Universität Zürich[UZH]

Topic 1 – Gravity Equation

Prof. Ralph Ossa

Fact 1: Trade is proportional to size

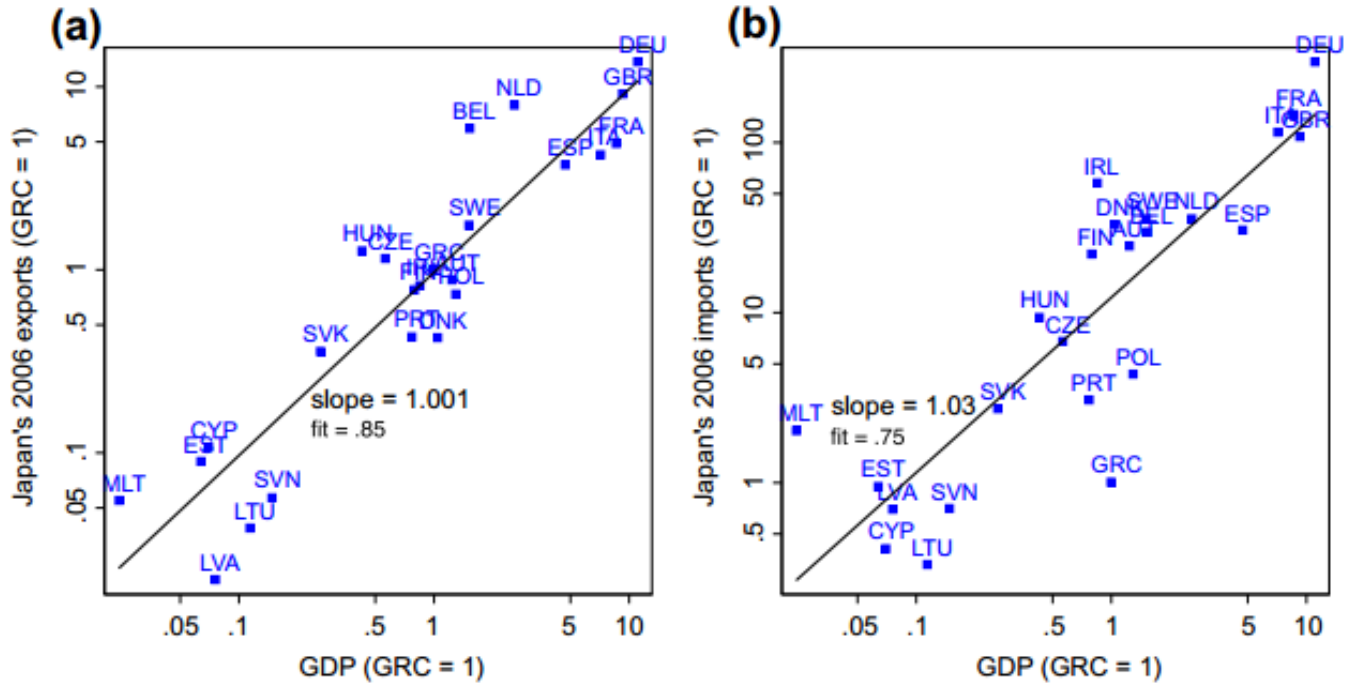

Figure 3.1 Trade is Proportional to Size; (a) Japan's Exports to EU, 2006; (b) Japan's Imports from EU, 2006. GRC: Greece

Source: Head and Mayer (2014)

