Augmented Gravity Models:
(5) A Gallery of Gravity Applications.

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Part I

Trade Facilitation

Trade Facilitation

"It takes 116 days to move an export container from the factory in Bangui (Central African Republic) to the nearest port and fulfill all the customs, administrative, and port requirements to load the cargo onto a ship. It takes 71 days to do so from Ouagadougou (Burkina Faso), 93 from Almaty (Kazakhstan), and 105 from Baghdad. In contrast, it takes only 5 days from Copenhagen, 6 from Berlin, 16 from Port Louis (Mauritius), and 20 days from Shanghai, Kuala Lumpur or Santiago de Chile."

- To what extent can streamlined customs procedures and faster border crossing times boost bilateral trade?
- How does the impact of trade facilitation vary across different countries and product groups?

Trade Facilitation: Djankov, Freund and Pham (2010)

Using this augmented version of the Gravity equation:

$$\ln X_{ij}^k = \alpha + \beta_1 \ln M_i + \beta_2 \ln M_j + \delta_1 \ln d_{ij} + \delta_2 \ln \text{time}_i^k + \epsilon_{ij} \quad (1)$$

Djankov, Freund and Pham (2010) use Doing Business data on border crossing times (98 countries) to show that :

- Slower border crossing times can significantly reduce bilateral trade: One extra day reduces exports by 1%.
- Using their numbers, an extra day's delay is equivalent to moving a country 70km further away from its trading partners.

Trade Facilitation: Djankov, Freund and Pham (2010)

Does Trade Facilitation Affect All Countries and Products Equally?

Djankov, Freund and Pham (2010) find that:

- Landlocked countries are particularly sensitive to border crossing times: One extra day reduces exports by as much as 4%.
- For landlocked countries, it is often border crossing times in neighboring (transit) countries that constrain exports more than border crossing times at home.
- Time-critical agricultural and manufactured goods are particularly sensitive to border crossing times:
  - Agriculture: Fresh fruits and vegetables.
  - Manufactures: Electronic goods; parts and components.

Part II

Corruption

Trade effects of corruption: Anderson and Marcouiller (2011)

- How does corruption affect international trade flows?
- How do other trade costs such as tariffs and border crossing times interact with corruption to affect trade?

Trade effects of corruption: Anderson and Marcouiller (2011)

Using this augmented version of the gravity equation:

$$\ln X_{ij}^{k} = \alpha + \beta_1 \ln M_i + \beta_2 \ln M_j + \delta_1 \ln d_{ij} + \delta_2 \ln \text{corruption}_{ij} + \epsilon_{ij} \quad (2)$$

Anderson and Marcouiller (2011), using a 58-country gravity model, and corruption data from the World Economic Forum, show that:

- Institutional weaknesses, generally corruption and lack of contract enforceability, have a significant negative impact on trade.
- If Latin America increased measured institutional quality to the same level as the EU, their trade would increase by about 30%: about the same as with a major tariff cut.

How Do Trade Costs and Corruption Interact to affect Trade?

Trade costs are in fact an important determinant of trade-related corruption, since businesses may be willing to pay "speed money" or "facilitation charges" to get around them:

- Fisman and Wei (2004) show that higher tariffs are associated with higher rates of customs "misclassification" or "under-reporting".
- Djankov and Sequiera (2009) and Shepherd (2009) show that time spent at ports and border crossings is also associated with higher rates of corruption.

How Do Trade Costs and Corruption Interact to affect Trade?

$$\begin{aligned} \ln X_{ij}^{k} &= \alpha + \beta_1 \ln M_i + \beta_2 \ln M_j + \delta_1 \ln d_{ij} + \\ &+ \delta_2 \ln \text{corruption}_{ij} + \delta_3 \ln \text{corruption}_{ij} \times \ln \text{time}_{ij}^{k} + \epsilon_{ij}. \end{aligned}$$

- Shepherd (2009) uses a gravity model to show that trade is more sensitive to corruption in countries with long border crossing times.

How Do Trade Costs and Corruption Interact to affect Trade?

$$
\begin{aligned}
\ln X_{ij}^{k} &= \alpha + \beta_1 \ln M_i + \beta_2 \ln M_j + \delta_1 \ln d_{ij} + \\
&+ \delta_2 \ln \text{corruption}_{ij} + \delta_3 \ln \text{corruption}_{ij} \times \ln \text{tariff}_{ij}^{k} + \\
&+ \delta_4 \ln \text{corruption}_{ij} \times \left[\ln \text{tariff}_{ij}^{k}\right]^2 + \epsilon_{ij}.
\end{aligned}
$$

- Dutt and Traca (2009) use a gravity model to show that:
  - Corruption is usually trade restricting, but ...
  - When tariffs are very high (5%-14% of their sample), it can actually be trade promoting: it is a way for business to avoid bad regulation.

