ECO 745: Theory of International Economics

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Fall 2015 - Lecture 6

Review

We've covered several models of trade, but the empirics have been mixed

- Difficulties identifying goods with a technological comparative advantage
- Not clear whether predictions of H-O theory hold
- Applied General Equilibrium models based off Armington assumption have difficulties predicting the sectoral effects of trade liberalization
- Dynamic models featuring growth and trade not fully consistent with observed growth patterns

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Are there models of trade that have been relatively successful empirically?

Gravity

In physics, the equation giving the gravitational force (F) between two objects is

$$F = G\frac{m_1 m_2}{r^2}$$

- G is the gravitational constant, m_1 and m_2 are the masses of the objects, and r is the distance between the centers of mass of the objects
- Gravity is proportional to the product of the masses divided by the squared distance between them

Gravity Models of Trade

Economists have adapted the gravity equation for predicting trade flows, the basic model is:

$$F_{ij} = e^{\beta_0} \frac{(Y_i)^{\beta_1}(Y_j)^{\beta_2}}{(D_{ij})^{\beta_3}}$$

- X_{ij} is exports from country i and j, Y_i and Y_j are the GDPs of the countries, D_{ij} is the distance between the countries, and the β's are constants.

- For gravity regressions, we take the log of the above formula to get

$$\log F_{ij} = \beta_0 + \beta_1 \log Y_i + \beta_2 \log Y_j - \beta_3 \log D_{ij}$$

- From which we can estimate the β coefficients using OLS (these specific coefficients are typically all positive)

Predictions of Gravity Models of Trade

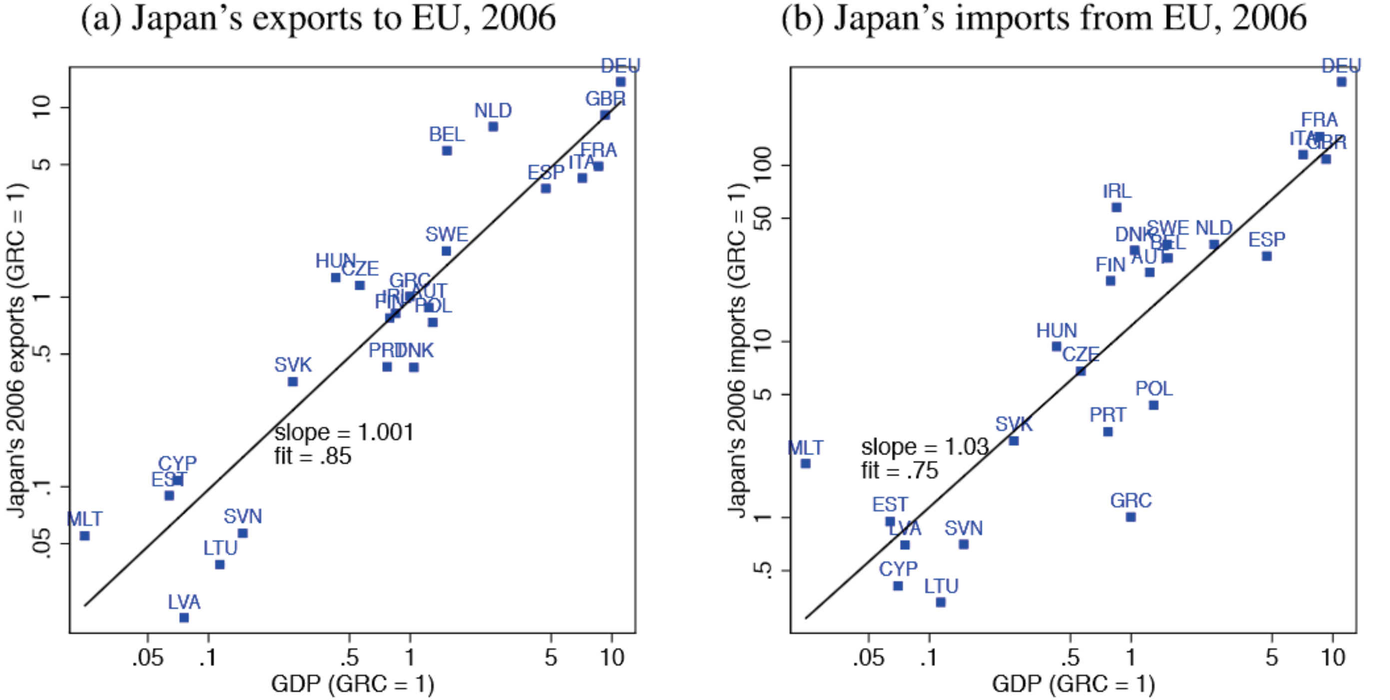
Trade data exhibits several features consistent with trade models.

