasticity overtime
  - using the PPML estimator (consistency & efficiency)
- Microfounded gravity equation (Anderson & Wincoop (2003)):

$$X_{ij,t} = \left(\frac{Y_{i,t}Y_{j,t}}{Y_t}\right)\left(\frac{\tau_{ij,t}}{\Pi_{i,t}P_{j,t}}\right)^{\epsilon_t}$$

- heterogeneity parameter: ϵ_t: $1-\sigma_t$ in Armington (sector or firm productivity heterogeneity in the frameworke respectively of Eaton & Kortum and Melitz)

Estimation procedure (2)

- Trade costs:
  - distance parameter: $\eth_{ij}$
  - time-invariant cost vector of controls (adjacency,...): Z_{ij}
  - time-varying cost vector of controls (policy: FTAs,...): S_{ijt}
  - unobserved bilateral trade cost component assumed to have mean zero conditional on the observables: ν_{ijt}

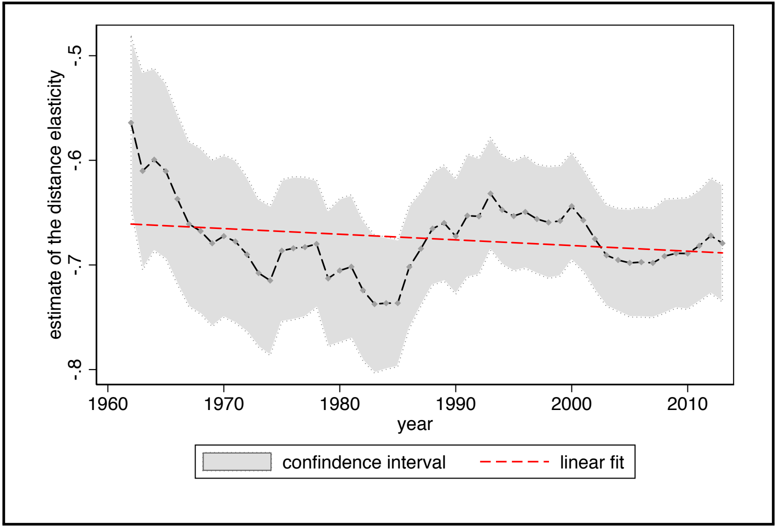
$$\tau_{ijt} = \exp\left\{\rho_t \ln \eth_{ij} + Z_{ij}\zeta_t + S_{ijt}\varsigma_t + \nu_{ijt}\right\}$$

  - ρ_t is the 'world shrinkage' parameter
    i.e. elasticity of trade costs to distance
- Estimated equation:

$$X_{ij,t} = \exp\left(\xi_t - \delta_t \ln \eth_{ij} + Z_{ij}\tilde{\zeta}_t + S_{ijt}\tilde{\varsigma}_t + f_{it} + f_{jt}\right)\eta_{ijt}$$

  - f_{it} and f_{jt} are fixed effects to control for price levels
  - ξ_{ijt} is a multiplicative error term which includes the exponentiated unobserved bilateral trade cost
  - distance elasticity: $-\delta_t = \epsilon_t \rho_t$

Baseline regression (PPML)