Part III

Migration

Migration: Beine, Docquier and Özdenc (2010)

"On the day I left Nigeria, I felt sad because I was leaving my family behind. I believed I would return eight years later, probably marry an Igbo girl, and then spend the rest of my life in Nigeria. But 25 years ago, I fell in love with an American girl, married her three years later, and became eligible to sponsor a Green Card visa for my 35 closest relatives, including my parents and all my siblings, nieces and nephews. The story of how I brought 35 people to the United States exemplifies how 10 million skilled people have emigrated out of Africa during the past 30 years. We came to the United States on student visas and then changed our status to become permanent residents and then naturalized citizens. Our new citizenship status helped us sponsor relatives, and also inspired our friends to immigrate here."

(Philip Emeagwali)

Philip Emeagwali won the 1989 Gordon Bell Prize, which has been called "supercomputing's Nobel Prize", for inventing a formula that allows computers to perform their fastest computations - a discovery that inspired the reinvention of supercomputers.

Migration: Beine, Docquier and Özdenc (2010)

Beine, Docquier and Özdenc (2010) use the following choice based "gravity" equation:

$$\ln N_{ij}(h) = \alpha_0 + \alpha_1 \ln M_{ij} + \alpha_2 d_{ij} + \alpha_3 \; w_i + A_j + \gamma_i + \epsilon_{ij}. \tag{3}$$

where

- $N_{ij}(h)$ is the change in the migrant stock observed between 1990 and 2000 from country i to country j, with education level h;
- M_{ij} is the size of the diaspora in 1990;
- d_{ij} is a vector of observable bilateral variables affecting the migration costs;
- w_i is the level of wages at destination;
- A_j and γ_i capture the impact of unobserved characteristics of host and home countries.

Migration: Beine, Docquier and Özdenc (2010)

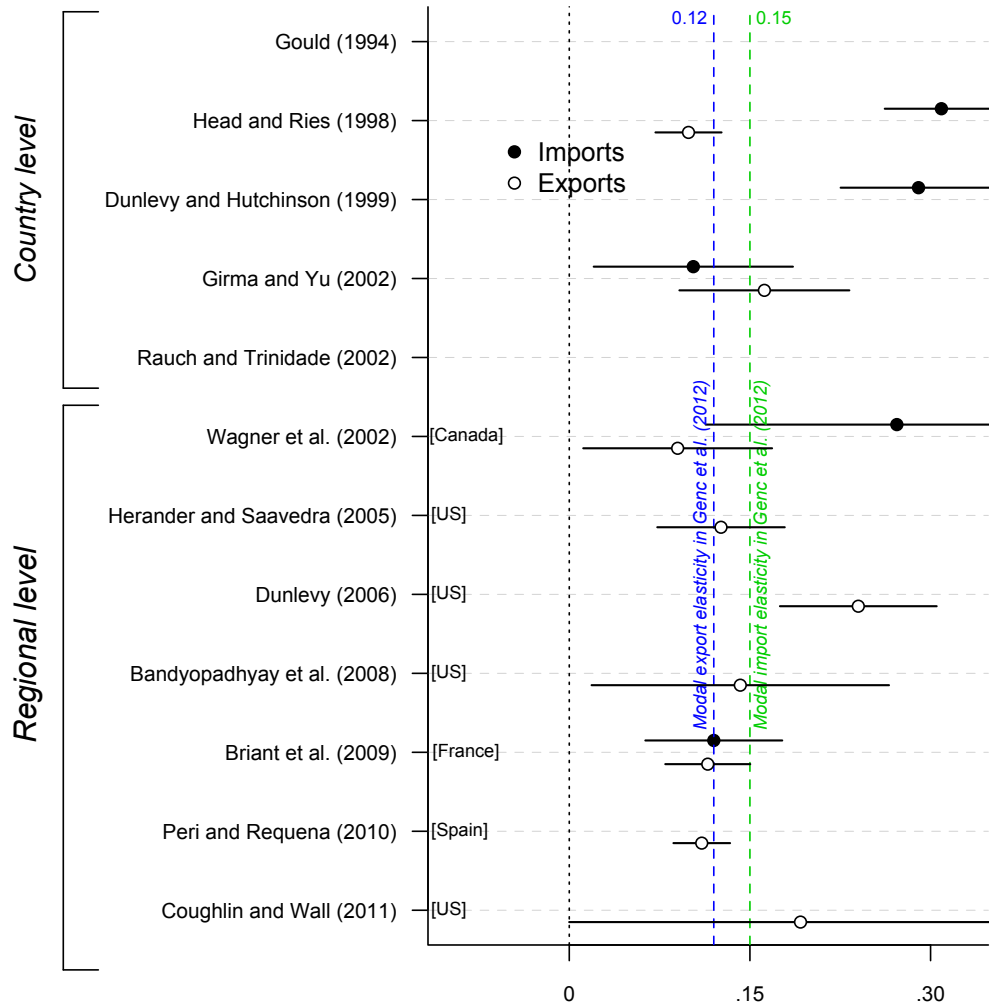
Table 2. Determinants of migration flows by skill level : OLS and Heckman regressions (1/2).

