Gravity Equations: (Theory and) Estimation

YUAN ZI[1]

[1]Graduate Institute of International Studies (yuan.zi@graduateinstitute.ch)

International Trade II, Chapter 6

Introduction

- "A gravity model is typically a log-linear relationship expressing bilateral trade between a pair of countries as a function of the two countries' income level, populations, and distance" Leamer & Levinsohn (1995)

- The good news: Gravity rules!

    - "[These estimates] have produced some of the clearest and most robust empirical finding in economics" Leamer & Levinsohn (1995)

Introduction

Traditional specification (Tinbergen, 1962)

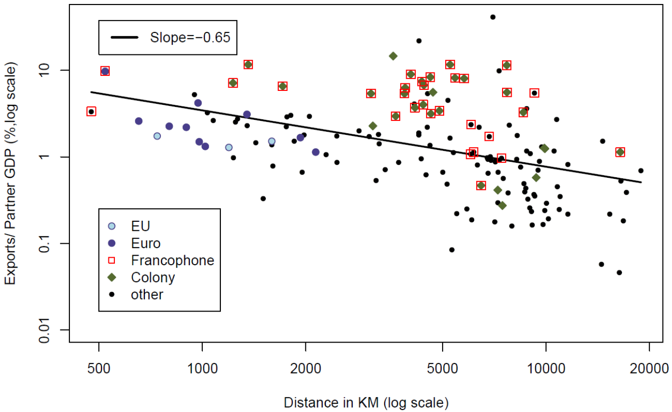
$$\ln X_{ij} = \beta_0 + \beta_1 \ln GDP_i + \beta_2 \ln GDP_j + \beta_3 \ln dist_{ij} + \varepsilon_{ij}$$

Typical estimates:

- $\beta_1, \beta_2 > 0, \beta_3 < 0$
- $\beta_1, \beta_2 \simeq 1, \beta_3 \simeq -1$
- R^2 around 80-90%

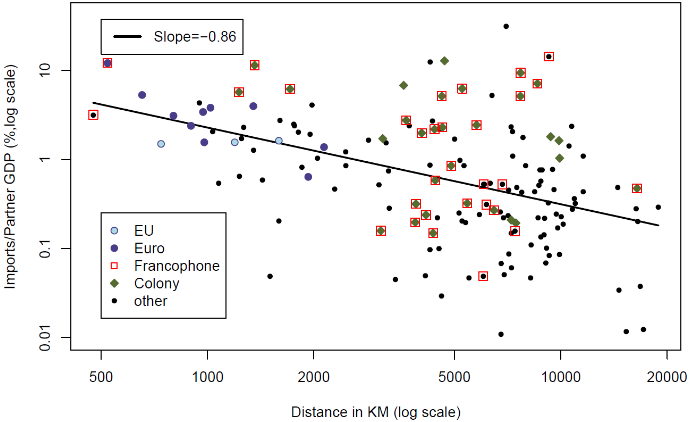
Introduction

France's exports in 2000



Introduction

France's imports in 2000



Gravity and the Margins of Trade

Table 3: Gravity and the Margins of U.S. Exports

	$\ln(\text{Value}_c)$	$\ln(\text{Firms}_c)$	$\ln(\text{Products}_c)$	$\ln(\text{Density}_c)$	$\ln(\text{Intensive}_c)$
$\ln(\text{Distance}_c)$	-1.37	-1.17	-1.10	0.84	0.05
	0.17	0.15	0.15	0.13	0.10
$\ln(\text{GDP}_c)$	1.01	0.71	0.55	-0.48	0.23
	0.04	0.03	0.03	0.03	0.02
Constant	7.82	0.52	3.48	-2.20	6.03
	1.83	1.59	1.55	1.37	1.07
Observations	175	175	175	175	175
R^2	0.82	0.76	0.68	0.66	0.37

Notes: Table reports results of country-level OLS regressions of U.S. exports or their components on trading-partners' GDP and great-circle distance (in kilometers) from the United States. Standard errors are noted below each coeficient. Data are for 2002.

Bernard, Redding and Schott (2008) "Multi-product Firms and Trade Liberalization"

Introduction

It always works, but for a long time, no theory-driven estimations. **However**,

- Recent theoretical and empirical research improved our understanding of the gravity relationship
- We know why it works... most trade models *require* gravity to work
- Gravity influenced theoretical analysis (NEG)

Reading

Head. K. and T. Mayer (2013), “Gravity equations: workhorse, toolkit, and cookbook”, CEPR DP 9322.

See also the associated webpage.

Outline

I - Gravity: general formulations

II - Gravity: specific models (not covered in class)

III - Goodness of fit of modern gravity equations (when trade costs observed)

III - Estimation and specification

IV - Applications

Theoretical foundations: general formulations

Most theories yield a specification of the form

$$X_{ij} = \frac{1}{Y}\frac{Y_i}{\Omega_i}\frac{X_j}{\Phi_j}\phi_{ij}$$

1. the exporter's value of production $Y_i = \sum_j X_{ij}$
2. The importer's total expenditures $X_j = \sum_i X_{ij}$
3. Bilateral accessibility of j to exporter i (i.e. bil. trade costs) ϕ_{ij}
4. "Multilateral resistance" terms: $\Omega_i = \sum_l \frac{\phi_{li} X_l}{\Phi_l}$ and $\Phi_j = \sum_l \frac{\phi_{jl} Y_l}{\Omega_l}$

$\rightarrow$ **Most specific trade models yield such a relationship**

Gravity: specific models

Theoretical foundations: CES demands

- Denote i the exporting country producing a set of varieties indexed h, being consumed in country j
- CES **utility function** is

$$U_j = \left[\int_{i=1}^{N} \int_{h=1}^{n_i} (b_{ij} q_{ijh})^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

$\rightarrow$ Interpret b_{ij}? σ?