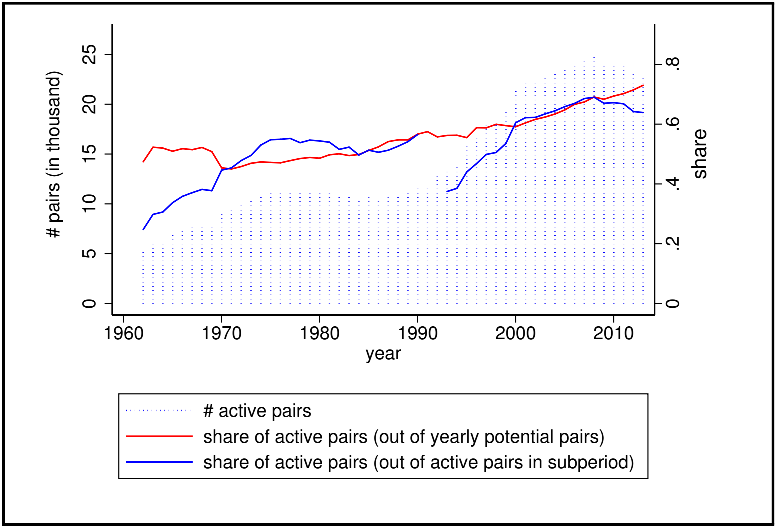


Increase in absolute value of 4.5% : basically stable

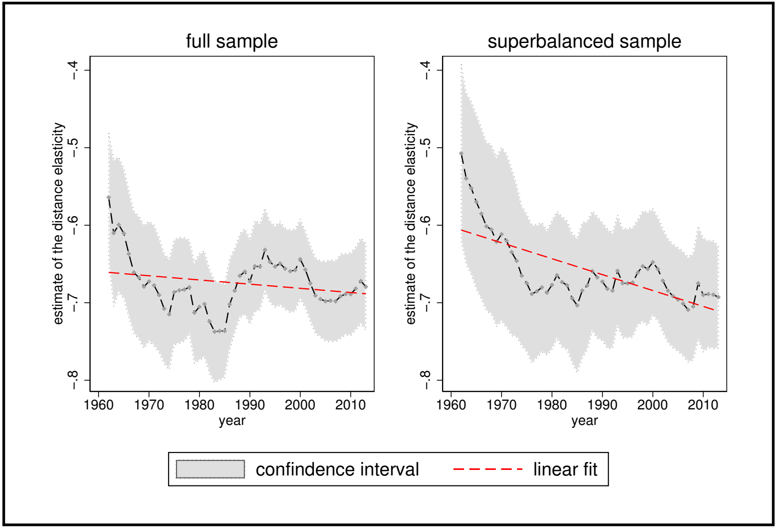
Sample composition effect

- We know the country sample potentially matters
  - Increasing number of new low volume long-distance relationship
  - Potentially increases the distance elasticity of trade (Mayer et al. (2019), Head & Mayer (2013))
  - Though it should be less of an issue with PPML
- There are big sample issues in the data
- Test: keep only trading pairs that have reciprocal non-zero trade every year from 1962 to 2009 ("Superbalanced sample")
  - It deepens the puzzle

Share of active pairs



Superbalanced sample



Increase in absolute value of 18.2%

Sector composition

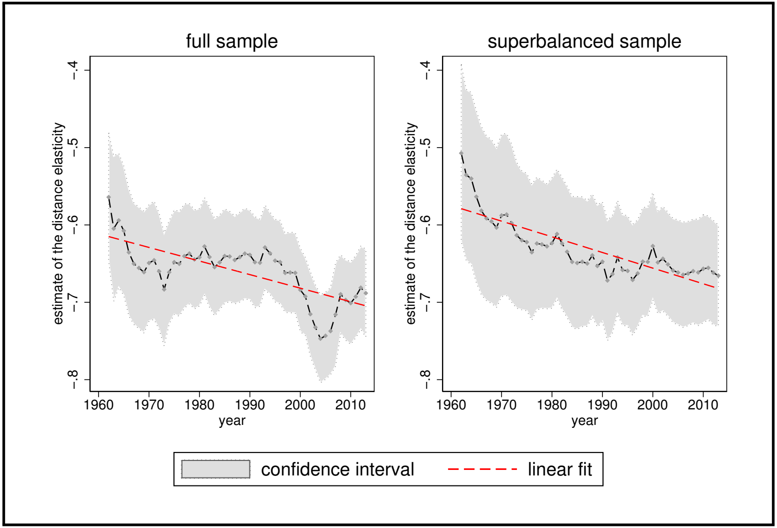
- We do not expect the elasticity of trade to distance to be constant by sector
  - Some sectors can only be procured in specific places (oil), other are more mobile (textile)
  - In the long-term, the decline of the share of oil should increase the absolute value of the elasticity of trade to distance
  - In the short-term, price variation of primary products change their share in trade and hence the elasticity of trade to distance
- We use two tests
  1. Fixing the sectoral compositon of total trade to 1962. We modify all trade flows by a sector-specific factor.