	(1) Total	(2) Total	(3) Total	(4) Total	(5) Low-skill	(6) Low-skill	(7) High-skill	(8) High-skill
Lagged diasp	0.620	0.616	0.699	0.831	0.778	1.192	0.625	0.728
	(34.35)***	(26.60)***	(43.91)***	(23.44)***	(22.25)***	(6.90)***	(44.57)***	(28.29)***
Col links	0.331	0.278	0.127	-0.051	0.153	-1.699	0.169	-0.023
	(2.45)**	(2.14)**	(1.10)	(0.29)	(0.64)	(2.05)**	(1.72)*	(0.16)
language	0.388	1.026	0.496	1.056	0.322	1.413	0.683	1.373
	(5.20)***	(10.02)***	(6.48)***	(8.34)***	(2.18)**	(3.23)***	(10.29)***	(13.22)***
Log(dist)	-0.408	-0.139	-0.448	-0.095	-0.613	0.057	-0.341	0.004
	(9.04)***	(2.48)**	(10.69)***	(1.63)	(7.40)***	(0.31)	(9.58)***	(0.08)
Schengen	0.168	0.065	0.277	0.599	-0.081	1.154	0.598	0.493
	(1.19)	(0.33)	(2.02)**	(2.56)**	(0.28)	(1.31)	(5.23)***	(2.71)***
Immig. pol		0.035		0.035		0.015		-0.338
		(7.85)***		(6.71)***		(0.87)		(3.33)***
Social exp		-0.290		0.175		2.411		0.236
		(2.25)**		(1.28)		(3.22)***		(6.98)***
Pop at dest		0.321		0.109		-0.131		0.033
		(9.66)***		(2.30)**		(0.83)		(7.51)***
Wages at dest		0.028		0.040		-0.020		0.069
		(3.70)***		(4.51)***		(0.75)		(9.32)***
Constant	3.750	-4.954	2.365	-6.119	1.388	-17.084	0.196	-6.701
	(6.92)***	(3.96)***	(4.02)***	(5.07)***	(1.20)	(2.99)***	(0.36)	(6.32)***

Part IV

Migration and Trade

Immigrants foster trade: literature review



Immigrants foster trade: from motives to hypotheses

The effects:

- *business and social network effect* of immigrants on trade
  - Idea originally developed in Rauch (2001) and Rauch and Trinidade (2002)
  - information costs plays a major role in the fixed cost that firms have to pay to enter foreign markets
  - ethnic networks are likely to reduce some of these information costs
  - cross-border networks of people sharing the same country of origin can substitute or integrate organized markets in matching international demand and supply.
  - moreover, "immigrant networks may provide contract enforcement through sanctions and exclusions, which substitutes for weak institutional rules and reduces trade costs."
  - the effect is both on exports and on imports.
- *transplanted home-bias effect* of immigrants on trade
  - immigrants are characterized by different habits in consumption with respect to natives
  - they slowly modify their original home-biased demand (Bronnenberg et al. 2010; Atkin 2010)
  - the effect is on imports

The log-linear gravity model

We adopt a log-linear specification for the gravity equation (see, for instance, Dunlevy, 2006, Peri and Requena-Silvente, 2010, Coughlin and Wall, 2011). Our *benchmark* model is

$$\ln(1 + X_{ijt}) = \delta_{rj} + \theta_{jt} + \phi_{rt} + \alpha \ln(Y_{it-1}\ Y_{jt-1}) + \\ + \beta \ln(1 + IMM_{ijt-1}) + \gamma \ln(dist_{ij}) + \epsilon_{ijt} \qquad (4)$$

- $\ln(1 + X_{ijt})$, log-trade (add one to include zeros)
- $\ln(Y_{it-1}\ Y_{jt-1})$, products of country and province GDPs, lagged one period
- δ_{rj}, trading-pair FE (regional-level)
- θ_{jt}, foreign country-year FE
- ϕ_{rt}, region-year FE
- $\ln(1 + IMM_{ijt-1})$, log-migration (add one to include zeros), lagged one period

Assume that conditional on the FE the error term is white-noise, and use OLS

Endogeneity and 2SLS - Results

	Export (1)	Import (2)
First stage		
$\ln(1 + \hat{IMM}_{ijt-1})$	0.433***	
	(0.007)	
F-test instrument	3,871.20 [0.000]	
Second stage		
$\ln(Y_{it-1} Y_{jt-1})$	2.207***	1.947***
	(0.038)	(0.049)
$\ln(1 + IMM_{ijt-1})$	0.005	0.548***
	(0.038)	(0.053)
$\ln(dist_{ij})$	-1.938***	-2.786***
	(0.367)	(0.566)
N. observations	135,586	135,586
N. clusters	20,009	20,009

*, **, ***, significant at the 10%, 5% and 1% statistical level
Note. The regressions also control for region-country, country-year and region-year fixed effects, and covers the period 2003-2009. Standard errors clustered at the province-country level are reported in parenthesis, p-values in brackets.