Theoretical foundations: CES demands

- The corresponding **demand function** for a given product from country i in country j is

$$q_{ij} = \frac{b_{ij}^{\sigma-1} p_{ij}^{-\sigma}}{\int\limits_{i=1}^{N} \int\limits_{h=1}^{n_i} b_{ij}^{\sigma-1} p_{ijh}^{1-\sigma}} Y_j$$

- Defining the welfare based price index

$$P_j = \left[\int\limits_{i=1}^{N} \int\limits_{h=1}^{n_i} \left(\frac{p_{ijh}}{b_{ij}} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

Theoretical foundations: CES demands

And using the fact that $X_{ij} = q_{ij} p_{ij}$ we now have an equation defining the **value of bilateral imports** for a given variety:

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

$\rightarrow$ **Specific models**?

National Product Differentiation (Anderson and Van Wincoop, 2003)

- As in Argmington (1968), each country is the unique source of each product
- Utility exhibits CES

$$U_j = \left(\sum_i q_{ij}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

- ”Iceberg” trade costs: $p_{ij} = p_i \tau_{ij}$
- “Phiness” of trade: $\phi_{ij} = \tau_{ij}^{1-\sigma}$

Theoretical foundations: CES #1: NPD-AvW

- We get

$$X_{ij} = \frac{(p_i)^{1-\sigma}\phi_{ij}}{P_j^{1-\sigma}} Y_j$$

with the price index: $P_j = \left[\sum_{k=1}^{N} \left(p_k \tau_{kj}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$

Theoretical foundations: CES #1: NPD-AvW

Anderson and Van Wincoop show that, in the special case of symmetric bilateral trade costs, the gravity equation can be rewritten:

$$\boxed{X_{ij} = \left(\frac{\tau_{ij}}{P_j P_i}\right)^{1-\sigma} \frac{Y_i Y_j}{Y^W}}$$

with $P_j = \left[\sum_{i=1}^{N} P_i^{\sigma-1} \tau_{ij}^{1-\sigma} \theta_i\right]^{\frac{1}{1-\sigma}}$ and θ_i denoting the income share of country i

$\rightarrow$ "**<u>multilateral resistance indexes</u>**

Theoretical foundations: CES #1: NPD-AvW

”**Multilateral resistance indexes**”

- Anderson and van Wincoop assume that trade costs are symmetric, and that trade is balanced, then use non-linear least squares to estimate the gravity equation
- Interpretation of these multilateral resistance terms?

Theoretical foundations: CES #2: D-S-K

CES #2: D-S-K (Dixit-Stiglitz-Krugman)

- DSK assumptions yield gravity
- Each country has n_i firms supplying one variety each to the world
- $n_i = \frac{L_i}{\sigma F}$ (what is F?)

We get:

$$\boxed{X_{ij} = n_{ij} x_{ij} = \frac{\left(p_i \tau_{ij}\right)^{1-\sigma}}{P_j^{1-\sigma}} \frac{Y_j L_i}{\sigma F}}$$

Theoretical foundations: Helpman, Melitz and Rubinstein (2008)

- Uses Melitz (2003): heterogeneous firms, monopolistic competition
- *Selection* into exporting: zero trade flows
- Assume productivity defined on $[\varphi_L, \varphi_H]$

$\rightarrow$ Firms export only if $\varphi \geq \varphi^*_{ij}$

Theoretical foundations: Helpman, Melitz and Rubinstein (2008)

Assume that the mass of potential entrants is $N_i = \alpha Y_i$

Bilateral exports (assuming the same G(φ) everywhere):

$$X_{ij} = \frac{\tau_{ij}^{1-\sigma}}{P_j^{1-\sigma}} Y_j N_i \int_{\varphi_{ij}}^{\varphi_H} p_i(\varphi)^{1-\sigma} dG(\varphi)$$

Theoretical foundations: Helpman, Melitz and Rubinstein (2008)

Prices: $p_i(\varphi) = \frac{\sigma}{\sigma-1}\frac{w_i}{\varphi}$

$$X_{ij} = \begin{cases} X_{ij} = \frac{\sigma}{\sigma-1}\frac{w_i^{1-\sigma}\tau_{ij}^{1-\sigma}}{P_j^{1-\sigma}} Y_j \alpha Y_i \int\limits_{\varphi_{ij}}^{\varphi_H} \left(\frac{1}{\varphi}\right)^{1-\sigma} dG(\varphi) & \text{if} \quad \varphi_{ij} > \varphi_L \\ X_{ij} = 0 & \text{if} \quad \varphi_{ij} \leq \varphi_L \end{cases}$$

$\rightarrow$ 2 issues: (i) omitted variables (ii) selection bias

HMR assume that $G(\varphi)$ is Pareto distributed with a shape parameter (inverse measure of heterogeneity)

Goodness of fit of gravity equations

Goodness of Fit of Gravity Equations

- Lai and Trefler (2002, unpublished) discuss (among other things) the fit of the gravity equation.

- Using the notation in Anderson and van Wincoop (2004, JEL), but study imports (M) into i from j rather than exports:

$$M_{ij}^k = \frac{E_i^k Y_j^k}{Y^k} \left(\frac{\tau_{ij}^k}{P_i^k \Pi_j^k}\right)^{1-\epsilon^k}$$

  - Where P_i^k and Π_j^k are price indices (that of course depend on E, M and τ).
  - Y^k is total world income/expenditure.
  - τ_{ij}^k here refers to tariffs.

