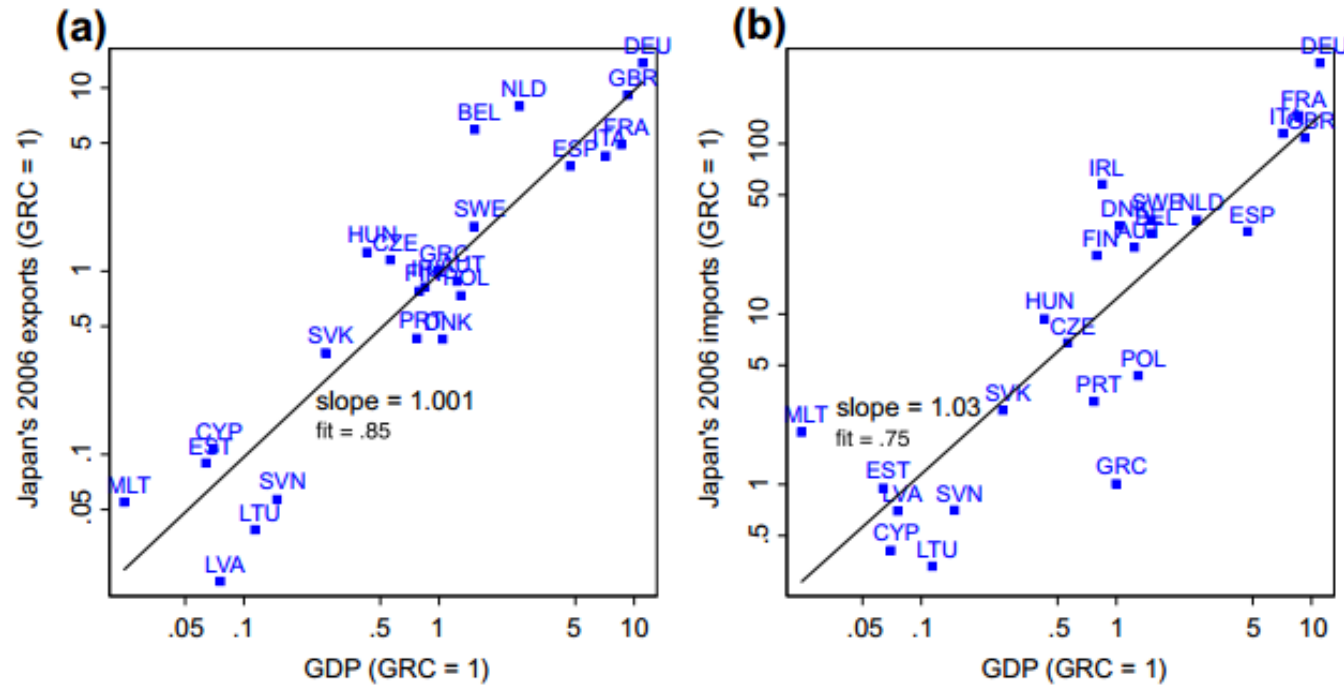




# Topic 1 – Gravity Equation

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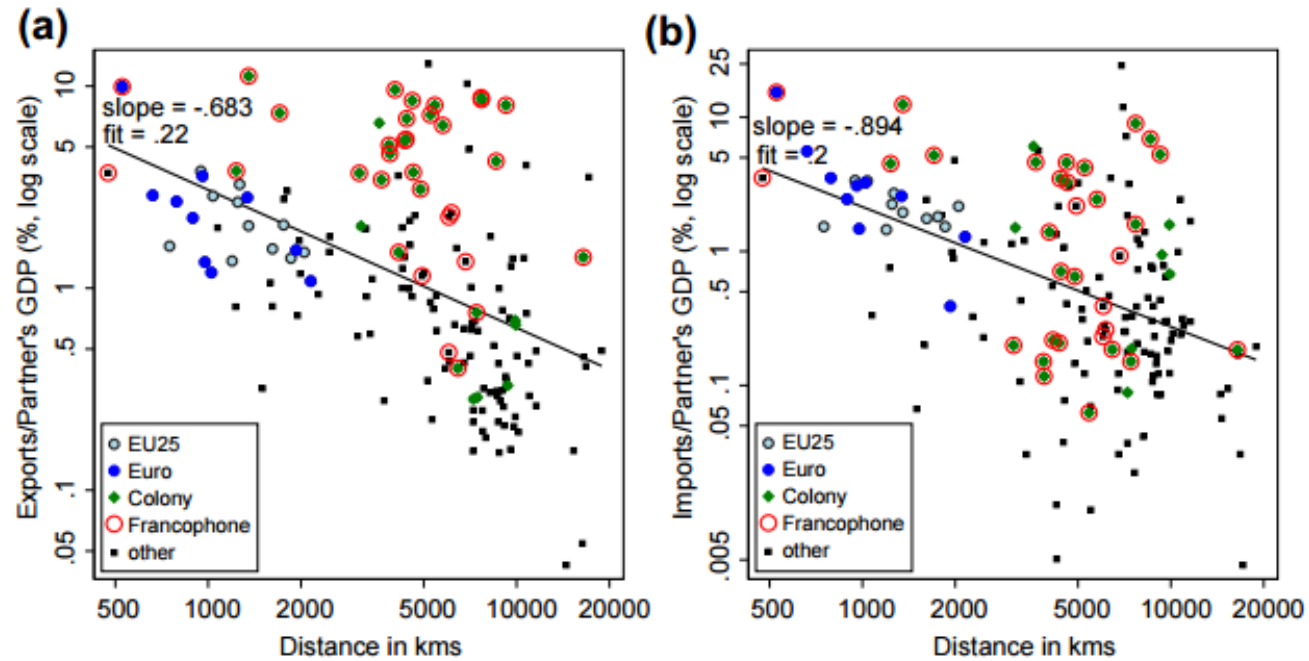
## Fact 1: Trade is proportional to size



