Gravity and gravitas

Course "Text-as-data analysis of international trade"

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Course outline

1. Preferential Trade Agreements and International Economic Order
2. **Gravity and Gravitas**
3. Text factorisation — I: Bag-of-words methods
4. Text factorisation — II: Distributive semantics
5. Welfare effects of Preferential Trade Agreements

Outline

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Gravity: from physics to economics

- Newton's Law of Gravitation:

$$F_{i,j} = G\frac{m_i m_j}{r_{i,j}^2},$$

where $F_{i,j}$ is gravitational force applied to object j by object i, m_i is the mass of object i, $r_{i,j}$ is distance between objects i and j, G is gravitational constant

- Tinbergen (1962):

$$X_{i,j} = G\frac{Y_i Y_j}{\phi_{i,j}},$$

where $X_{i,j}$ are exports of country i to country j, Y_i is GDP of country i, $\phi_{i,j}$ is trade costs between i and j (distance in the original rendition)

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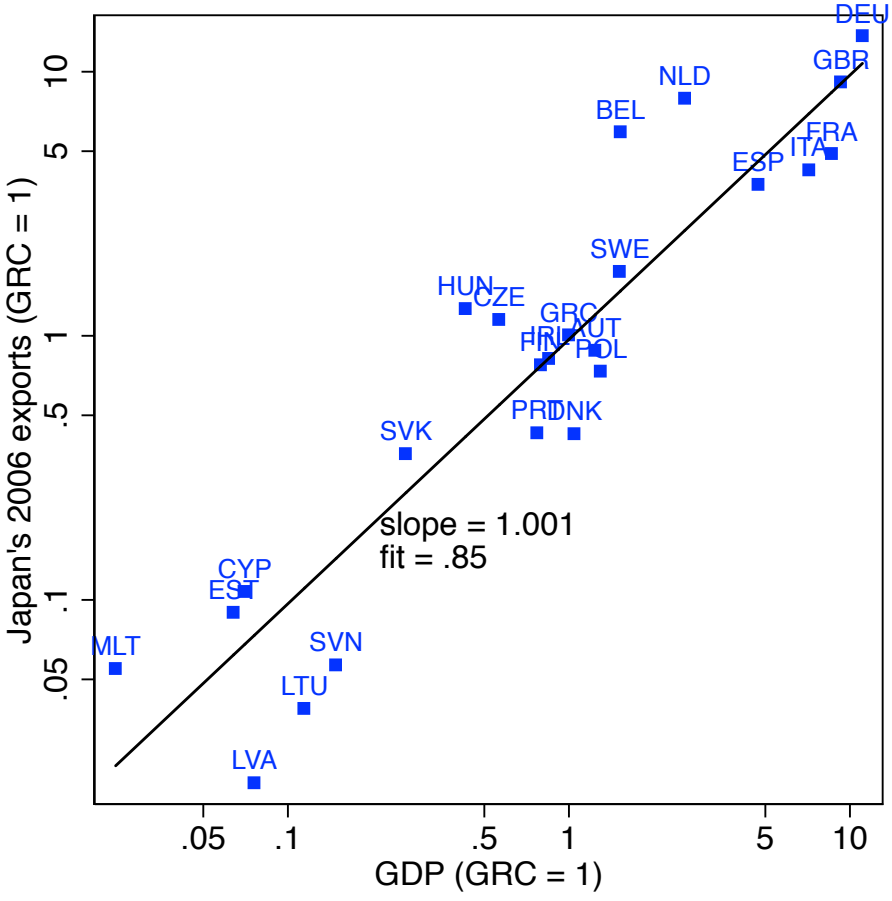
Figure 1: Trade and economy size (Head and Mayer, 2014, fig. 1)