Goodness of Fit of Gravity Equations

$$M_{ij}^k = \frac{E_i^k Y_j^k}{Y^k} \left(\frac{\tau_{ij}^k}{P_i^k \Pi_j^k} \right)^{1-\epsilon^k}$$

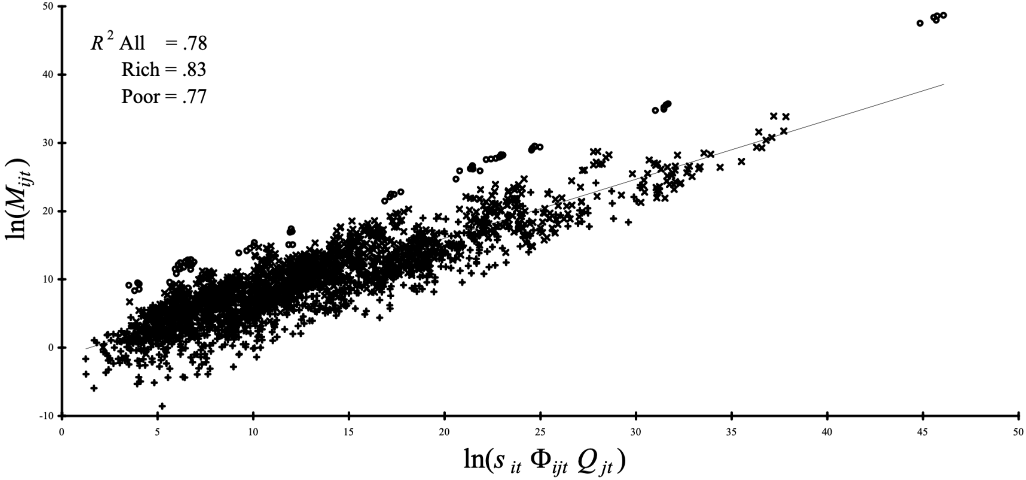
- Lai and Trefler (2002) discuss the fit of this equation, and then divide up the fit into 3 parts (mapping to their notation):
  1. $Q_j^k \equiv Y_j^k$. Fit from this, they argue, is uninteresting due to the “data identity” that $\sum_i M_{ij}^k = Y_j^k$.
  2. $s_i^k \equiv E_i^k$. Fit from this, they argue, is somewhat interesting as it’s due to homothetic preferences. But not *that* interesting.
  3. $\Phi_{ij}^k \equiv \left(\frac{\tau_{ij}^k}{P_i^k \Pi_j^k} \right)^{1-\epsilon^k}$. This, they argue, is the interesting bit of the gravity equation. It includes the partial-equilibrium effect of trade costs τ_{ij}^k, as well as the general equilibrium effects in P_i^k and Π_j^k.

Lai and Trefler (2002): Other Notes

- Other notes on their estimation procedure:
  - They use 3-digit manufacturing industries (28 industries), every 5 years from 1972-1992, 14 importers (OECD) and 36 exporters. (Big constraint is data on tariffs.)
  - They assume that trade costs τ_{ij}^k (which could, in principle, include transport costs, etc) is just equal to tariffs.
  - They estimate one parameter ϵ^k per industry k.
  - They also allow for unrestricted taste-shifters by country (fixed over time).
  - Note that the term Φ_{ij}^k is highly non-linear in parameters. So this is done via NLS. But that isn't strictly necessary because one could instead use the normal gravity method of regressing lnM_{ij}^k on $ln\tau_{ij}^k$ using OLS with ik and jk fixed-effects.