$$\tilde{X}_{ijt}^{k} = X_{ijt}^{k} * \frac{s_{w,1962}^{k}}{s_{w,t}^{k}}$$

  2. Fixing the sectoral composition of each country's export to 1962. We modify all trade flows by a sector and country-specific factor

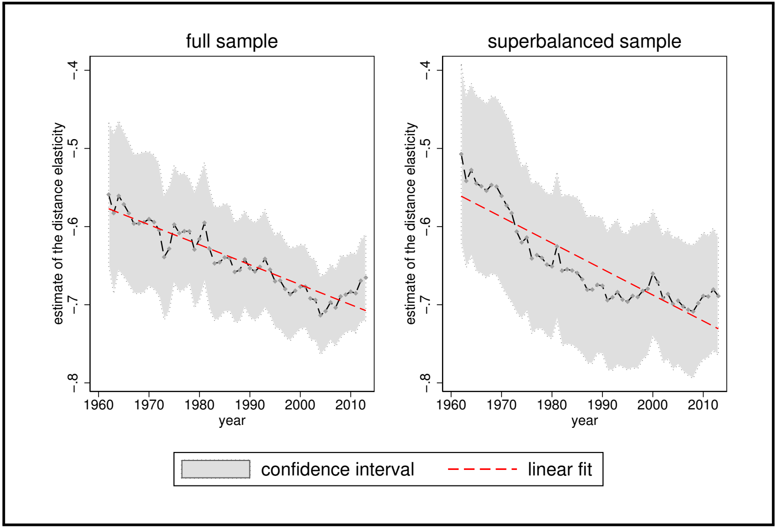
$$\tilde{X}_{ijt}^{k} = X_{ijt}^{k} * \frac{s_{i,1962}^{k}}{s_{i,t}^{k}}$$

Product composition effect: fixing the world bundle



Increase in absolute value of 14.5 and 18.4%

Product composition effect: fixing the country bundle



Increase in absolute value of 22.7 and 31.4%

Summary (PPML)

Table: Evolution of δ_t: sample and composition effecs

	FULL			STABLE		
	rate (%)	R-sq	total change	rate (%)	R-sq	total change
Baseline	.09*	.07	1.045	.33***	.49	1.182
World bundle	.26***	.53	1.145	.33***	.68	1.184
Country bundle	.40***	.87	1.227	.54***	.77	1.314

Note: Estimated annualized growth rates reported in col.2 and col.5 are obtained as a geometric fit on the basis of annual point estimates of the distance coefficient in 1962-2013. Col.3 and col.6 report the share of time variation in the point estimate explained with the annualized growth rate.

Ingredients of the puzzle

- The distance coefficient is the elasticity of trade to distance
  - Trivial: the whole point of log-linear equations
  - Still the case in the Poisson specification
- It is a product of two coefficients:
  - Elasticity of trade flows to trade costs ϵ
  - Elasticity of trade costs to distance ρ
- The 'death of distance' intuition is really about the elasticity of trade costs to distance (Which should be going down)
- But it does not tell much about the heterogeneity dimension, i.e. the trade elasticity ϵ

Short incursion in microfoundations (1)

- The gravity equation can be justified by three canonical families of theories: (see Head &Meyer(2014))
- Ricardian framework (Eaton & Kortum (2002))
  Homogeneous goods
  Shop around the world for lowest cost supplier (intersectoral productivity heterogeneity)
- Heterogeneous firms framework: (Melitz (2003), Chaney (2008))
  Trade because all firms produce different varieties
  A subset of firms enters export markets (intrasectoral productivity heterogeneity)
- Armington framework (Anderson and Wincoop (2003))
  Trade because consumers value variety
  Country-specific goods (heterogeneity: degree of substitutability between bundles)