Fact 2: Trade is inversely proportional to distance

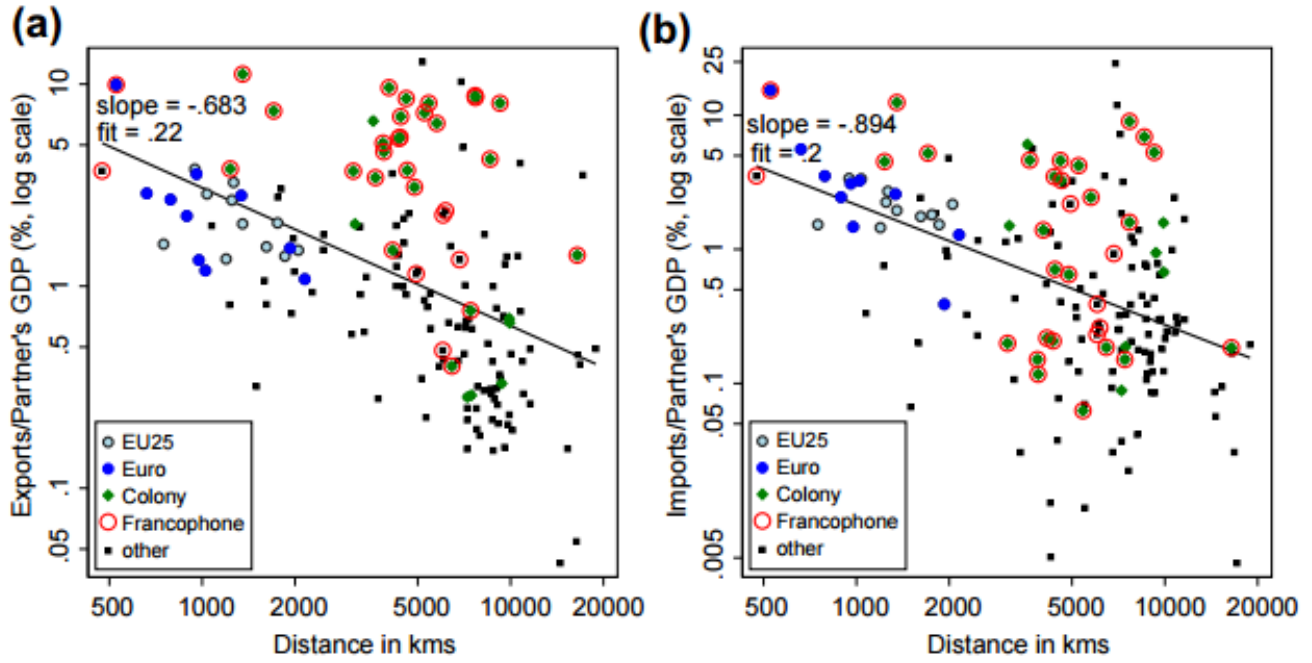

Figure 3.2 Trade is Inversely Proportional to Distance; (a) France's Exports (2006); (b) France's Imports (2006)

Source: Head and Mayer (2014)

Overview of the lecture

- Introduce the gravity equation which can rationalize these facts
- Explain how it has been used to estimate policy impacts
- Describe how it has been used to recover trade costs

Gravity equation

- These facts directly motivate the original **gravity equation**

$$Trade_{ij} = Constant \times GDP_i^{\alpha_o} \times GDP_j^{\alpha_d} \times Trade\ Costs_{ij}^{-1}$$

- Trade costs are specified as a function of distance and other factors

$$Trade\ Costs_{ij} = exp\left(\beta_1 ln\left(Distance_{ij}\right) + \beta_2 Border_{ij} + \cdots\right)$$

- This can be estimated in logs with a linear regression model

$$ln\left(Trade_{ij}\right) = Constant + \alpha_o ln(GDP_i) + \alpha_d ln\left(GDP_j\right) - \beta_1 ln\left(Distance_{ij}\right) - \beta_2 Border_{ij} + \cdots$$

Gravity equation - Comments

- This equation is called a gravity equation because it resembles Newton's law of gravitation
- It fits the data remarkably well and has been referred to as an example of "social physics"
- However, we now know that this original gravity equation is actually misspecified
- Modern trade models instead suggest an augmented estimating equation of the form

$$ln(Trade_{ij}) = Fixed\ Effect_i + Fixed\ Effect_j - \beta_1 ln(Distance_{ij}) - \beta_2 Border_{ij} + \cdots$$

Gravity equation – Comments (contd.)