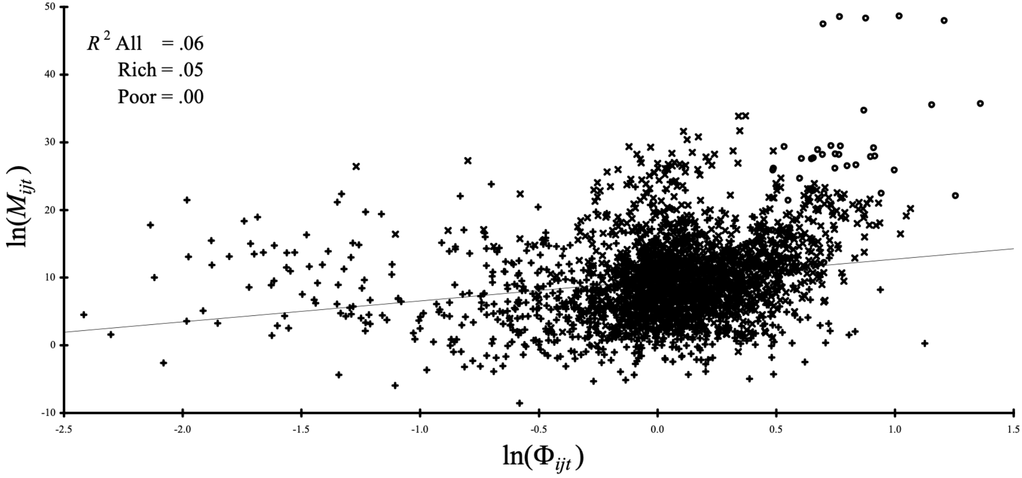
Lai and Trefler (2002): Results

Overall fit, pooled cross-sections



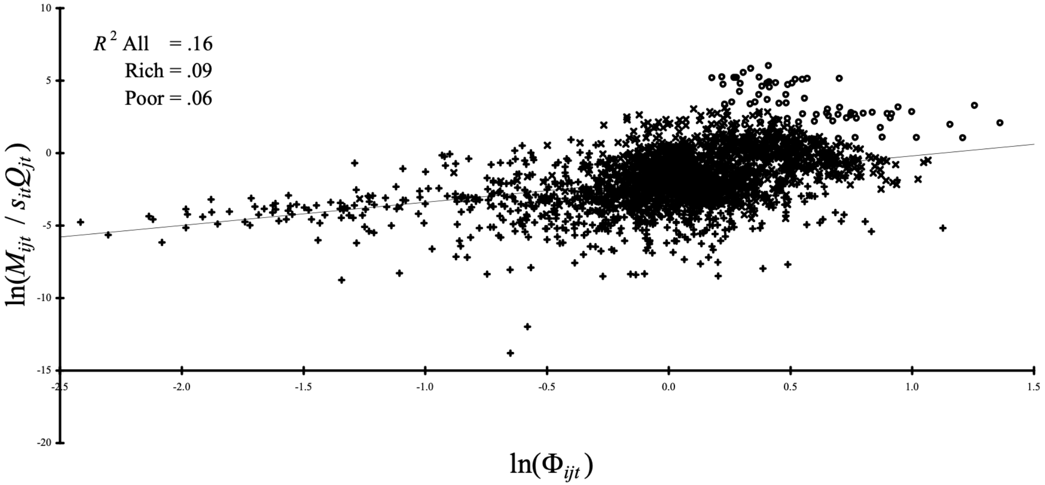
Lai and Trefler (2002): Results

Fit from just Φ_{ij}^{k}, pooled cross-sections



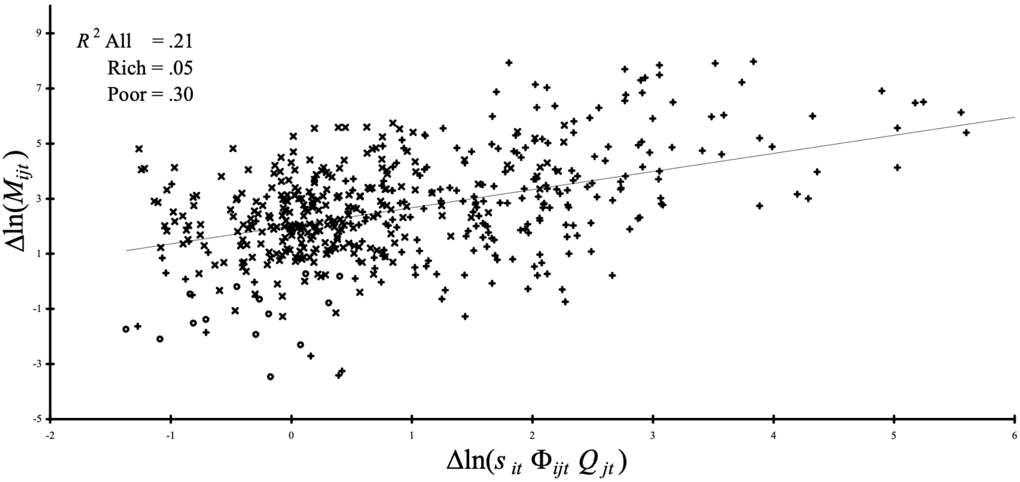
Lai and Trefler (2002): Results

Fit from just Φ_{ij}^{k}, but controlling for s_{it}^{k} and Q_{it}^{k}, pooled cross-sections