Short incursion in microfoundations (2)

- Ricardian framework:
  - Distance coefficient: $\rho\theta$
  - θ captures intersectoral productivity dispersion
  - if sectors have similar productivity
    $\rightarrow$ small differences in variable costs have a large effect on trade flows
    $\rightarrow$ high elasticity of trade to trade costs

- Monopolistic competition between heterogeneous firms:
  - Distance coefficient: $\rho\gamma$
  - γ captures productivity dispersion across firms (parameter of Pareto)
  - if distribution decays swiftly, higher probability that productivity cut-off for exporting is close to the mass of firms
    $\rightarrow$ small differences in variable costs have large effect on entry
    $\rightarrow$ high elasticity of trade to trade costs

Short incursion in microfoundations (3)

- Armington framework
  - Distance coefficent: $\rho(1-\sigma)$
  - σ captures degree of similarity between country-specific product bundles
  - if the set of goods produced by different countries is similar
    $\rightarrow$ high Armington elasticity
    $\rightarrow$ high elasticity of trade to trade costs

- In all cases: elasticity of trade flows to trade costs is inversely related to heterogeneity

Measuring the trade elasticity (1)

- Evolution on the supply side
  - Technological dissimilarity in productivity between sectors or firms
  - Levchenko & Zhang (2016) 1960-2010 in 75 countries: within-country convergence in knowledge shocks between sectors (but not the Eaton & Kortum parameter)
  - Andrews et al. (2016) 1997-2014 OECD: divergence between firm productivity inside sectors. But there are difficulties in interpreting it in the Meltiz framework
- Evolution on the demand side
  - Welsch (2006): among exporters to the French market the lower-tier Armington elastiticy peaked in the 1970s and declined thereafter
  - Broda et al. (2006): compares American imports between 1972-1988 and 1990-2001 they find a decrease
  - These results would deepen the distance puzzle

Measuring the trade elasticity (2)

- Measuring the level of Armington elasticity
  - A perenial question in trade economics from Feenstra (1994) to the review in Feenstra (2018)
  - The canonical method assumes that it is constant through time: that is not interesting for us
  - Feenstra's elasticity parametre determines short-run, marginal, longitudinal effects, whereas we are interested in the parameter that determines long-run, equilibrium, cross-section outcomes
- Our method
  - Measure the evolution of Armington elasticites
  - Its irrelevance in the Meltiz and Eaton & Kortum framework is linked to the specific distribution functon of productivity
  - uses cif unit values and bilateral trade flows to estimate the trade elasticity
  - we need a measure of the aggregate level: that cannot be generally mimicked by a theoretically grounded weighted average of sector-specifie trade elasticities (Imbs & Mjean (2015)). So we assume they are all the same and work on agregrate data

Our equation (1)

- One-good Armington framework. X_{ij} is the cif value of the exports from i to j are:

$$X_{ij} = \left(\frac{P_{ij}}{P_j}\right)^{1-\sigma} Y_j$$

  P_{ij} is the cif price and P_j is the price index in the destination and Y_j total import demand in the destination. The exponent $(1-\sigma)$ is the trade elasticity
- Aggregate exports are the sum of imports from each sector k where a sector corresponds to a SITC 4-digit category: $X_{ij} = \sum_k X_{k,ij}$. Sectoral demand in country in sector for imported goods is given by:

$$Y_{k,j} = \left(\frac{P_{k,j}}{\beta_k P_j}\right)^{1-\sigma} Y_j$$

  Where $P_{k,j}$ and P_j are price indexes, $\beta_k > 0$ is a sector-specific preference parameter, Y_j is total demand for imported goods, $\sigma > 1$ is the elasticity of substitution between sectors.