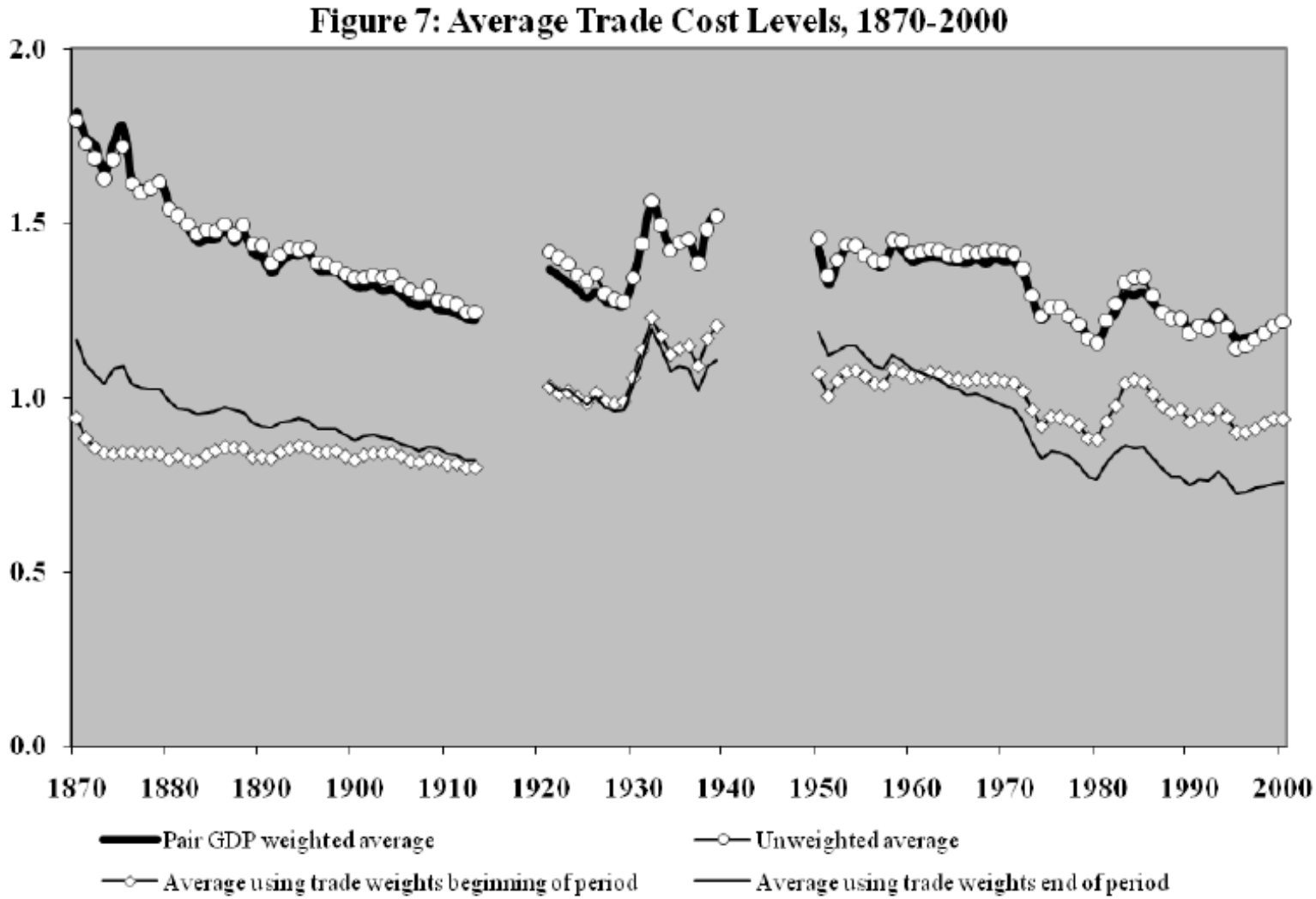
Main 'take-away'

- Data: When using regional data, using trading-pair FE may absorb all the variation in the immigrant stock. If possible, better go for a finer spatial unit of analysis.
- FE: using a specification that only partially controls for unobserved heterogeneity (see Wagner et al., 2002, Dunlevy, 2006, Briant et al., 2009) might result in misleading estimates of the trade elasticities to immigration (MAUP problem?).
- Spillovers: our estimates show that geographic spillovers do not bias the estimates of the effect of province own migration on province trade.
- Exports and Imports: the *benchmark* specification returns a lower elasticity of exports and a higher elasticity of imports with respect to immigrant stocks (0.058 and 0.344, respectively). This is consistent with the transplanted home-bias effect being the main explanation for the pro-trade effect of immigration.
- IV estimates: when we use 2SLS the instruments are very strong, but we estimate a significant and positive elasticity only for imports (0.548). No effect for exports. Is the business and social network effect irrelevant? No!