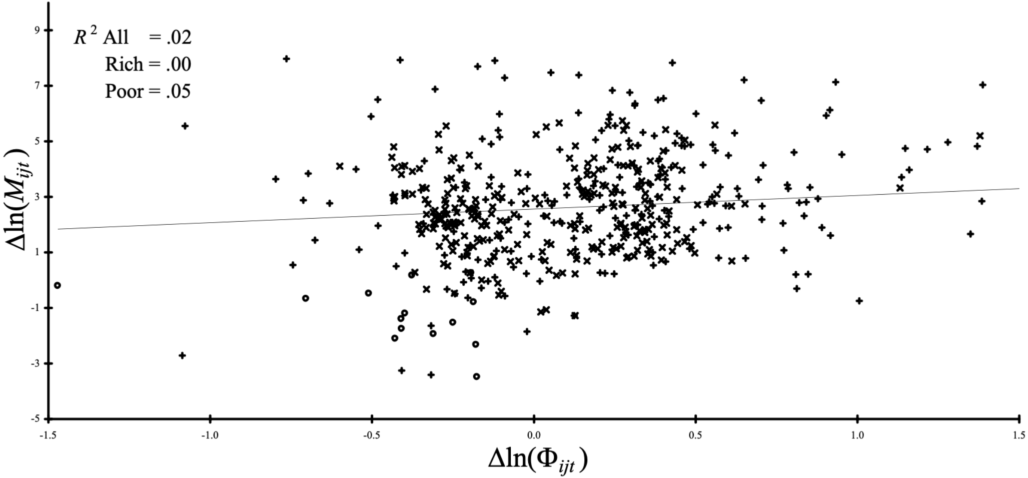
Lai and Trefler (2002): Results

Overall fit, long differences



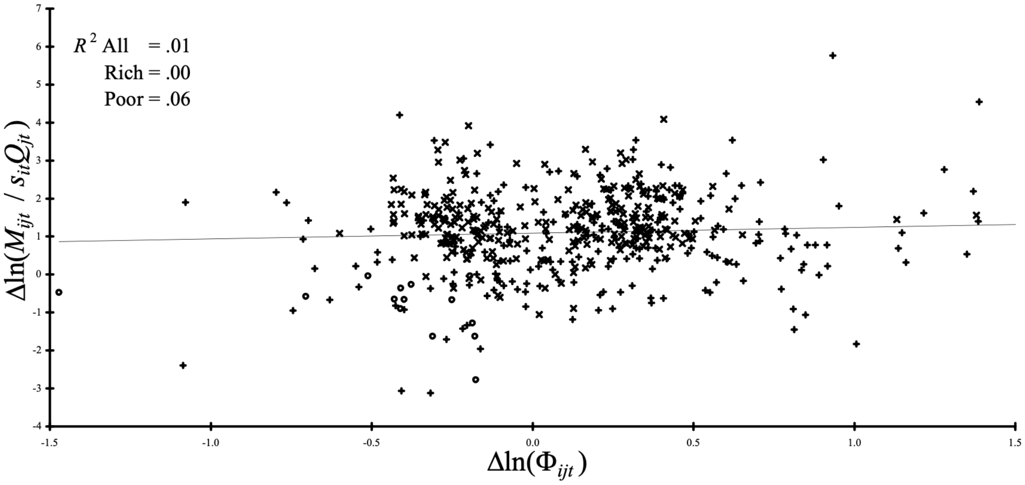
Lai and Trefler (2002): Results

Fit from just Φ_{ij}^k, long differences



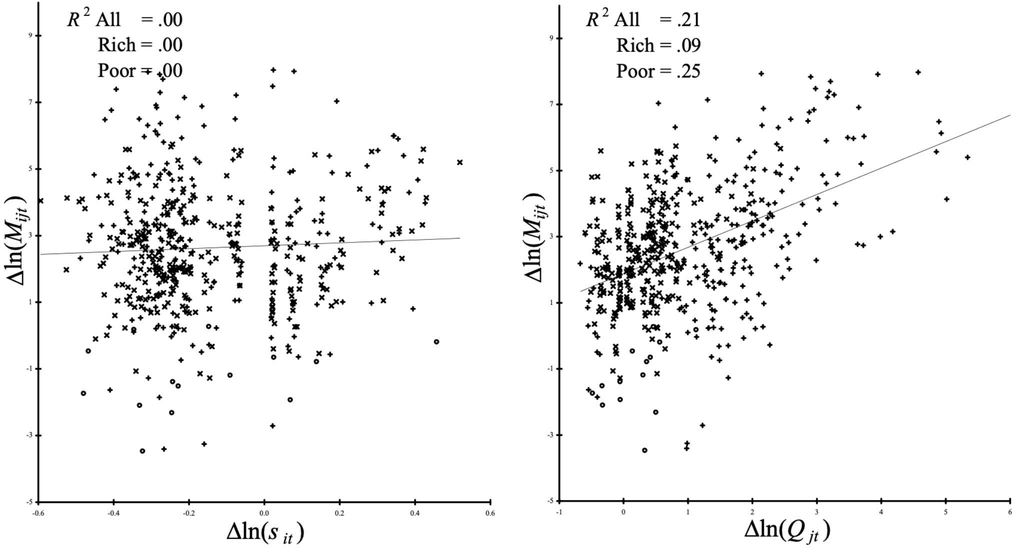
Lai and Trefler (2002): Results

Fit from just Φ_{ij}^{k}, but controlling for s_{it}^{k} and Q_{it}^{k}, long differences



Lai and Trefler (2002): Results

Is fit over long diffs driven by s_{it}^k or Q_{it}^k?



Estimation and specification issues

Estimation methods

- The general form of the gravity equation is

$$X_{ij} = \frac{1}{Y}\frac{Y_i}{\Phi_i}\frac{Y_j}{\Phi_j}\phi_{ij}$$

- Taking logs

$$\ln X_{ij} = \ln Y + \ln \frac{Y_i}{\Phi_i} + \ln \frac{Y_j}{\Phi_j} + \ln \phi_{ij}$$

Estimation methods

$$\ln X_{ij} = \ln Y + \ln \frac{Y_i}{\Phi_i} + \ln \frac{Y_j}{\Phi_j} + \ln \phi_{ij}$$

- Tradition: using ln GDPs (and possibly other variables, such as GDP per capita) as proxies for $\ln \frac{Y_i}{\Phi_i}$ and $\ln \frac{Y_j}{\Phi_j}$
- With GDPs only, omitted variable bias: "**gold medal mistake**"
- What bias? Solution?

Estimation methods

Method matters for the interpretation of coefficients. Take AvW (2003):

$$X_{ij} = \frac{Y_i Y_j}{Y} \left(\frac{\phi_{ij}}{\Phi_i \Phi_j} \right)$$

- Bilateral trade is increasing in the ”remoteness” of the pair $\frac{1}{\Phi_i \Phi_j}$. When omitted, all ϕ_{ij} variables that affect trade positively will tend to be biased downwards if they are negatively correlated with remoteness, and vice-versa

- With $\phi_{ij} = \tau_{ij}^{1-\sigma}$, estimation of σ is possible if one has data on direct price shifter like tariffs

Estimation methods

Main solutions:

1. Include proxies for Φ_i and Φ_j such as “Remoteness indexes”, e.g the inverse of Harris market potential $\sum_i Y_i / Dist_{ji}$
2. Ratio-type estimation
3. More fancy approximation of the multilateral resistance terms
4. Fixed effects estimations

Estimation methods

Main solutions:

1. Include proxies for Φ_i and Φ_j such as "remoteness indexes", e.g the inverse of Harris market potential $\sum_i Y_i / Dist_{ji}$

Problem: doesn't take the theory seriously... why?

Estimation methods

"Ratio-type gravity"

- One can use the multiplicative structure of the gravity model to get rid of trouble terms

- Bilateral "relative" imports by country j from country i for a given industry / year (Head and Mayer, 2001)

$$\frac{X_{ij}}{X_{jj}} = \frac{n_i}{n_j}\left(\frac{p_i}{p_j}\right)^{1-\sigma}\left(\frac{\phi_{ij}}{\phi_{jj}}\right) \qquad (8)$$

Estimation methods

"Ratio-type gravity"

- Problem: we need to observe "trade with self"
- But these manipulations can be done with any **reference country** (Martin et al., 2008)

$$\frac{X_{ij}}{X_{USj}} = \frac{n_i}{n_{US}} \left(\frac{p_i}{p_{US}}\right)^{1-\sigma} \left(\frac{\phi_{ij}}{\phi_{USj}}\right)$$

Estimation methods

“Bonus Vetus OLS”, Baier and Bergstrand, 2009

B&B Approximate the multilateral resistance terms using a first-order log linear Taylor series expansion. They show that if trade costs are symmetric:

$$\ln \Pi_i = \sum_{j=1}^{N} \theta_j \ln \tau_{ij} - \frac{1}{2} \sum_{k=1}^{N} \sum_{m=1}^{N} \theta_k \theta_m \tau_{km} \quad i = 2, ..., N$$

$$\ln P_j = \sum_{i=1}^{N} \theta_i \ln \tau_{ij} - \frac{1}{2} \sum_{k=1}^{N} \sum_{m=1}^{N} \theta_k \theta_m \tau_{km}, quadj = 2, ..., N$$