In particular, the following relationships are predicted to be linear in logs:

- Larger countries should exhibit larger trade volumes
- Trade volumes should decrease with distance

Relationship between Trade Flows and Country Size

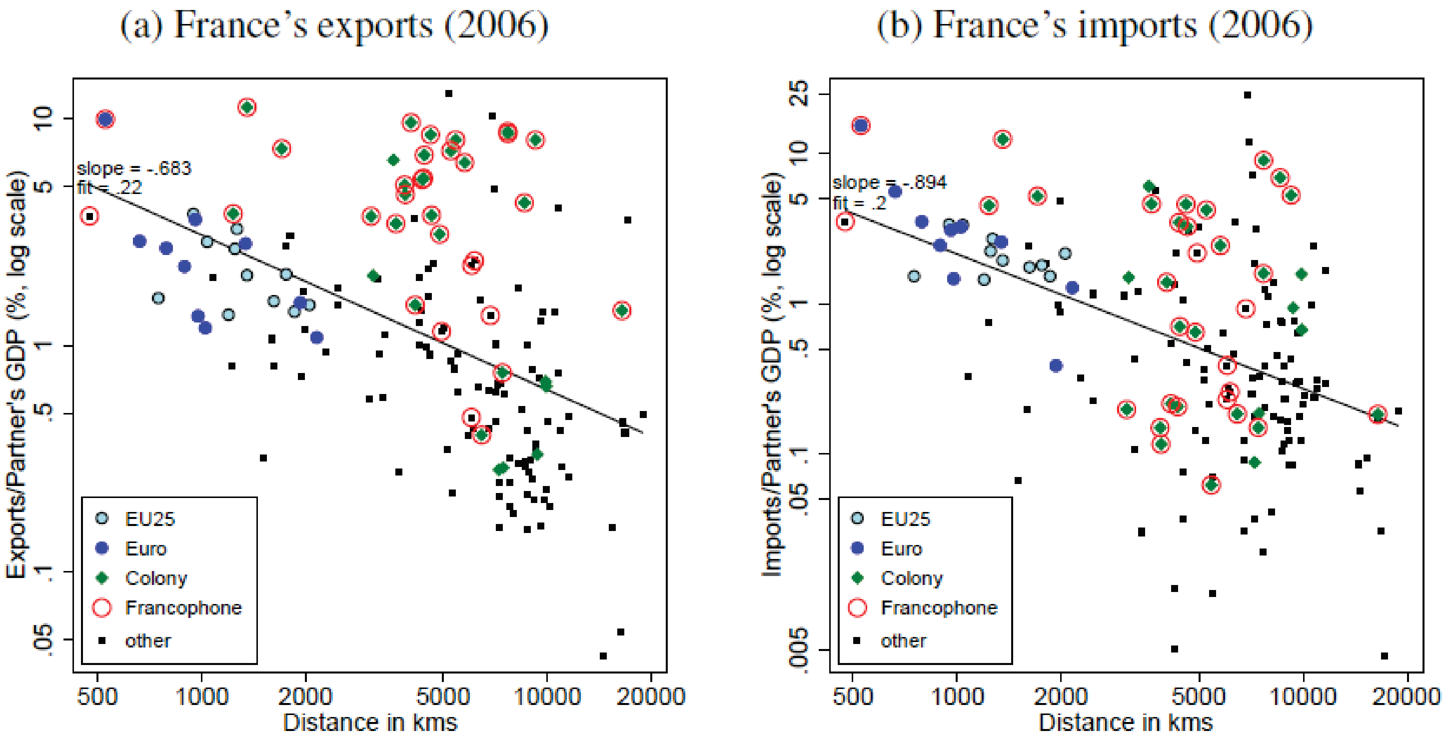
Figure 1 – Trade is proportional to size