Part V

Trade costs

Trade costs: Jacks, Meissner, Novy, 2008



A comprehensive measure of trade costs: Jacks, Meissner, Novy, 2008

Starting from a structural gravity equation (Anderson and van Wincoop, 2003; Head and Mayer, 2015):

$$X_{ij} = Y_i Y_j \left(\frac{d_{ij}}{\Pi_i P_j} \right)^{1-\sigma}, \tag{5}$$

X_{ij} denotes exports from country i to j (including domestic trade, X_{ii} and X_{jj});
Y_i and Y_j are the income levels of country i and j;
$\sigma > 0$ is the elasticity of substitution;
$d_{ij} \geq 1$ is the trade cost factor: the gross bilateral cost of importing a good (one plus the tariff equivalent) $\rightsquigarrow p_{ij} = d_{ij} p_i$;
Π_i and P_j are multilateral resistance variables $\rightsquigarrow X_{ij}$ depend on the bilateral trade cost factor d_{ij} relative to average international trade costs.

From the accounting identities

$$Y_i \equiv \sum_{j \neq i}^{N-1} X_{ij} + X_{ii}; \tag{6}$$

$$Y_j \equiv \sum_{i \neq j}^{N-1} X_{ij} + X_{jj}. \tag{7}$$

we can derive X_{ii} and X_{jj}, to be substituted in $N \times N$ equations system, analogous to (1).

A comprehensive measure of trade costs: Jacks, Meissner, Novy, 2008

For country i domestic trade we obtain

$$X_{ii} = Y_i Y_i \left(\frac{d_{ii}}{\Pi_i P_i} \right)^{1-\sigma}, \tag{8}$$

from which we can isolate the multilateral resistance variables:

$$\Pi_i P_i = \left(\frac{X_{ii}}{Y_i Y_i} \right)^{\frac{1}{\sigma-1}} d_{ii}, \tag{9}$$

$\Pi_i P_j$ can be measured using domestic variables only (conditional on σ). We exploit this to solve the gravity model for bilateral trade costs.

Let's multiply the gravity equation (1) by the corresponding gravity equation for trade flows in the opposite direction: X_{ji}.

$$X_{ij} X_{ji} = (Y_i Y_i)^2 \left(\frac{d_{ij} d_{ji}}{\Pi_i P_j \Pi_j P_i} \right)^{1-\sigma}; \tag{10}$$

substituting for $\Pi_i P_i$ and $\Pi_j P_j$.

$$\frac{d_{ij} d_{ji}}{d_{ii} d_{jj}} = \left(\frac{X_{ii} X_{jj}}{X_{ij} X_{ji}} \right)^{\frac{1}{\sigma-1}}. \tag{11}$$

A comprehensive measure of trade costs: Jacks, Meissner, Novy, 2008

In that case, Jacks, Meissner and Novy (2008) show that, taking the square root of equation (7) and deducting one to get an expression for the tariff equivalent:

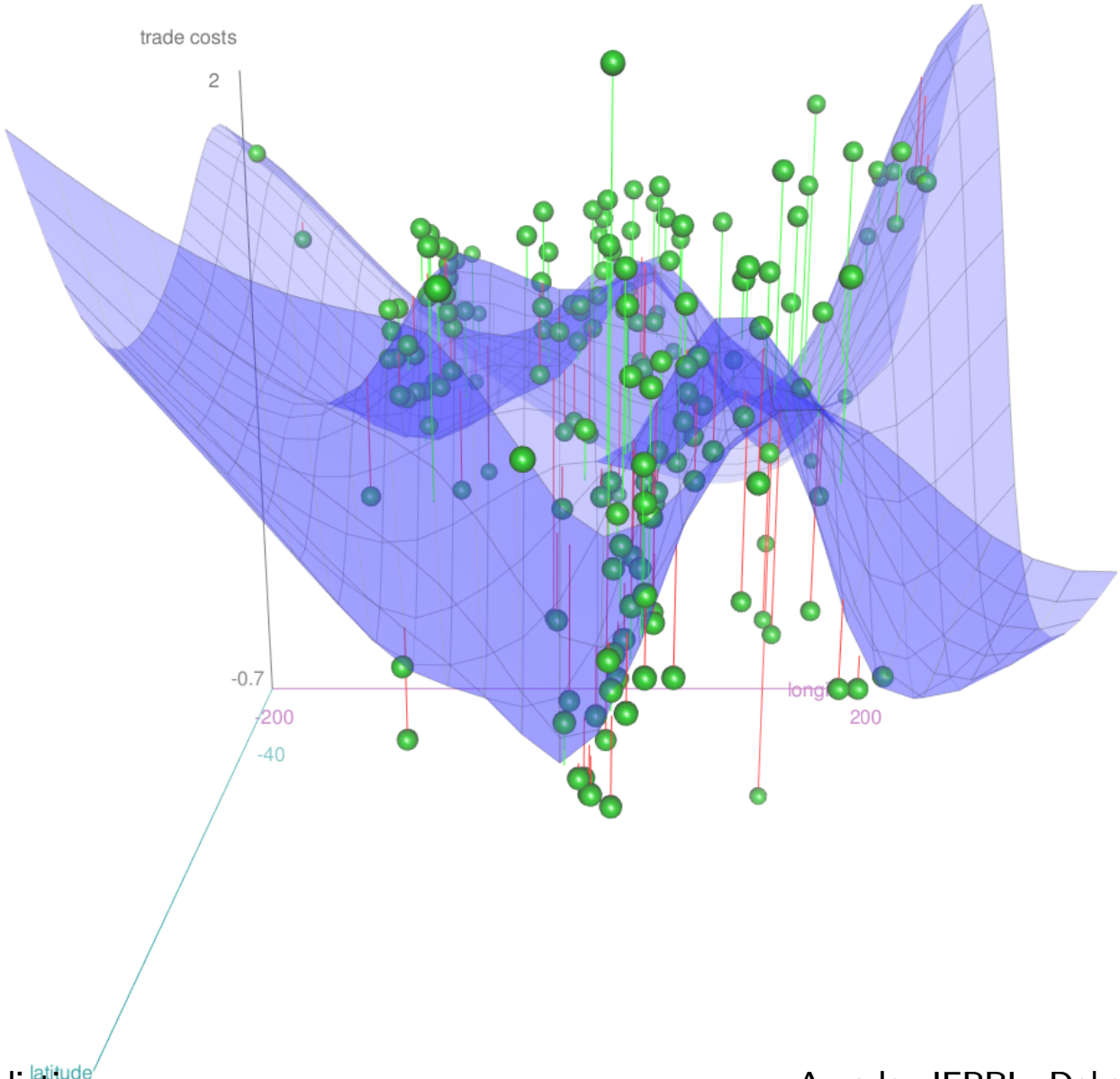
$$\tau_{ij} \equiv \left(\frac{d_{ij}d_{ji}}{d_{ii}d_{jj}}\right)^{\frac{1}{2}} - 1 = \left(\frac{X_{ii}X_{jj}}{X_{ij}X_{ji}}\right)^{\frac{1}{2(\sigma-1)}} - 1 \qquad (12)$$