Estimation methods

Fixed effects estimation

- Include in the estimation fixed effects of the dimension of Φ_i and Φ_j
- In a cross-section, means including importer and exporter FE
- With panel data, importer $\times$ year and exporter $\times$ year FE
- No structural assumption on the underlying model, and can capture potential country-specific determinants of trade
- Problem: computational difficulties (imagine a model with 150 countries and 50 years...)
- Use **reg2hdfe** or **reg3hdfe**

Estimation methods

Fixed effects estimation

- Issue with these approaches?
- What if we want to identify country-specific effects (income elasticities, effect of financial crises, effect of institutional determinants)
- A possibility is to estimate the specific with FE, and then regress the FE on the (country-specific) variable of interest

Method matters: Rose (2004), AER

Table 1: Benchmark Results

	Default	No Industrial Countries	Post '70	With Country Effects
Both in GATT/WTO	-.04 (.05)	-.21 (.07)	-.08 (.07)	.15 (.05)
One in GATT/WTO	-.06 (.05)	-.20 (.06)	-.09 (.07)	.05 (.04)
GSP	.86 (.03)	.04 (.10)	.84 (.03)	.70 (.03)
Log Distance	-1.12 (.02)	-1.23 (.03)	-1.22 (.02)	-1.31 (.02)
Log product Real GDP	.92 (.01)	.96 (.02)	.95 (.01)	.16 (.05)
Log product Real GDP p/c	.32 (.01)	.20 (.02)	.32 (.02)	.54 (.05)
Regional FTA	1.20 (.11)	1.50 (.15)	1.10 (.12)	.94 (.13)
Currency Union	1.12 (.12)	1.00 (.15)	1.23 (.15)	1.19 (.12)
Common Language	.31 (.04)	.10 (.06)	.35 (.04)	.27 (.04)
Land Border	.53 (.11)	.72 (.12)	.69 (.12)	.28 (.11)

Method matters: Baier and Bergstrand (2009), JIE

Table 1
Estimation results: Canada–U.S

Parameters	(1) OLS w/o MR terms	(2) A-vW NLS-2	(3) A-vW NLS-3	(4) OLS with MR terms	(5) Fixed effects	(6) A-vW NLS-2-a	(7) OLS with MR terms-a
$-\rho(\sigma-1)$ for	−1.06	−0.79	−0.82	−0.82	−1.25	−0.92	−1.02
distance	(0.04)	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)
$-\alpha(\sigma-1)$ for	−0.71	−1.65	−1.59	−1.11	−1.54	−1.65	−1.24
border	(0.06)	(0.08)	(0.08)	(0.07)	(0.06)	(0.07)	(0.07)
Avg. error terms							
US–US	−0.21	0.06	0.06	0.39	0.00	0.05	0.27
CA–CA	1.95	−0.17	−0.02	−0.34	0.00	−0.22	−0.23
US–CA	0.00	−0.05	−0.04	−0.50	0.00	−0.04	−0.35
R^2	0.42	n.a.	n.a.	0.36	0.66	n.a.	0.60
No. of obs.	1511	1511	1511	1511	1511	1511	1511

Numbers in parentheses are standard errors of the estimates. n.a. denotes not applicable.

Method matters: Martin, Mayer, Thoenig (2008), REStud

Impact of militarized interstate dispute on trade

	Dependent variables			
	ln imports		$\ln m_{ijt}/m_{iut}$	
	Model (1)	Model (2)	Model (3)	Model (4)
ln GDP origin	0·959***	0·940***	1·001***	0·976***
	(0·006)	(0·007)	(0·007)	(0·008)
ln GDP destination	0·847***	0·846***	—	—
	(0·006)	(0·007)	—	—
ln distance	−1·008***	−0·991***	−1·188***	−1·158***
	(0·017)	(0·019)	(0·018)	(0·019)
Contiguity	0·452***	0·412***	0·663***	0·680***
	(0·075)	(0·078)	(0·066)	(0·069)
Similarity in language index	0·331***	0·301***	0·128**	0·112*
	(0·070)	(0·074)	(0·062)	(0·065)
Colonial link ever	1·121***	1·060***	0·302***	0·257***
	(0·088)	(0·093)	(0·061)	(0·063)
Common colonizer post-1945	0·568***	0·499***	0·545***	0·450***
	(0·058)	(0·064)	(0·063)	(0·069)
Preferential trade arrangement	0·545***	0·539***	0·441***	0·426***
	(0·049)	(0·052)	(0·049)	(0·053)
Number of GATT/WTO members	0·204***	0·223***	0·337***	0·364***
	(0·021)	(0·022)	(0·034)	(0·036)
One communist regime among partners	−0·399***	−0·422***	−0·720***	−0·767***
	(0·032)	(0·034)	(0·045)	(0·045)
bil. MID + 0 years	−0·245***	−0·244***	−0·485***	−0·434***
	(0·059)	(0·044)	(0·036)	(0·032)

Estimation methods

Other problem: heteroscedasticity (pointed out by Santos Silva and Tenreyro (2006))

- Problems with log-specification: heteroskedasticity
  - ... which may lead to inconsistent OLS estimates of log-linearized models due to heteroscedasticity
- Why? Because the expected value of the log of a random var. depends on its mean and on higher order moments of the distribution
- More precisely, $E[\log(u|X)] \simeq \log[E(u|X)] - \frac{\text{Var}(u|X)}{2E(u|X)}$
- **Poisson pseudo-maximum likelihood estimations** (PPML) or Gamma PML

Estimation methods

Problem with log-specification: zeros

- Log of zero does not exist... but we observe zeros in trade data
- At the aggregated level only 50% of possible trade lines are filled
- What to do with these zeros?

Estimation methods: zero trade flows

What to do with these zeros?