(a) Japan's exports to EU, 2006



(b) Japan's imports from EU, 2006

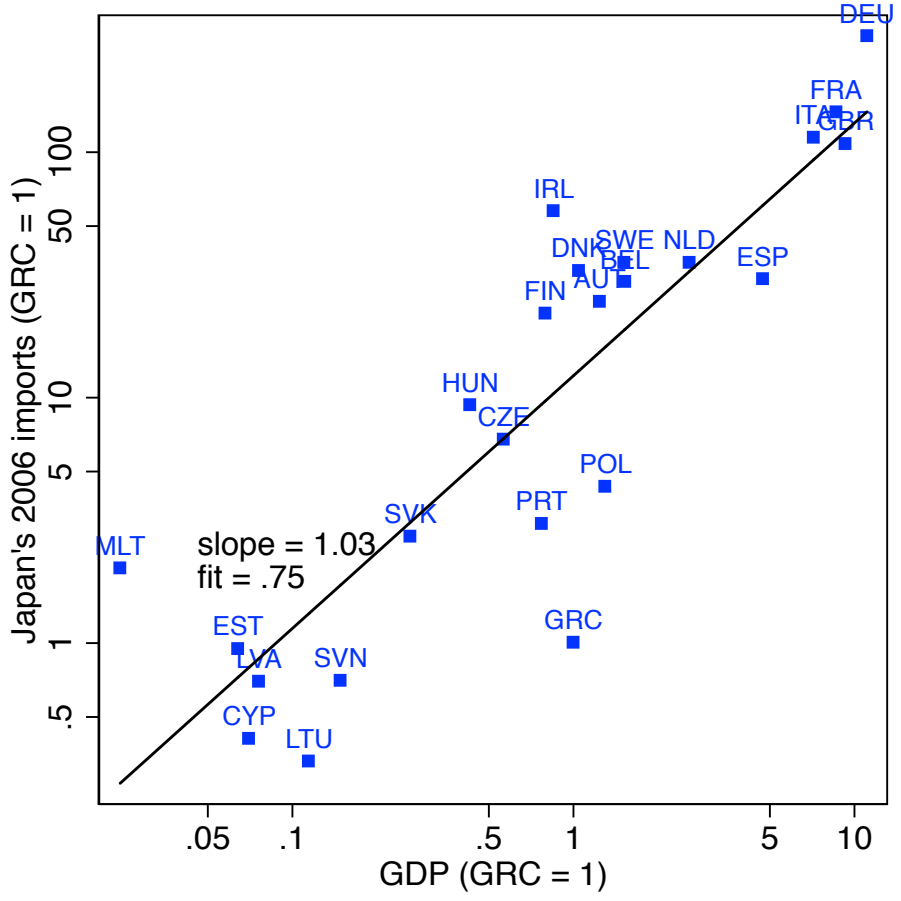
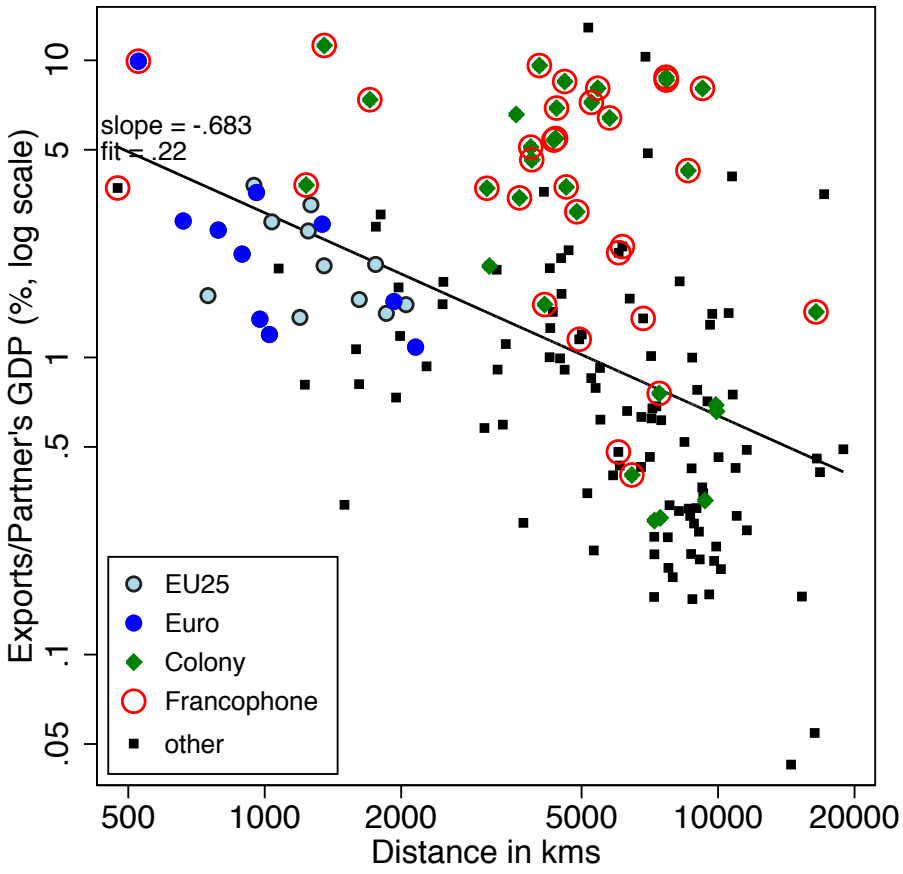