- τ_{ij} is the geometric average of international trade costs between countries i and j relative to domestic trade costs within each country

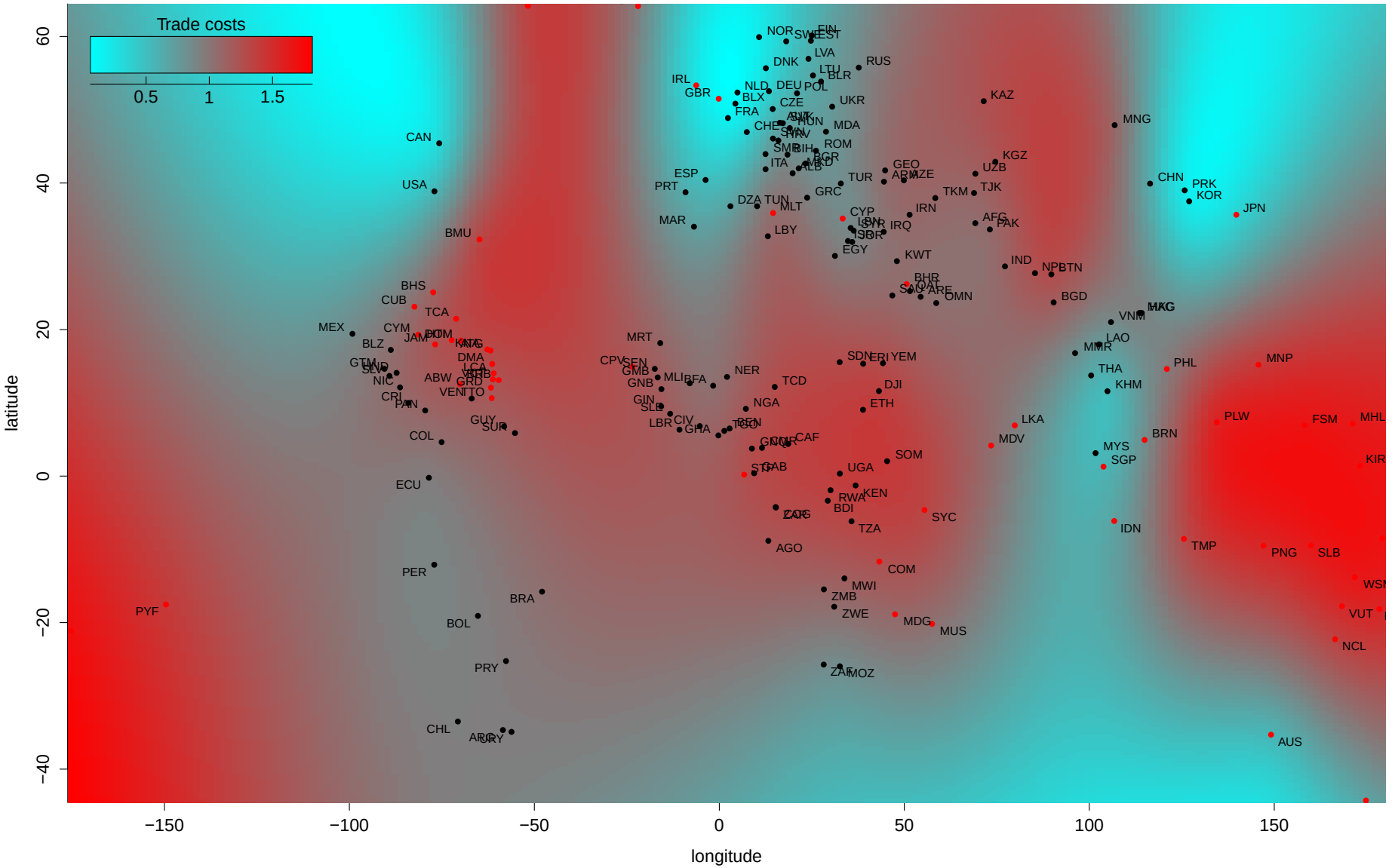
- $\tau_{ij} \in [-1, \infty)$; in our case $\tau_{ij} \geq 0$
- $d_{ij}d_{ji} = d_{ii}d_{jj} \rightsquigarrow \tau_{ij} = 0$
- τ_{ij} is a tariff equivalent of all trade costs: $\tau_{ij} = 0.5 \rightsquigarrow p_{ij} = p_i(1 + 0.5)$