- Drop them? Selection bias
- Assume they are small positive trade flows: replace all observations by $x + 1$: inconsistent estimator
- Use an estimator that allows the inclusion of zeros (PPML or Tobit)
- Control for selection bias? Heckman model: need an exclusion variable (which explains the selection but not the value of traded flow). Problems with Heckman model?
- Related question: where do the zeros come from? “Real” zeros or statistical issue?

Gravity equations: applications

The gravity equation: what for?

Estimate / evaluate the impact of trade barriers

- Direct estimation: influence of RTAs, tariffs, exchange rate volatility
- Estimate parameters of trade model (σ)
- Measure border effects
- Proxies of trade costs: influence of distance, cultural proximity (language, colonial links, migrations, etc...)

The gravity equation: what for?

Measuring the influence of distance

- Consider the real extent of globalization: is the world really flat?

Evaluating (overall) trade barriers

- Track informal barriers (norms, administrative barriers, etc)
- Border effects

Measuring the impact of joining WTO, FTA, Monetary Union

Estimating the effect of the financial crisis

Meta-analysis of gravity variables (Head and Mayer, 2013)

Table 4: Estimates of typical gravity variables

	All Gravity				Structural Gravity			
Estimates:	median	mean	s.d.	#	median	mean	s.d.	#
Origin GDP	.97	.98	.42	700	.86	.74	.45	31
Destination GDP	.85	.84	.28	671	.67	.58	.41	29
Distance	-.89	-.93	.4	1835	-1.14	-1.1	.41	328
Contiguity	.49	.53	.57	1066	.52	.66	.65	266
Common language	.49	.54	.44	680	.33	.39	.29	205
Colonial link	.91	.92	.61	147	.84	.75	.49	60
RTA/FTA	.47	.59	.5	257	.28	.36	.42	108
EU	.23	.14	.56	329	.19	.16	.5	26
CUSA/NAFTA	.39	.43	.67	94	.53	.76	.64	17
Common currency	.87	.79	.48	104	.98	.86	.39	37
Home	1.93	1.96	1.28	279	1.55	1.9	1.68	71

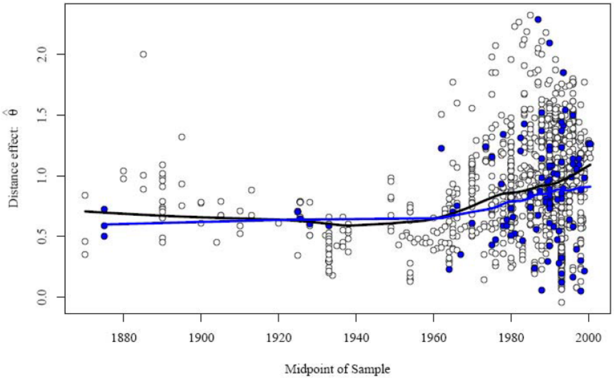
Notes: The number of estimates is 2508, obtained from 159 papers. Structural gravity refers here to some use of country fixed effects or ratio-type method.

The impact of distance: Disdier & Head (2008, Restat)

Meta Analysis: examine 1467 distance effects estimated in 103 papers

Finding: the estimated negative impact of distance on trade actually **rose** aroun[d] the middle of the XXth century

Solid point: highest R^2 in the paper



The gravity equation: what for?

Impact of currency unions on bilateral trade: Rose (2000, Economic Policy)

- Very simple analysis of the impact of CUs
- Focus on *all* existing unions (but discussion oriented toward the EMU)
- Very basic methodology: create a dummy CU. plug it into a gravity equation, estimate with OLS

$$\ln(x_{ij}) = \alpha_1 \ln GDP_i + \alpha_2 \ln GDP_j + \alpha_3 \ln Dist_{ij} + +\alpha_4 CU_{ij} + X_{ij} + \varepsilon_{ij}$$

- Belonging to a CU multiplies bilateral trade by $\exp(\alpha_4)$

The impact of CU: Rose (2000, Economic Policy)

Belonging to a CU multiplies trade by $e^{1.21}=3.35$!

Problems with Rose's methodology?

	1970	1975	1980	1985	1990	Pooled
Currency Union γ	.87	1.28	1.09	1.40	1.51	1.21
	(.43)	(.41)	(.26)	(.27)	(.27)	(.14)
Exchange Rate Volatility δ	-.062	.001	-.060	-.028	-.009	.017
	(.012)	(.008)	(.010)	(.005)	(.002)	(.002)
Output b_1	.77	.81	.81	.80	.83	.80
	(.02)	(.01)	(.01)	(.01)	(.01)	(.01)
Output/Capita b_2	.65	.66	.61	.66	.73	.66
	(.03)	(.03)	(.02)	(.02)	(.02)	(.01)
Distance b_3	-1.09	-1.15	-1.03	-1.05	-1.12	-1.09
	(.05)	(.04)	(.04)	(.04)	(.04)	(.02)
Contiguity b_4	.48	.36	.73	.52	.63	.53
	(.21)	(.19)	(.18)	(.18)	(.18)	(.08)
Language b_5	.56	.36	.28	.36	.50	.40
	(.10)	(.10)	(.09)	(.08)	(.08)	(.04)
FTA b_6	.87	1.02	1.26	1.21	.67	.99
	(.16)	(.21)	(.16)	(.17)	(.14)	(.08)
Same Nation b_7	1.02	1.37	1.12	1.36	.88	1.29
	(.74)	(.59)	(.38)	(.64)	(.52)	(.26)

The gravity equation: the effect of currency unions

Obvious critics

- *Awkward data*: most of the common currency pairs involved nations that were very small / very poor
- *Omitted variables*: that are pro-trade and correlated with CU dummy; biases the estimates upward (e.g. trust, peaceful relations, etc)
- *Reverse causality*: large bilateral flows cause a CU...
- *Model mis-specification*