Our equation (2)

Each country exports a specific national variety. Preferences within each sector k between national varieties are assumed well represented by a CES utility function with the same σ parameter as the intersectoral CES utility function. Intrasectoral demand for varieties exported by i in j in sector k is:

$$X_{k,ij} \quad = \quad \left(\frac{p_{k,ij}}{\gamma_i P_{k,j}}\right)^{1-\sigma} Y_{k,j}$$

Where $\gamma_i > 0$ is a origin-country-specific preference parameter and $P_{k,j}$ is the CES price index:

$$P_{k,j} \quad = \quad \left[\sum_{i \neq j} \left(\frac{p_{k,ij}}{\gamma_i}\right)^{1-\sigma}\right]^{1/(1-\sigma)}$$

Defining $\frac{Y_{k,j}}{Y_j} = \omega_{k,j}$, we get:

$$\frac{X_{k,ij}}{Y_j} \quad = \quad \omega_{k,j} \left(\frac{p_{k,ij}}{\gamma_i P_{k,j}}\right)^{1-\sigma}$$

Our equation (3)

Summing over all SITC 4-digit sectors:

$$\sum_{k=1}^{K} \frac{X_{k,ij}}{Y_j} = \frac{X_{ij}}{Y_j} \quad = \quad \gamma_i^{\sigma-1} \sum_{k=1}^{K} \omega_{k,j} \left[\frac{p_{k,ij}}{P_{k,j}} \right]^{1-\sigma}$$

Changing notation to $\kappa_i = \gamma_i^{\sigma-1}$, the market share becomes, assuming multiplicative errors of measurement:

$$\frac{X_{ij}}{Y_j} \quad = \quad \kappa_i \sum_{k=1}^{K} \omega_{k,j} \frac{p_{k,ij}^{1-\sigma}}{\sum_{l \neq j} \kappa_l p_{k,lj}^{1-\sigma}} . e^{\varepsilon_{i,j}}$$

We take logs to transform the errors into additive ones and estimate the following equation with a non-linear least square procedure year by year:

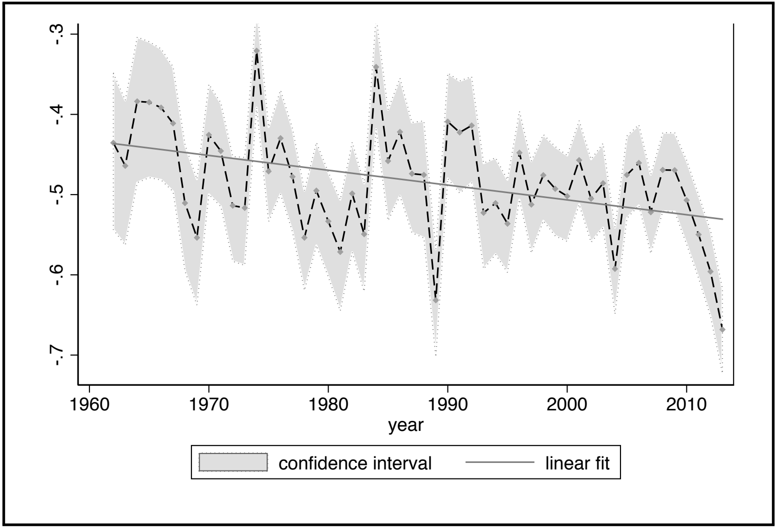
$$\ln \left(\frac{X_{ij}}{Y_j} \right) \quad = \quad \ln \kappa_i + \ln \left(\sum_{k=1}^{K} \frac{Y_{k,j}}{Y_j} . \frac{p_{k,ij}^{1-\sigma}}{\sum_{l \neq j} \kappa_l p_{k,lj}^{1-\sigma}} \right) + \varepsilon_{i,j} \qquad (1)$$

This approach yields annual estimates of κ_i and σ.