- Given σ (taken from the literature: $\sigma = 5$, $\sigma = 9$, $\sigma = 11$)
- τ_{ij} is an indirect measure that includes everything (transport; trade policy; culture; institutions etc).
- τ_{ij} is model-dependent, symmetric, time-variant, and can be sector specific.

Average τ_{ij} for country i: Geography and Insularity (3D)



Average τ_{ij} for country i: Heatmap



Simple descriptives of the ln of τ_{ij}

$Island_{ij}$	$Landlocked_{ij}$	Partial $insularity_{ij}$	N	mean	geo.mean (level)	sd	se
0	0	0	7132	0.767	2.326	0.756	0.009
0	0	1	2890	0.456	1.637	0.727	0.014
0	0	2	272	0.212	1.259	0.692	0.042
0	1	0	5440	1.094	3.198	0.757	0.010
0	1	1	1088	0.785	2.280	0.718	0.022
0	2	0	992	1.277	3.799	0.778	0.025
1	0	0	8824	1.217	3.549	0.747	0.008
1	0	1	1768	0.873	2.498	0.804	0.019
1	1	0	3320	1.493	4.616	0.607	0.010
2	0	0	2640	1.256	3.687	0.746	0.015

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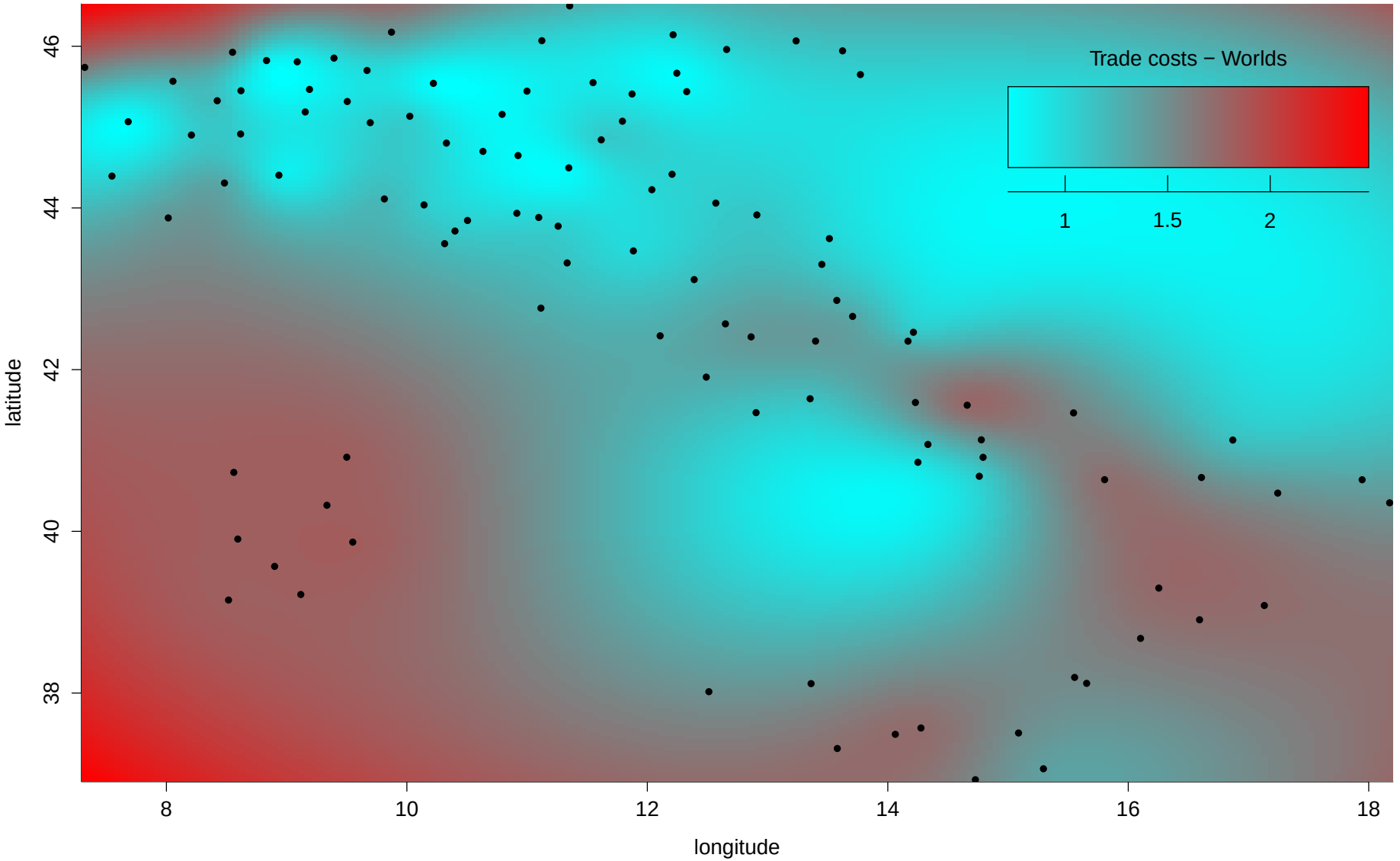
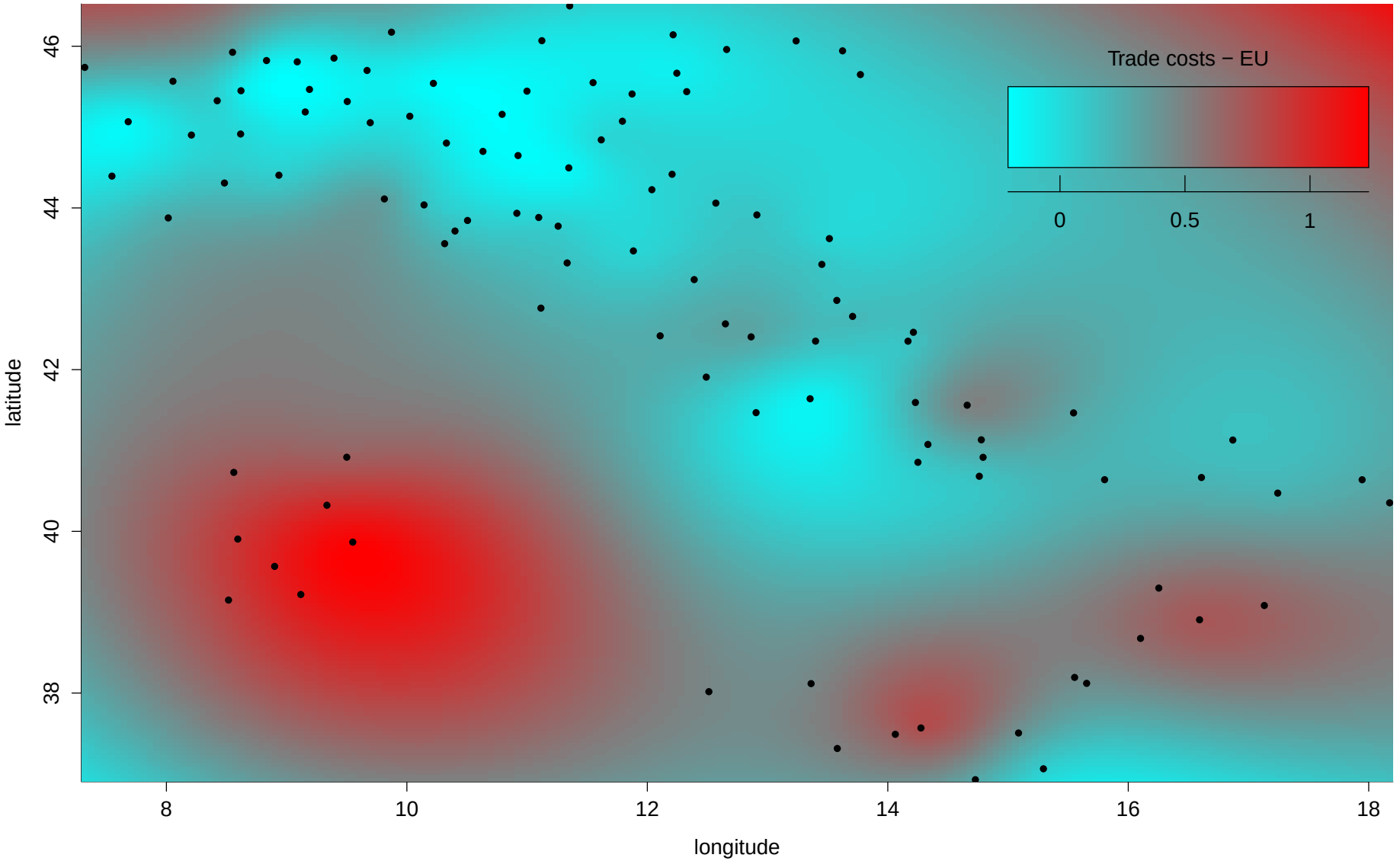
Average τ_{ij} for Province i in Italy vs World: Heatmap



Average τ_{ij} for Province i in Italy vs EU: Heatmap



Part VI

Let's move to the Stata Lab