Figure 2: Trade and distance (Head and Mayer, 2014, fig. 2)

(a) France's exports (2006)



(b) France's imports (2006)

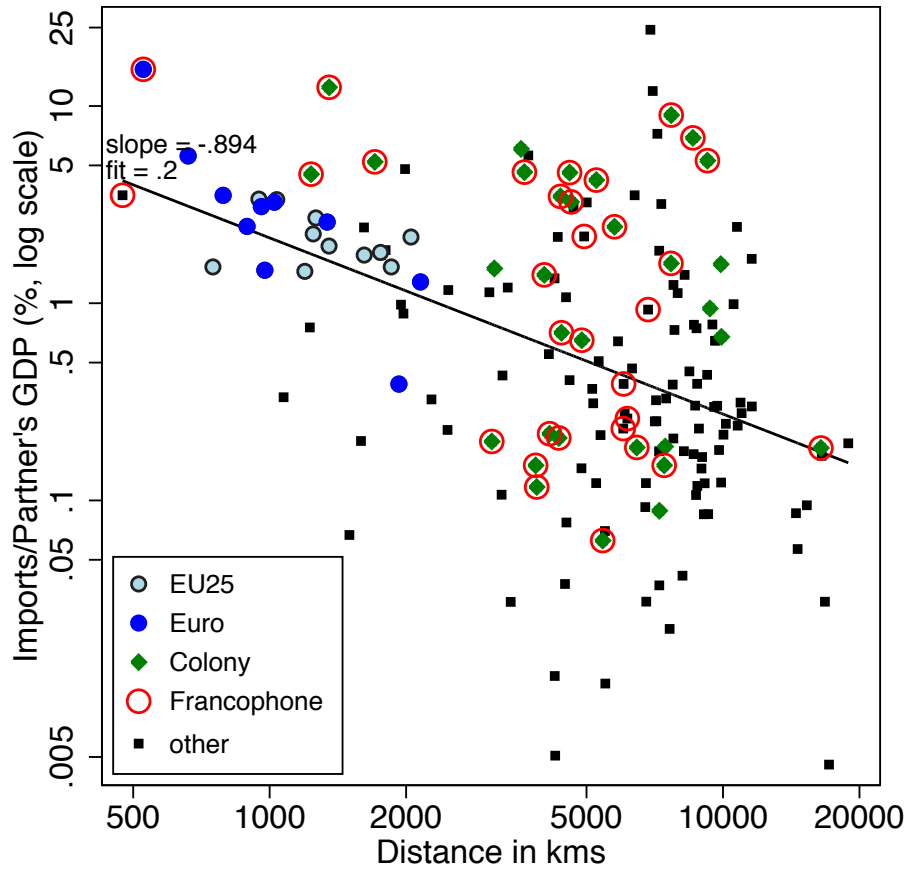
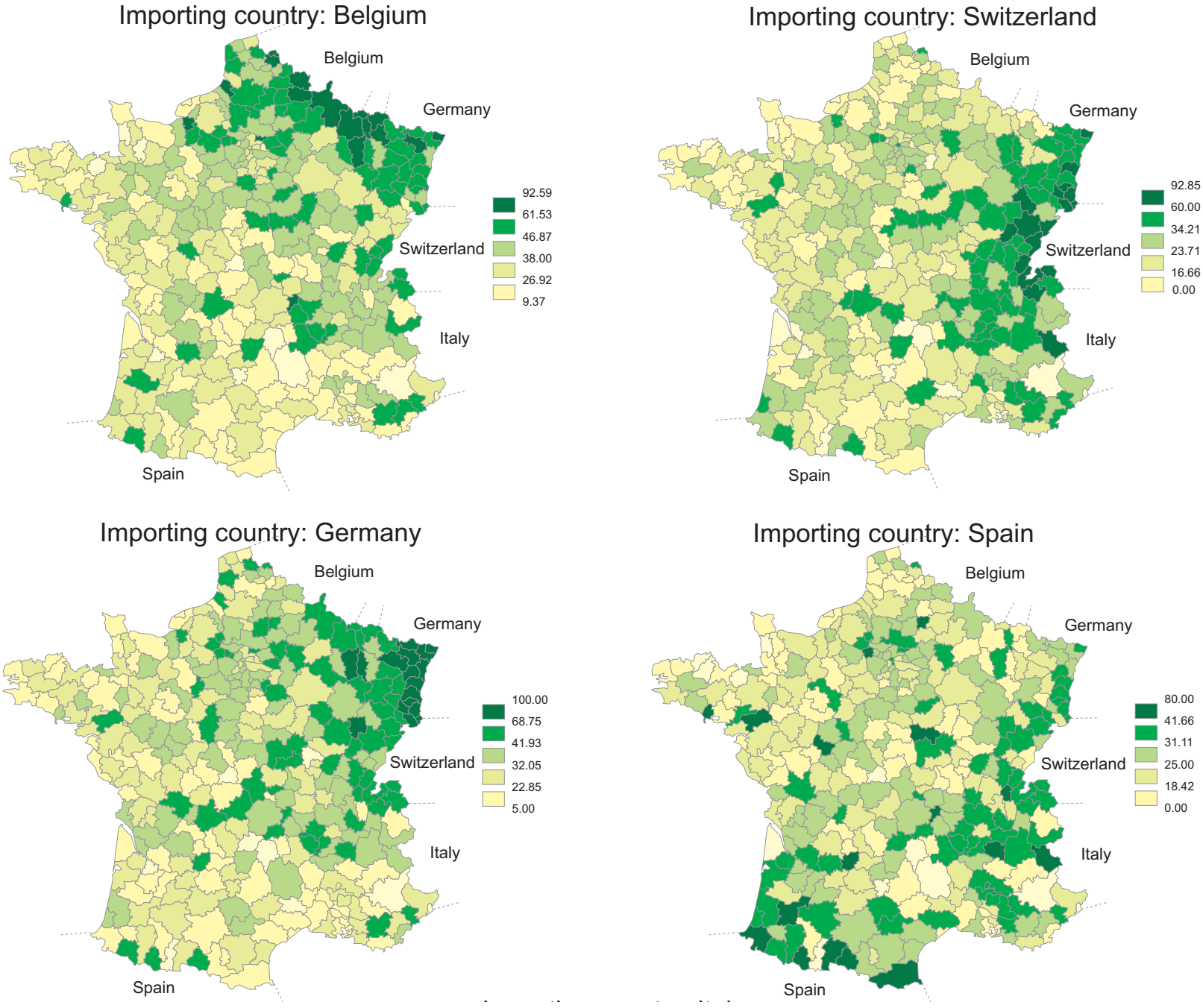


Figure 3: % of single-region firms exporting in 1992 (Crozet and Koenig, 2010, fig. 2)



Gravity: from physics to economics

- Tinbergen (1962)'s:

$$X_{i,j} = G\frac{Y_i Y_j}{\phi_{i,j}}$$

can be written in terms of observables and parameters:

$$X_{i,j} = GY_i^{\alpha} Y_j^{\beta} \phi_{i,j}$$

$$\log X_{i,j} = g + \alpha \log Y_i + \beta \log Y_j - \phi_{i,j} \left(\log distance_{i,j} + other_{i,j}\right) + \varepsilon_{i,j}$$