From Head and Mayer (2013)

Relationship between Trade Flows and Distance

Figure 2 – Trade is inversely proportional to distance



From Head and Mayer (2013)

Gravity Applications

Gravity regressions can be extended by adding additional terms to the regression, for example:

- Shared language
- Colonial ties
- Existence of FTA
- Tariff levels
- Borders

Gravity Regressions: How Big is the Border

McCallum (1995) wanted to estimate the impact of international borders on trade flows

- Looked at trade flows between Canadian provinces and trade flows between Canadian provinces and states in the U.S.
- Estimated the following gravity regression

$$\log F_{ij} = \beta_0 + \beta_1 \log Y_i + \beta_2 \log Y_j - \beta_3 \log D_{ij} + \beta_4 DUMMY_{ij} + \epsilon_{ij}$$

- where $DUMMY_{ij}$ is 0 for trade between Canada and the U.S. and 1 for trade between Canadian provinces.
- McCallum found that the coefficient β_4 was positive and statistically significant
    - This indicates trade flows are significantly higher when an international border isn't present

Gravity Regressions: How Big is the Border

TABLE 1—SENSITIVITY TESTS: ECONOMETRIC ISSUES

$$x_{ij} = a + by_i + cy_j + d\,\mathrm{dist}_{ij} + e\,\mathrm{DUMMY}_{ij}$$

Independent variable	Equation 1	2	3	4	5	6	7
y_i	1.30 (0.06)	1.21 (0.03)	1.15 (0.04)	1.20 (0.03)	1.24 (0.03)	1.20 (0.03)	1.36 (0.04)
y_j	0.96 (0.06)	1.06 (0.03)	1.03 (0.04)	1.07 (0.03)	1.09 (0.03)	1.05 (0.03)	1.19 (0.04)
dist_{ij}	−1.52 (0.10)	−1.42 (0.06)	−1.23 (0.07)	−1.34 (0.06)	−1.46 (0.06)	−1.43 (0.06)	−1.48 (0.07)
DUMMY_{ij}		3.09 (0.13)	3.11 (0.16)	3.09 (0.13)	3.16 (0.13)	3.08 (0.13)	3.07 (0.14)
Estimation method:	OLS	OLS	OLS	OLS	OLS	IV	OLS
Number of observations:	90	683	462	683	690	683	683
Standard error:	0.80	1.10	0.97	1.07	1.13	1.11	1.15
Adjusted R^2:	0.890	0.811	0.801	0.887	0.820	0.811	0.797

Notes: Standard errors are given in parentheses. Definitions of the equations are as follows:
Equation 1: Basic equation, Canada only;
Equation 2: Basic equation, Canada + United States;
Equation 3: Sample includes only jurisdictions with GDP exceeding $10 billion;
Equation 4: Regression weighted by $y_i + y_j$;
Equation 5: Seven observations of zero trade set equal to minimum values;
Equation 6: Logarithms of population, pop_i and pop_j, used as instruments for y_i and y_j;
Equation 7: Regression estimated by ordinary least squares, but with population variables replacing income variables.

From McCullum (1995)

Gravity Regressions: How Big is the Border

With the gravity estimates, McCallum could compare how much trade we would expect if there was no border between the U.S. and Canada to how much trade we observe

- In absence of borders, Ontario and Quebec should export 10x as much to California as to British Columbia
- In the data, Quebec and Ontario export more than three times as much to British Columbia as to California
- Finds trade flows should be 22 times larger if no international borders

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- In the data, Quebec and Ontario export more than three times as much to British Columbia as to California
- Finds trade flows should be 22 times larger if no international borders
  - Important caveat for this paper: This is before NAFTA was passed, so there were tariffs for international trade
  - Estimated border effects decrease as tariffs are lowered, but still remain high

Gravity Regressions: How Big is the Border

TABLE 2—CANADIAN SHIPMENTS OF GOODS BY DESTINATION, 1988

Origin	Shipments ($ billion)	Destination (percentage of total shipments) Own province	Other provinces	United States	Rest of world
Canada	387	44	23 [4]	24 [43]	9
Atlantic provinces	18	37	29 [12]	19 [36]	15
Quebec	85	47	27 [6]	19 [40]	7
Ontario	179	45	21 [3]	29 [47]	5
Prairie provinces	67	41	28 [9]	18 [37]	13
British Columbia	37	43	13 [2]	19 [30]	25

Note: Figures in brackets are predictions based on the gravity model.
Source: Statistics Canada (1989a, b, 1992).