- The reason is that the original gravity equation is missing so-called multilateral resistance terms which can be absorbed into origin and destination fixed effects together with GDP

- In particular, there is an inward multilateral resistance term which captures how much competition exporters face in a destination market (which matters in addition to destination GDP)

- Moreover, there is an outward multilateral resistance term which captures how much market access exporters have from an origin market (which matters in addition to origin GDP)

- The details of this are beyond the scope of this class, so the key message is that implementing the original gravity equation is not appropriate

Gravity equation – Typical results

Table 3.4 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
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.

Source: Head and Mayer (2014)

Clicker question:

Should we expect the RTA/FTA coefficient to be unbiased?

$$ln(Trade_{ij}) = Fixed\ Effect_i + Fixed\ Effect_j + \beta_1 ln(Distance_{ij}) + \beta_2 Contiguity_{ij} + \cdots + \beta_5 RTA/FTA_{ij}$$

Gravity equation – Estimating policy impacts

- Given that the gravity equation is easy to estimate and has solid theoretical underpinnings, it is often used to predict the impacts of policy changes

- For example, it was used in a recent study by the German Bertelsmann Foundation to predict the trade effects of the Transatlantic Trade and Investment Partnership (TTIP)

- Consistent with earlier studies they find huge trade effects (e.g. trade between the US and Germany is predicted to grow by around 90%!)

- However, such numbers have to be interpreted with a huge grain of salt given the reverse causality problem discussed in the clicker question. In particular, countries that trade more are also more likely to sign a regional trade agreement which biases the RTA/FTA coefficient upwards

Gravity equation – Estimating trade costs

- Besides estimating the effects of individual components of trade costs on trade flows, the gravity equation can also be used to back out overall trade costs

- In particular, consider again the original gravity equation (the augmented one works as well)

$$Trade_{ij} = Constant \times GDP_i^{\alpha_o} \times GDP_j^{\alpha_d} \times Trade\ Costs_{ij}^{-1}$$

- If we assume $Trade\ Costs_{ij} = Trade\ Costs_{ji}$ and $Trade\ Costs_{ii} = 1$, we can infer trade costs directly from trade flows (this formula is known as the **Head-Ries-Index**)

$$Trade\ Costs_{ij}^{-1} = \sqrt{\frac{Trade_{ij}Trade_{ji}}{Trade_{ii}Trade_{jj}}}$$