(time index is dropped for the moment)

- This is known as **naïve gravity**

Outline

From empirical regularity to theory

- "The [gravity] equation has <...> gone from an embarrassing poverty of theoretical foundations to an embarrassment of riches!" (Frankel et al., 1997, p. 53)
- Initial rejection in 1962–1995 by trade theorists
- McCallum (1995) border puzzle: in Canada-USA provinces intra-country trade is 22 times as large as inter-country trade
  - surprisingly large international border effect given NAFTA
- Anderson and Van Wincoop (2003): border effect of McCallum (1995) is upward biased because it ignores the role of relative prices
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Krugman (1995) Mars example

- "Consider, for example, two small equal-size economies."
- "If they were located on Mars, able to trade with each other but separated from all other economies by near-prohibitive transport costs, half of each country's spending on tradeables should consist of imports from the other."
- "On the other hand, if the two countries were located in the middle of Europe, close to much larger countries offering competing products, then each would spend only a small fraction of its income on imports from the other."
- "Thus the trade between them would be much less, even if the distance between the two were the same."
- "Even in a one-industry world, the trade between two countries should depend not only on their incomes and the distance between them but on the sizes and distances of other economies."

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CES demand-side derivation

- Let country $i = \{1, \ldots, N\}$ produce a unique product consumed in country j[1]
- CES utility of consumer in country j:

$$U_j \equiv \left\{ \sum_{i=1}^{N} q_{i,j}^{\frac{\sigma-1}{\sigma}} \right\}^{\frac{\sigma}{\sigma-1}}$$

- Demand function for a product produced by country i and exported to country j:

$$q_{i,j} \equiv \frac{p_{i,j}^{-\sigma}}{\sum_{i=1}^{N} p_{i,j}^{1-\sigma}} Y_j$$

- Welfare-based price index:

$$P_j \equiv \left\{ \sum_{i=1}^{N} p_{i,j}^{1-\sigma} \right\}^{\frac{1}{1-\sigma}}$$

[1] Slides follow Nicolas Berman's course International Trade I at IHEID

Deriving exports

- Exports of country i to country j are defined as

$$X_{i,j} \equiv q_{i,j} p_{i,j}$$

- Using the above,

$$X_{i,j} = \frac{p_{i,j}^{1-\sigma}}{P_j^{\sigma-1}} Y_j$$

Iceberg costs and phi-ness of trade

- Further assume iceberg trade costs:

$$p_{i,j} = p_i \tau_{i,j}$$

(a fraction of the goods shipped "melts in transit", Samuelson (1954))

- Define phi-ness of trade $\phi_{i,j} = \tau_{i,j}^{1-\sigma}$.
  - $\phi_{i,j} = 0$ is autarky, $\phi_{i,j} = 1$ is full economic integration (Baldwin et al., 2011)
- Then export equation simplifies to

$$X_{i,j} = \frac{p_i^{1-\sigma} \phi_{i,j}}{P_j^{\sigma-1}} Y_j$$

whereas the price index becomes

$$P_j \equiv \left\{ \sum_{i=1}^{N} p_i \tau_{i,j}^{1-\sigma} \right\}^{\frac{1}{1-\sigma}}$$

Multilateral resistance terms

- Anderson and Van Wincoop (2003) show that when $\tau_{i,j} = \tau_{j,i}$ (symmetric trade costs) export equation can be rewritten as

$$X_{i,j} = \left\{ \frac{\tau_{i,j}}{P_j P_i} \right\}^{1-\sigma} \frac{Y_i Y_j}{Y_{world}}$$

where

$$P_j = \left\{ \sum_{i=1}^{N} P_i^{\sigma-1} \tau_{i,j}^{1-\sigma} \theta_i \right\}^{\frac{1}{1-\sigma}},$$

and θ_i is income share of country i

- This is **structural** gravity model

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Figure 4: Estimates of typical gravity variables (Head and Mayer, 2014, tab. 4)