From McCullum (1995)

Trade Models with Gravity

Initially, there was no theory behind the use of gravity equations

- Models made intuitive sense, but otherwise, no theoretical reason to believe they should work

Anderson and van Wincoop (2003) showed that gravity equations could be derived from an Armington model

- Showed that a-theoretic gravity equations such as McCallum (1995) suffered from omitted variable bias.
- Finds much smaller, although still large, border effects compared to McCallum after taking the omitted variables into account.

Back to the Armington Setup

- $i, j = 1, \ldots, N$ countries; each country produces it‘s own country specific good

- Consumers have CES preferences over goods and income y_j:

$$U_j = \left(\sum_{i=1}^{N} (\beta_i)^{\frac{1-\sigma}{\sigma}} (c_{ij})^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

Where β_{ij} determines each good‘s expenditure share and σ is the elasticity of substitution.

- Export prices are equal to the domestic price times a trade cost t_{ij}:

$$p_{ij} = t_{ij} p_i$$

Armington Demand and Price Indices

- Can derive the CES price indice (P_j such that $P_j U_j = I_j$) as:

$$P_j = \left(\sum_{i=1}^{N} \left(\beta_i t_{ij} p_i\right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$$

While value of exports of good i to country j are ($x_{ij} = p_{ij} q_{ij}$):

$$x_{ij} = \left(\frac{\beta_i t_{ij} p_i}{P_j} \right)^{1-\sigma} y_j$$

Scaled Prices

The total output of country i is (note domestic production/consumption included in the sum)

$$y_i = \sum_{j=1}^{N} x_{ij} = \sum_{j=1}^{N} \left(\frac{\beta_i t_{ij} p_i}{P_j}\right)^{1-\sigma} y_j = (\beta_i p_i)^{1-\sigma} \sum_{j=1}^{N} \left(\frac{t_{ij}}{P_j}\right)^{1-\sigma} y_j$$

And we can rearrange the above to find scaled prices, $\beta_i p_i$:

$$(\beta_i p_i)^{1-\sigma} = \frac{y_i}{y^w} (\Pi_i)^{-(1-\sigma)}$$

Where $y^w \coloneqq \sum_{j=1}^{N} y_j$ and (define $\theta_j \coloneqq y_j / y^w$)

$$\Pi_i \coloneqq \left(\sum_{j=1}^{N} \left(\frac{t_{ij}}{P_j}\right)^{1-\sigma} \theta_j\right)^{\frac{1}{1-\sigma}}$$

Total Output

Substituting scaled prices into our formula for the CES price index yields

$$P_j = \left(\sum_{i=1}^{N} \left(\frac{t_{ij}}{\Pi_i} \right)^{1-\sigma} \theta_i \right)^{\frac{1}{1-\sigma}}$$

Which, under symmetry ($t_{ij} = t_{ji}$), yields a unique solution with $\Pi_i = P_i$ and

$$\left(P_j\right)^{1-\sigma} = \sum_{i=1}^{N} (P_i)^{\sigma-1} \theta_i \left(t_{ij}\right)^{1-\sigma}, \qquad \forall j$$

Gravity Equation

Substituting the price indices into the demand function gives

$$x_{ij} = \frac{y_i y_j}{y^W}\left(\frac{t_{ij}}{P_i P_j}\right)^{1-\sigma}$$

Which is similar to the original most basic gravity equation

$$X_{ij} = G\,\frac{Y_i Y_j}{D_{ij}}$$

Where $D_{ij} = \left(t_{ij}\right)^{\sigma-1}$ and $G = \left(P_i P_j\right)^{\sigma-1}/y^W$