Hub and Spoke arrangements		**Multilateral currency unions**	**Misc.**
√ **Australia**	√ **USA**	**CFA**	√ **India**
Christmas Island	American Samoa	√ Benin	√ Bhutan
Cocos (Keeling) Islands	Guam	√ Burkina Faso	√ **Denmark**
Norfolk Island	√ US Virgin Islands	√ Cameroon	Faeroe Islands
√ Kiribati	Puerto Rico	√ Central African Republic	√ Greenland
√ Nauru	Northern Mariana Islands	√ Chad	**Turkey**
√ Tuvalu	√ British Virgin Islands	Comoros	N. Cyprus
Tonga (pre '75)	√ Turks & Caicos	√ Congo	**Singapore**
√ **France**	√ Bahamas	√ Cote d'Ivoire	Brunei
√ French Guyana (OD)	Bermuda	Equatorial Guinea (post '84)	**Norway**
√ French Polynesia	√ Liberia	√ Gabon	Svalbard
√ Guadeloupe (OD)	Marshall Islands	Guinea-Bissau	**South Africa**
Martinique (OD)	Micronesia	√ Mali (post '84)	Lesotho
Mayotte	Palau	√ Niger	Namibia
√ New Caledonia (OT)	√ Panama	√ Senegal	Swaziland
√ Reunion (OD)	√ Barbados	√ Togo	**Switzerland**
Andorra	√ Belize	**ECCA**	Liechtenstein
√ St.Pierre & Miquelon	√ **Britain**	√ Anguilla	**Spain**
Wallis & Futuna Islands	√ Falkland Islands	√ Antigua and Barbuda	Andorra
Monaco	√ Gibraltar	√ Dominica	**Singapore**
√ **New Zealand**	Guernsey	√ Grenada	Brunei
√ Cook Islands	Jersey	√ Montserrat	**Italy**
√ Niue	Isle of Man	√ St. Kitts and Nevis	San Marino
Pitcairn Islands	√ Saint Helena	√ St. Lucia	Vatican

The impact of CU: Rose and Van Wincoop (2001)

Table 1: Impact of Currency Union on International Trade, 1970-1995

Currency Union Dummy	1.38 (.19)	.86 (.19)
Log Distance	-1.06 (.03)	-1.31 (.03)
Log Product Real GDP	.94 (.01)	1.06 (.04)
Common Language Dummy	.56 (.06)	.48 (.06)
Common Land Border Dummy	.63 (.12)	.30 (.13)
Free Trade Agreement Dummy	1.09 (.10)	.46 (.12)
Common Colonizer Dummy	.41 (.08)	.68 (.08)
Ex-Colony/ Colonizer Dummy	1.97 (.13)	1.74 (.13)
Political Union Dummy	.95 (.37)	.81 (.32)
Log Product Real GDP/capita	.48 (.02)	
Number landlocked	-.32 (.04)	
Log of Land Area Product	-.15 (.01)	
RMSE	1.97	1.74
R^2	.64	.72
Observations	31,101	31,101
	Time Effects	Time, Country Effects

« Gold Medal » Mistake: Rose (2000) omitted country FE

The effect drops… the estimates were severely biased upwards

…but the effect is still very large

Without FE: Trade * 3.97

With FE: Trade*2.36

Other ways to control for omitted variable bias?

The gravity equation: the effect of currency unions

Omitted variables

- Simple solution: dyadic fixed effects
- Will control for anything that does not vary over time and affects bilateral trade
- Glick and Rose (2000, European Economic Review): coefficient decrease to 0.65: CU increase trade by 90%

The gravity equation: the effect of currency unions

Omitted variable

- Volker Nitsch (”Honey, I shrunk the currency union effect on trade”)
- Finds that exit have a very negative impact, entry have an insignificant one
- Exit often go together with time-varying troubles (political, etc)

The gravity equation: the effect of currency unions

Self-selection

- CU pairs are very unusual countries: very small country, nearby a one, that trade a lot
- The “experiment” CU is by no way random (self selection)
- Solution: **Matching.** Find for each pair of country the most proximate country pair which is not a CU

Self-selection

– Persson (2001)

First Step: Probability of joining a CU

Table 2. Propensity score (logit parameter estimates)

Output	−0.240
	(0.033)
Output/per capita	−0.168
	(0.058)
Distance	−1.016
	(0.088)
Contiguity	−0.390
	(0.278)
Language	1.743
	(0.208)
Free trade area	−1.431
	(0.292)
Same nation	6.246
	(0.546)
Same colonizer	1.401
	(0.203)
Colonial relation	−1.817
	(0.695)
No. Obs.	26 607
Pseudo R^2	0.489

Note: Standard errors in brackets.

The gravity equation: the effect of RTAs

Effects of Regional Trade Agreements

- Previous discussion on CU also applied to RTAs

Table 4
Panel gravity equations in levels using various specifications

Variable	(1) No fixed or time effects	(2) With time effects	(3) With bilateral fixed effects	(4) With time and bilateral fixed effects
ln $RGDP_i$	0.95 (217.50)	0.97 (230.98)	0.71 (34.54)	1.27 (47.16)
ln $RGDP_j$	0.94 (224.99)	0.97 (235.43)	0.58 (26.57)	1.22 (41.60)
ln $DIST_{ij}$	−1.03 (−79.09)	−1.01 (−78.60)		
ADJ_{ij}	0.41 (8.23)	0.38 (7.28)		
$LANG_{ij}$	0.63 (19.06)	0.58 (17.73)		
FTA_{ij}	0.13 (3.73)	0.27 (7.19)	0.51 (10.74)	0.68 (14.27)
RMSE	1.9270	1.8601		
Overall R^2	0.6575	0.6809		
Within R^2			0.2036	0.2268
No. observations	47,081	47,081	47,081	47,081

t-statistics are in parentheses. The dependent variable is the (natural log of the) real bilateral trade flow from i to j. Coefficient estimates for various fixed/time effects are not reported for brevity.

Acknowledgment

Slides of this course are inspired by those taught by N. Berman, T. Chaney, M. Crozet, D. Donaldson, T. Mayer, I. Mejean