Gravity equation – Estimating trade costs

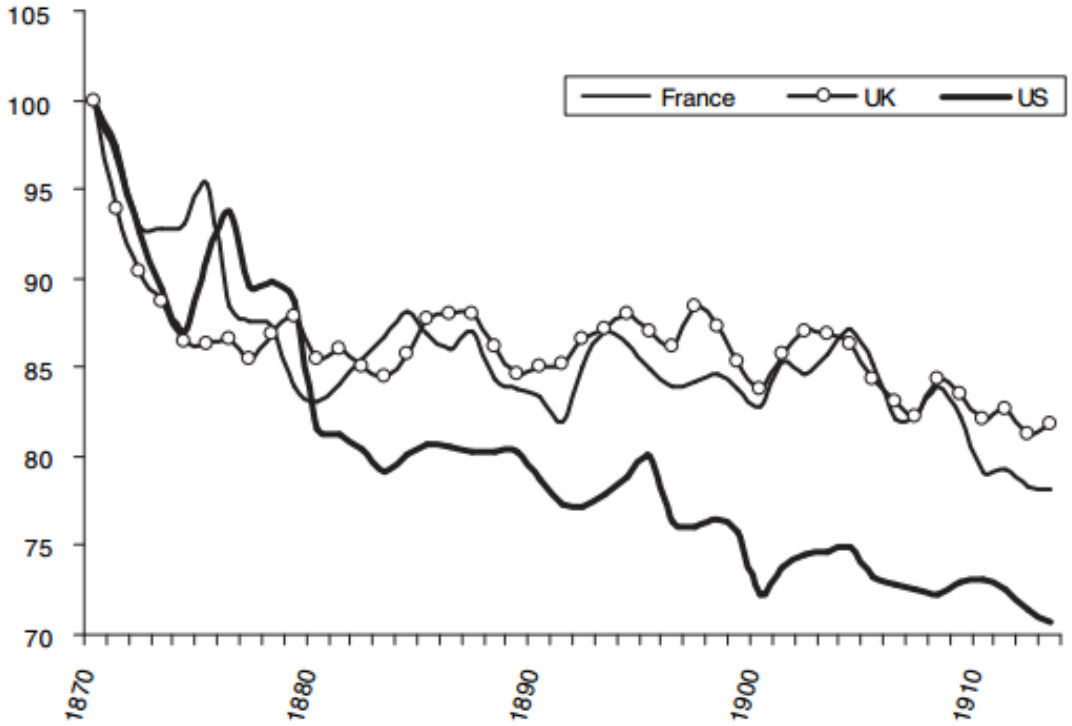

FIGURE 1A. TRADE COST INDICES, 1870–1913 (1870 = 100)

Source: Jacks, Meissner, and Novy (2008)

Gravity equation – Estimating trade costs

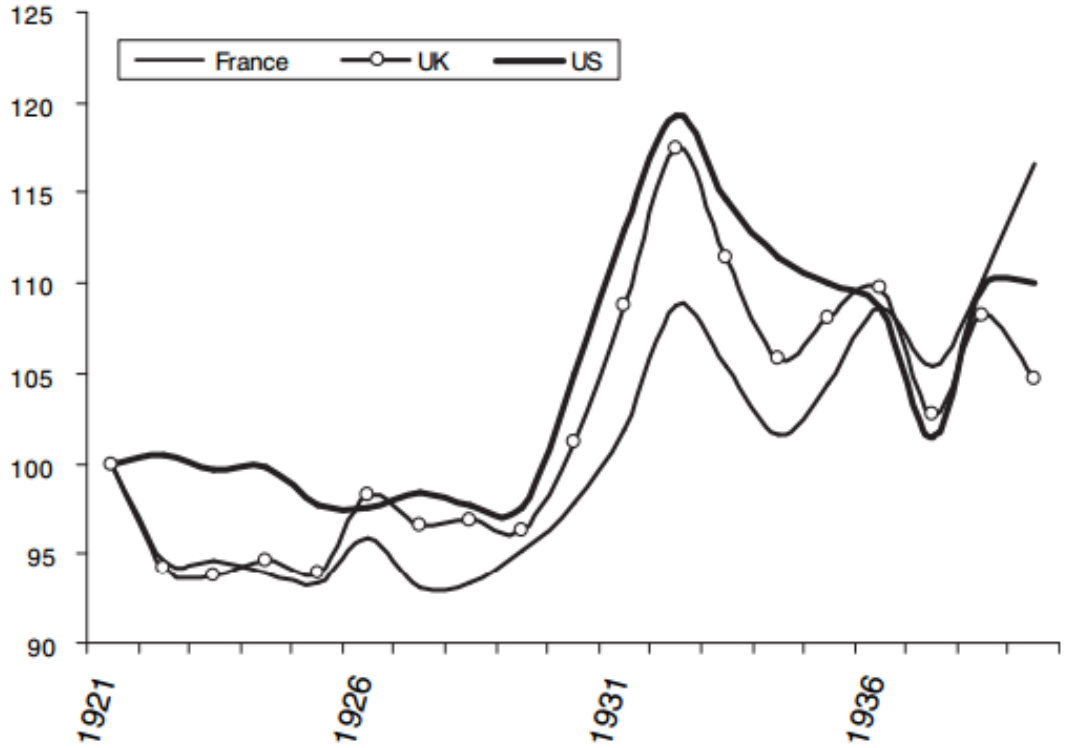

FIGURE 1B. TRADE COST INDICES, 1921–1939 (1921 = 100)