Gravity Implications

There are several implications to the derived Gravity Equation: $x_{ij} = \frac{y_i y_j}{y^W}\left(\frac{t_{ij}}{P_i P_j}\right)^{1-\sigma}$

- Trade barriers reduce size-adjusted trade between large countries more than small countries
- Trade barriers raise size-adjusted trade within small countries more than large countries
- Trade barriers raise size-adjusted trade within country 1 relative to size-adjusted trade between countries 1 and 2 by more the smaller country 1 is and the larger country 2 is.
- Trade barriers have a larger impact if output is more substitutable across countries

Trade Costs and Distance

Trade costs are unobservable, so assume they are function of observables

$$t_{ij} = b_{ij}\left(d_{ij}\right)^{\rho}$$

Where b_{ij} indicates the tariff-equivalent border barrier between i and j, where $b_{ii} = 1$ and d_{ij} is the distance between the countries.

- If only two countries: $b_{ij} = b^{1-\delta_{ij}}$ where $\delta_{ij} = 0$ if $i \neq j$ and $\delta_{ii} = 1$

Updated Gravity Regression

Estimate the following gravity regression on the Canadian/U.S. Province/State data:

$$\log z_{ij} \coloneqq \log\left(\frac{x_{ij}}{y_i y_j}\right) = k + a_1 \log d_{ij} + a_2\left(1 - \delta_{ij}\right) - \boldsymbol{(1-\sigma)}\,\mathbf{log}\,\boldsymbol{P_i} - \boldsymbol{(1-\sigma)}\,\boldsymbol{log}\,\boldsymbol{P_j} + \epsilon_{ij}$$

- Where the price indices are the variables that were ommitted by McCallum

- Note the price indices are not CPIs, but can be estimated jointly with the gravity equation by

$$\left(P_j\right)^{1-\sigma} = \sum_{i=1}^{N} (P_i)^{\sigma-1}\theta_i e^{a_1 \log d_{ij} + a_2 \log 1 - \delta_{ij}}$$

Updated Gravity Results

Anderson and Van Wincoop find a much smaller impact of border on trade flows

- Can only estimate $(1-\sigma)\rho$ and $(1-\sigma)\log b$, so border effect depends on unidentified elasticity parameter, but can plug in plausible elasticity estimate $(\sigma = 5)$ and examine sensitivity.
- With a multicountry specification, the estimated effects further decrease

Updated Border Effects

	US-US	CA-CA	US-CA	US-ROW	CA-ROW	ROW-ROW
			Two-Country Model			
Ratio BB/NB	1.05 (0.01)	4.31 (0.34)	0.41 (0.02)			
Due to bilateral resistance	1.0 (0.0)	1.0 (0.0)	0.19 (0.01)			
Due to multilateral resistance	1.05 (0.01)	4.31 (0.34)	2.13 (0.09)			
			Multi-Country Model			
Ratio BB/NB	1.25 (0.02)	5.96 (0.42)	0.56 (0.03)	0.40 (0.01)	0.46 (0.01)	0.71 (0.02)
Due to bilateral resistance	1.0 (0.0)	1.0 (0.0)	0.20 (0.02)	0.19 (0.01)	0.10 (0.01)	0.19 (0.01)
Due to multilateral resistance	1.25 (0.02)	5.96 (0.42)	2.72 (0.12)	2.15 (0.09)	4.70 (0.31)	3.71 (0.25)

Notes : The table reports the ratio of trade with the estimated border barriers (BB) to that under borderless trade (NB). This ratio is broken down into the impact of border barriers on trade through bilateral resistance ($t_{ij}^{1-\sigma}$) and through multilateral resistance ($P_i^{\sigma-1}P_j^{\sigma-1}$).