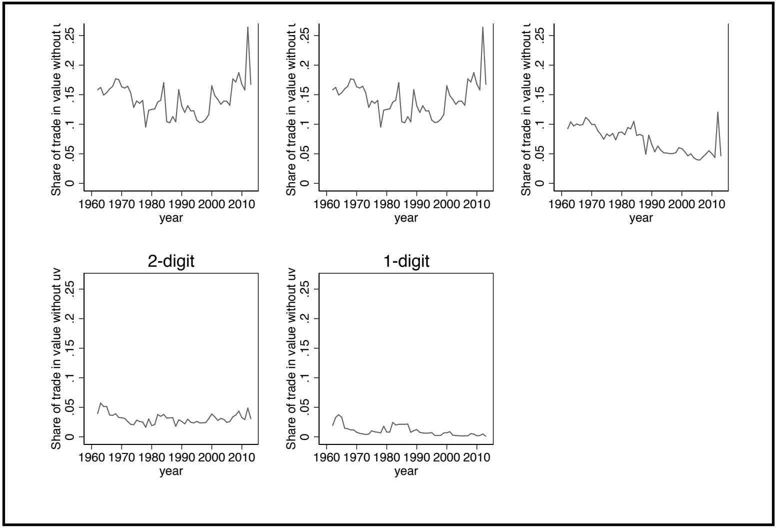
Results

- Benchmark results: $|1-\sigma|$ has increased by 22% from 1962 to 2013
  - Point estimate in the low range $|1-\sigma| \in \{.4, .5\}$
  - For the US, Feenstra (2018) obtain a point estimate in the $\{0.5, 3\}$ range, depending on the estimator used,
  - Imbs & Mjan (2015) obtain a point estimate of $1-\sigma = -2$
- Missing unit values: Trade flow observed, but information on quantities missing
  - we use a stepwise precedure to evaluate missing unit values from similar products
  - $|1-\sigma|$ has increased by 35% from 1962 to 2013
- Zero trade flows: from 96.5% to 91%
  - A priori not compatible with the Armington framework: we assume a statistical threshold
  - To test the robustness of the effect, we use the superbalanced sample: the share of zero trade flows is much smaller (but the rate of decline is similar)
  - $|1-\sigma|$ has increased by 69% from 1962 to 2013
- Bad data ? The increase is faster in BACI (1995-2006): $+1.18\%$ a year instead of $+.4\%$