	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

Note: 2508 estimates from 158 papers

Multilateral resistance terms

- Naïve gravity can lead to opposite results
- But where to get the data on P_i and P_j in

$$X_{i,j} = \left\{ \frac{\tau_{i,j}}{P_j P_i} \right\}^{1-\sigma} \frac{Y_i Y_j}{Y_{world}}?$$

1. GDP deflators or remoteness indices, e.g. $\sum_i \frac{Y_i}{dist_{i,j}}$
2. Iterative approach of Anderson and Van Wincoop (2003)
3. Importer×year and exporter×year fixed effects

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Figure 5: Do We Really Know That the WTO Increases Trade? (Rose, 2004, tab. 1)

	Default	No industrial countries	Post 1970	With country effects
Both in GATT/WTO	−0.04	−0.21	−0.08	0.15
	(0.05)	(0.07)	(0.07)	(0.05)
One in GATT/WTO	−0.06	−0.20	−0.09	0.05
	(0.05)	(0.06)	(0.07)	(0.04)
GSP	0.86	0.04	0.84	0.70
	(0.03)	(0.10)	(0.03)	(0.03)
Log distance	−1.12	−1.23	−1.22	−1.31
	(0.02)	(0.03)	(0.02)	(0.02)
Log product real GDP	0.92	0.96	0.95	0.16
	(0.01)	(0.02)	(0.01)	(0.05)
Log product real GDP p/c	0.32	0.20	0.32	0.54
	(0.01)	(0.02)	(0.02)	(0.05)
Regional FTA	1.20	1.50	1.10	0.94
	(0.11)	(0.15)	(0.12)	(0.13)
Currency union	1.12	1.00	1.23	1.19
	(0.12)	(0.15)	(0.15)	(0.12)
Common language	0.31	0.10	0.35	0.27
	(0.04)	(0.06)	(0.04)	(0.04)
Land border	0.53	0.72	0.69	0.28
	(0.11)	(0.12)	(0.12)	(0.11)
Number landlocked	−0.27	−0.28	−0.31	−1.54
	(0.03)	(0.05)	(0.03)	(0.32)
Number islands	0.04	−0.14	0.03	−0.87
	(0.04)	(0.06)	(0.04)	(0.19)
Log product land area	−0.10	−0.17	−0.10	0.38
	(0.01)	(0.01)	(0.01)	(0.03)
Common colonizer	0.58	0.73	0.52	0.60
	(0.07)	(0.07)	(0.07)	(0.06)
Currently colonized	1.08	—	1.12	0.72
	(0.23)		(0.41)	(0.26)
Ever colony	1.16	−0.42	1.28	1.27
	(0.12)	(0.57)	(0.12)	(0.11)
Common country	−0.02	—	−0.32	0.31
	(1.08)		(1.04)	(0.58)
Observations	234,597	114,615	183,328	234,597
R^2	0.65	0.47	0.65	0.70
RMSE	1.98	2.36	2.10	1.82

Figure 6: Solving McCallum (1995) puzzle? (Baier and Bergstrand, 2009, tab. 1)

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 distance	−1.06 (0.04)	−0.79 (0.03)	−0.82 (0.03)	−0.82 (0.04)	−1.25 (0.04)	−0.92 (0.03)	−1.02 (0.03)
$-\alpha\,(\sigma-1)$ for border	−0.71 (0.06)	−1.65 (0.08)	−1.59 (0.08)	−1.11 (0.07)	−1.54 (0.06)	−1.65 (0.07)	−1.24 (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

Take-aways

- Gravity model is one of the most stable empirical regularities in Economics
- Until 2000s it was not theoretically founded, while 2000s witnessed convergence of theory around the gravity-based trade flows equation
- Estimation issues loomed large with the naïve model until Anderson and Van Wincoop (2003)'s contribution stressed the importance of multilateral resistance terms
- The main appeal of gravity for empirical economists is that it permits to examine policy variables and their impact in tractable fashion

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Thank you for your attention!

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