Table 4: Impact of Border Barriers on Bilateral Trade

From Anderson and Van Wincoop (2013)

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Borders estimated to reduce trade by 44%, not by 95% as in McCullum

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Distance vs Trade Costs

Asturais and Petty (2013) examine relationship between distance and port-to-port shipping costs

- Find almost zero correlation between the two
- Find a negative correlation between shipping costs and amount of trade
  - Countries that trade more are serviced by more shipping companies and employ more efficient technology.
  - Welfare gains from trade liberalization increase after taking into account endogenous shipping costs

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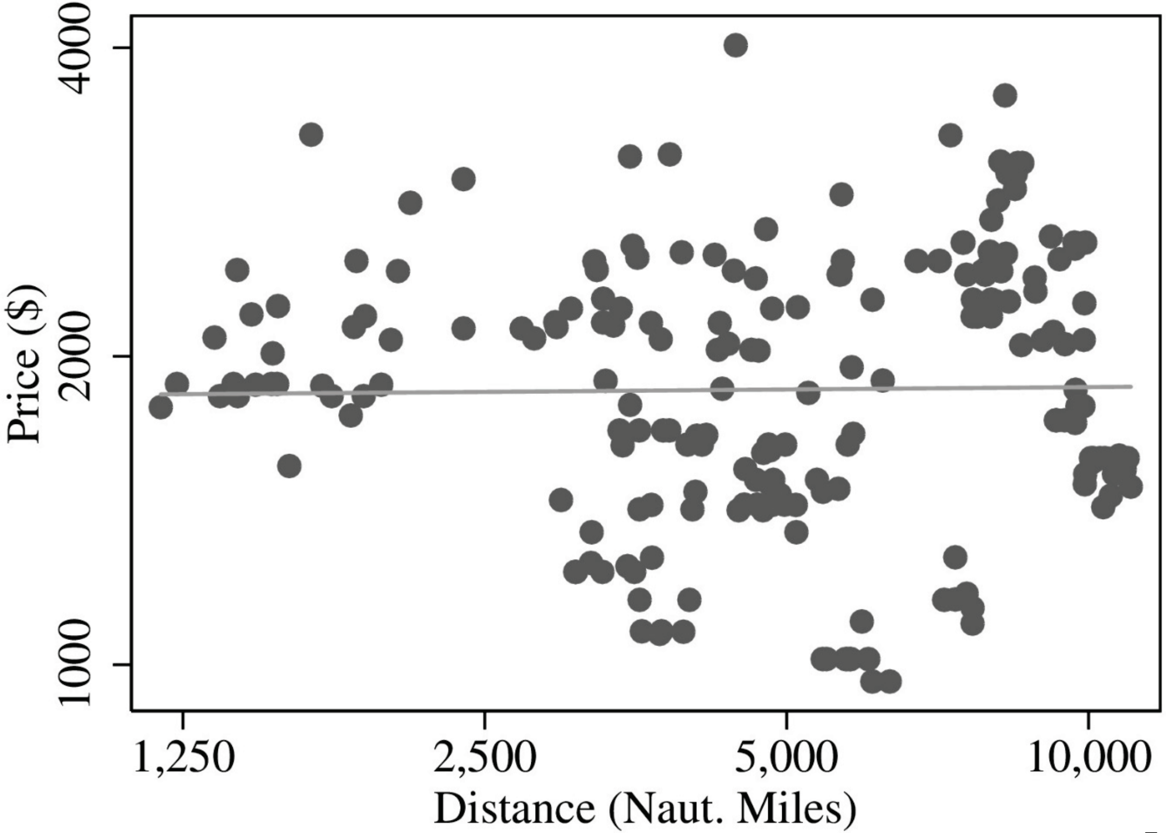
  - Countries that trade more are serviced by more shipping companies and employ more efficient technology.
  - Welfare gains from trade liberalization increase after taking into account endogeneous shipping costs
- Begs the question: Why does distance reduce trade flows?