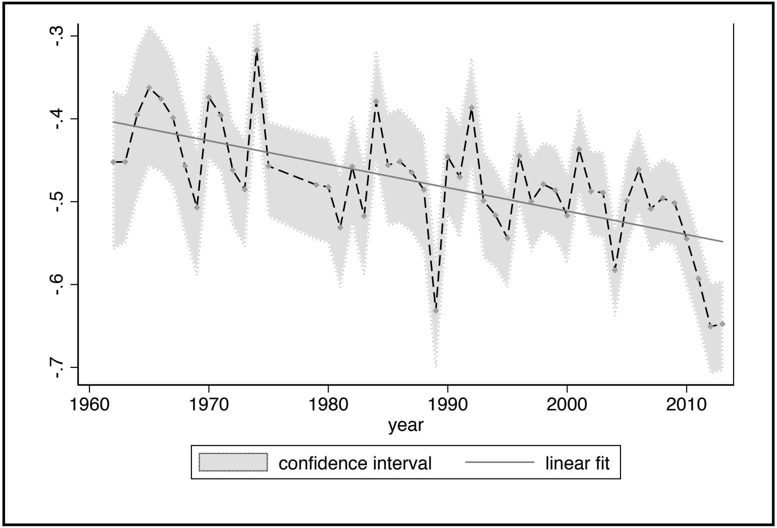
Benchmark results



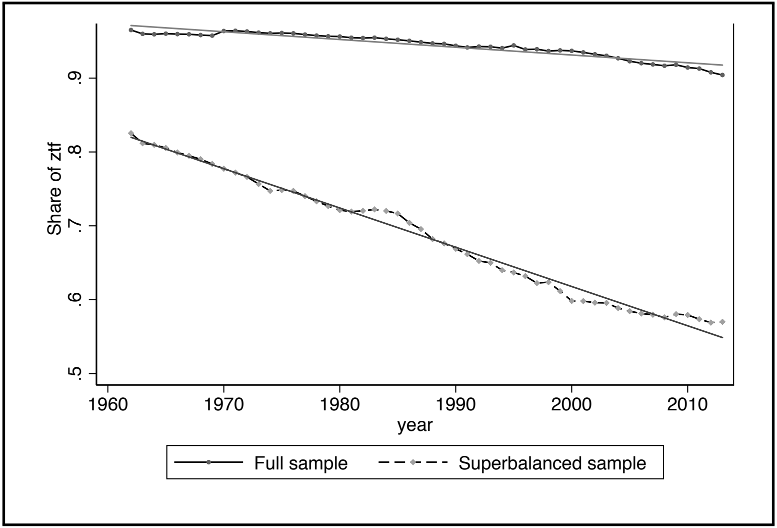
Trade with missing unit values



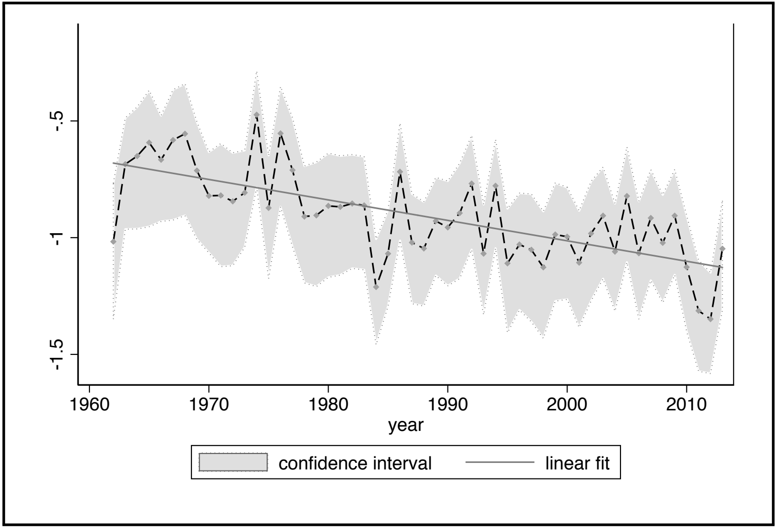
Imputed unit values



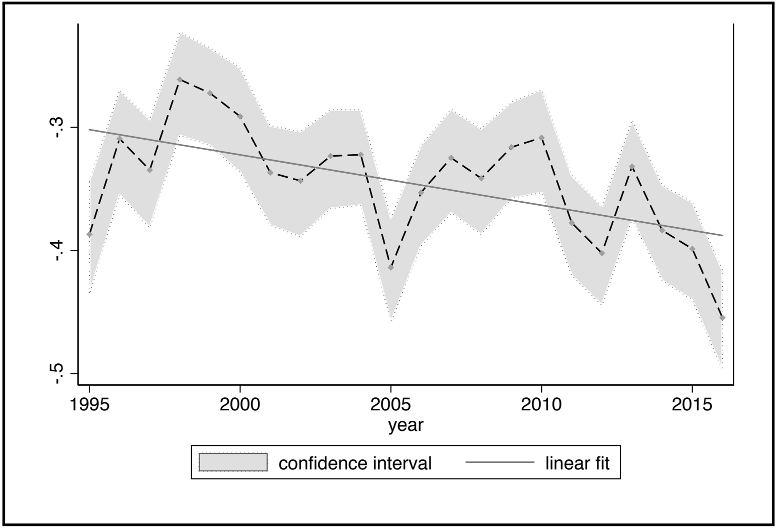
The prevalence of zero trade flows



Regression using the superbalanced sample (testing for ztf)