**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



## Gravity equation

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

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

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

$$Trade Costs_{ij} = exp(\beta_1 \ln(Distance_{ij}) + \beta_2 Contiguity_{ij} + \dots)$$

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

$$\ln(Trade_{ij}) = Constant + \alpha_o \ln(GDP_i) + \alpha_d \ln(GDP_j) - \beta_1 \ln(Distance_{ij}) - \beta_2 Contiguity_{ij} + \dots$$



## 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

$$\ln(\text{Trade}_{ij}) = \text{Fixed Effect}_i + \text{Fixed Effect}_j + \beta_1 \ln(\text{Distance}_{ij}) + \beta_2 \text{Contiguity}_{ij} + \dots$$



## 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

Estimates:	All Gravity				Structural Gravity			
	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)

$$\ln(\text{Trade}_{ij}) = \text{Fixed Effect}_i + \text{Fixed Effect}_j + \beta_1 \ln(\text{Distance}_{ij}) + \beta_2 \text{Contiguity}_{ij} + \dots$$



## Gravity equation – Classic results – Border effects

- What is the effect of borders? The classic reference is McCallum (1995) who studies the effect of the border between Canada and the US
- He finds that, controlling for size and distance, Canadian provinces trade up to 22 times more with each other than with US states – a result that became known as the “border puzzle”
- Anderson and van Wincoop (2003) show that the introduction of multilateral resistance terms (see slide 7) can solve this puzzle
- Their theory-consistent estimation finds that borders reduce Canada-US trade by (a more plausible) 44%, and trade among other industrialized economies by 29%



## Gravity equation – Classic results - Free trade agreements

- Do free trade agreements (FTAs) increase trade? The classic reference is Baier and Bergstrand (2007) who find that FTAs double bilateral trade after 10 years
- As shown on slide 8, Head and Mayer (2014) conclude that the average FTA effect is  $\exp(0.36) = 1.43$  (43%), which is smaller but still substantial
- However, such numbers have to be interpreted with caution given a clear (and only partially solvable) reverse causality problem
- In particular, countries that trade more are also more likely to sign a free trade agreement, which biases the FTA coefficient upwards



## Gravity equation – Classic results - WTO

- Does the WTO increase trade? The classic reference is Rose (2004), who found no significant evidence that GATT/WTO membership increased trade between members
- Subramanian and Wei (2007) point out that Rose's (2004) benchmark regression was misspecified, notably because it omitted country fixed effects
- Correcting this and related issues, they show that WTO membership has a strong positive effect, raising trade by about 120% on average
- However, the impact is uneven: it depends on how actively a member uses its WTO commitments, which partners it negotiates with, and which products are covered



## Gravity models

- Costinot and Rodriguez-Clare (2013) show that many of the models we will study give rise to a gravity equation
- Exploring the full structure of these models makes it possible to perform general equilibrium analyses of policy shocks
- This approach underlies much of the modern quantitative trade literature going back to Eaton and Kortum (2002)
- It is also the basis of the computable general equilibrium (CGE) models widely used by policy institutions, including the WTO's *Global Trade Model*



## 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



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