Source: Jacks, Meissner, and Novy (2008)

Gravity equation – Estimating trade costs

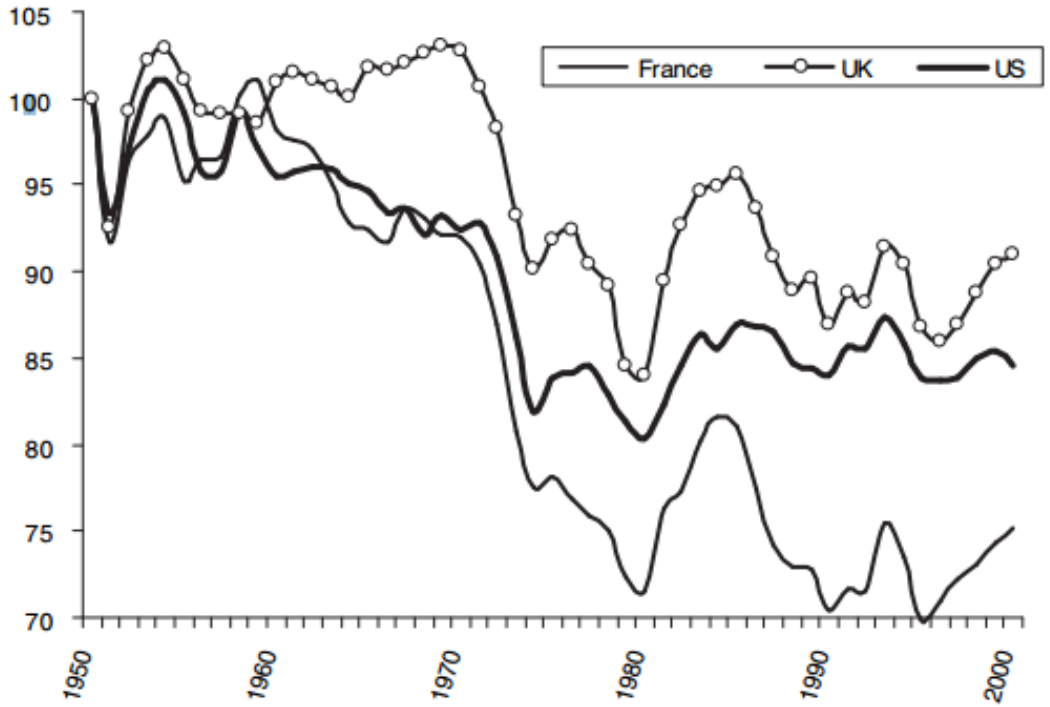

FIGURE 1C. TRADE COST INDICES, 1950–2000 (1950 = 100).

Source: Jacks, Meissner, and Novy (2008)

Gravity equation – Estimating trade costs

- Jacks, Meissner, and Novy (2008) also explore the importance of trade cost changes for trade growth
- Trade cost declines explain roughly 55% of the pre-WWI boom and 33% of the post-WWII boom
- In contrast, the sharp rise in trade costs explains almost the entire inter-war trade collapse

Conclusion

- Documented that trade is proportional to size and inversely proportional to distance
- Introduced the gravity equation which can rationalize these facts
- Explained how it has been used to estimate policy impacts
- Described how it has been used to recover trade costs

References

- *G. Felbermayr, B. Heid, and S. Lehwald. 2013. "Transatlantic Trade and Investment Partnership (TTIP) – Who Benefits from a Free Trade Deal?". Bertelsmann Stiftung*
- *K. Head and T. Mayer. 2014. "Gravity Equations: Workhorse, Toolkit, and Cookbook". Handbook of International Economics*
- *D. Jacks, C. Meissner, and D. Novy. 2008. "Trade Costs, 1870-2000". American Economic Review Papers and Proceedings*