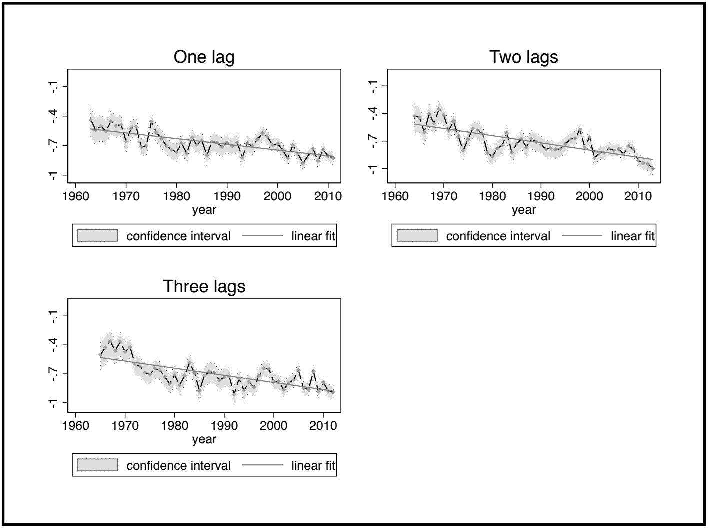
Regression using BACI dataset



Instrumenting: motivation

- Unobserved demand shocks will result in increase in prices and quantities
  - attenuation bias
  - matters not only for level, but also for evolution (Feenstra(1994))
- Objective: capture exporter-specific shocks to the price of the composite good which are not demand-driven
  - GDP price level (Penn World Tables 9.0: 180 countries, 1950-2014)
  - investment price level
  - price evolution in other markets
- We instrument the evolution of cif unit prices by the evolution of GDP prices, investment prices and prices in other markets
  - with varying number of lags
  - we cannot produce the usual statistic tests
  - there is a lot of noise...
  - Still, in the second stage, between 75 and 81% increase

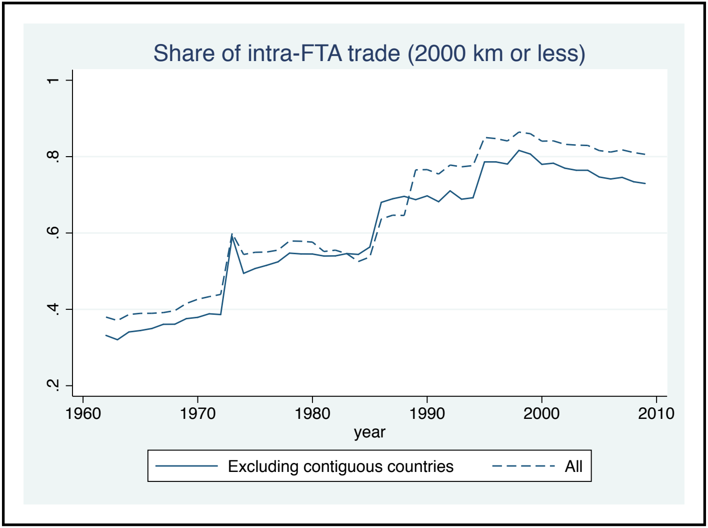
Instrumented regressions



Is there a distance puzzle left?

- What do we have?
  - Empirical evidence on 22 to 81% increase in substitutability parameter
  - This is aggregate trade elasticity in Armington framework
  - Combined with a 4.5 to 31% increase in distance elasticity
  - Provides a direct explanation of the distance puzzle
- What is going on?
  - Perceived increasing similarity in the country-specific bundles
  - Because of the declining importance of location-specific primary products?
  - Because of the geographical dispersion of development?

About FTA



Share of intra-FTA trade (2000 km or less)
1
.8
.6
.4
.2
1960
1970
1980
1990
2000
2010
year
Excluding contiguous countries
All