Shipping Price versus Distance between Ports

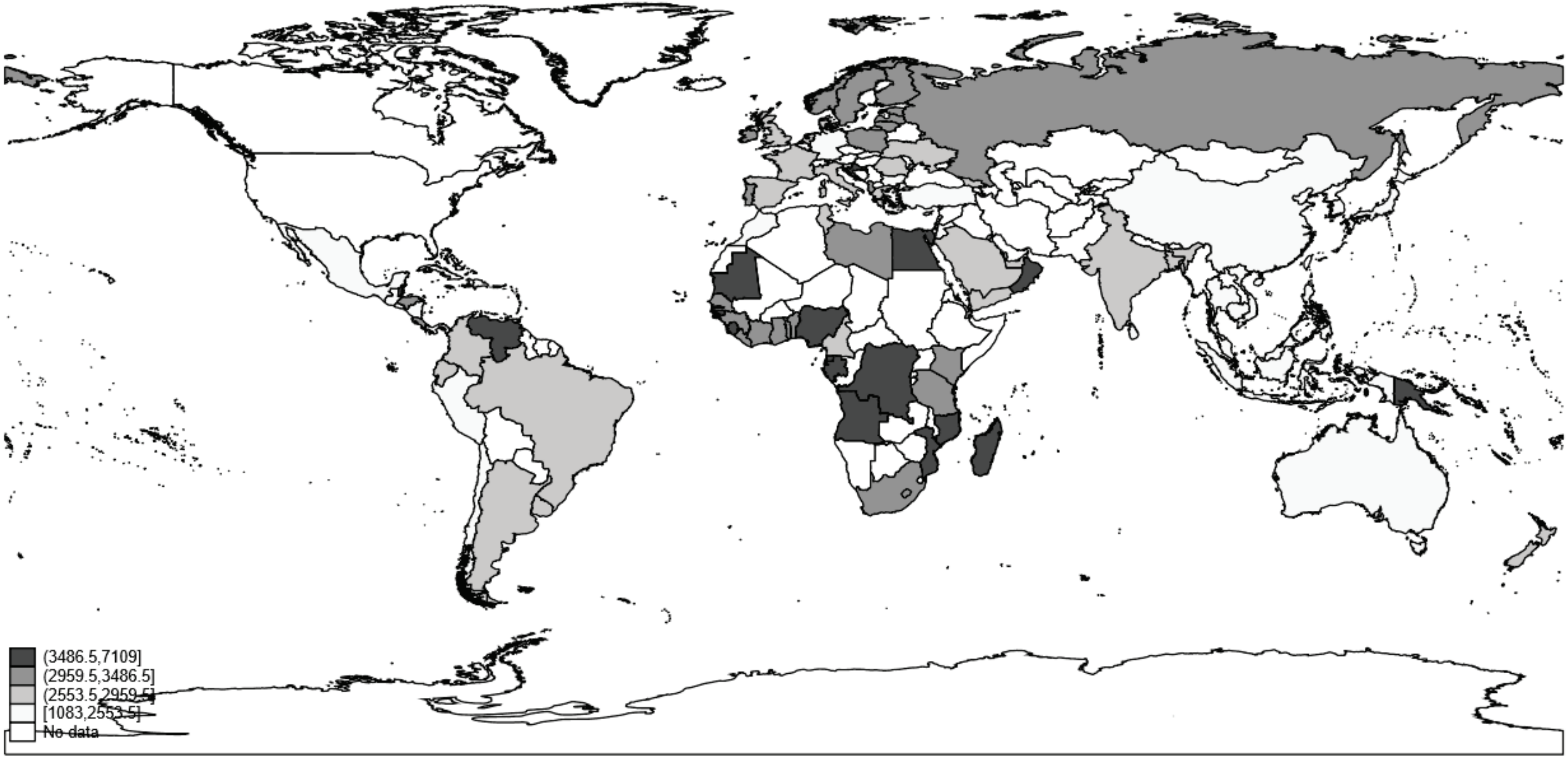


From Asturais and Petty (2013)

Shipping Price versus Distance for Los Angeles

From Asturais and Petty (2013)

Figure 2.7: Map of Prices from Los Angeles



Small versus Large Transportation Markets

Table 1: Comparing Small and Large Transportation Markets

	Bottom 20%	Top 20%	Top / Bottom 20%
Price ($)	2,330	1,390	0.60
Number of firms	1.55	4.95	3.19
Containerized trade flows / firm (millions $)	23	2,493	108.39
Containerized trade flows (millions $)	27	10,120	374.81
Distance (naut. miles)	3,990	5,730	1.44

Large transportation markets, despite being further apart on average:

- Have lower shipping costs
- Are serviced by more shipping companies
- Have greater trade flows, both overall and per shipping company

From Asturais and Petty (2013)