ARTNeT- GIZ Capacity Building Workshop on Introduction to Gravity Modelling:
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Session 2: Introduction to the basic gravity model

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ARTNeT

Introduction

- Gravity model is a very popular econometric model in international trade
- Origins with Tinbergen (1962). Thousands of published articles and working papers since then.
  - "Some of the clearest and most robust findings in empirical economics." (Leamer & Levinsohn, 1995)
- The name came from its utilizing the gravitational force concept as an analogy to explain the volume of bilateral trade flows
- Initially, it was not based on theoretical model, but just intuition only
- Later on, a range of rigorous theoretical foundation has been given.

Introduction

- Gravity's main comparative advantage lies in its ability to use real data to assess the sensitivity of trade flows with respect to policy factors we are interested in.
- Numerous applications looking at different types of factors affecting trade costs, and their impacts on trade flows:
  - Transport costs.
  - Tariffs and non-tariff barriers.
  - Regional integration agreements, currency unions, and the
  - GATT/WTO.
  - Time delays at export/import and trade facilitation.
  - Governance, corruption, and contract enforcement.

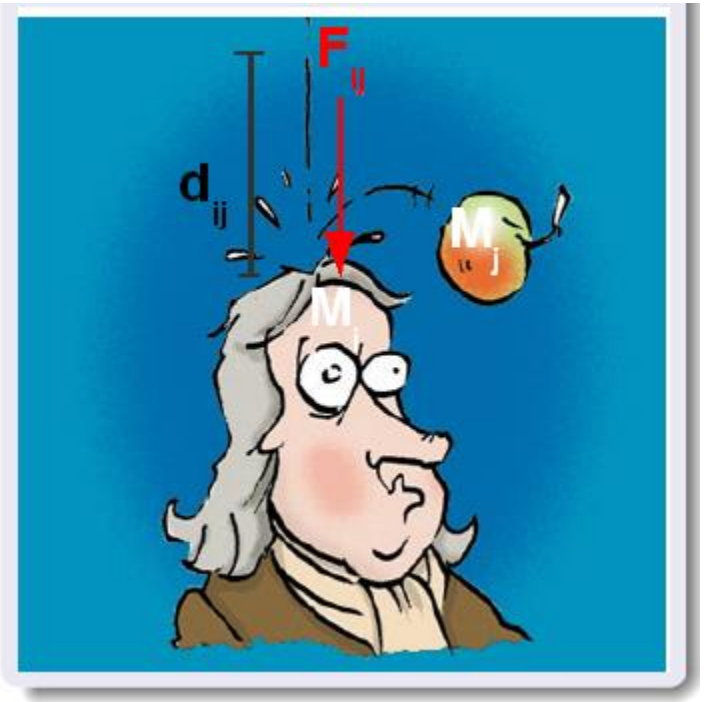
Introduction

- In recent years, intuition is not enough.
- Gravity models have become a complex business: back to microfoundations!
  - Different microfoundations imply different estimation techniques.
  - Use of sectorally disaggregated data, and broad country samples, brings out new issues for theory and empirics.
- To do good applied/policy research, it is important to be on top of the latest developments in the literature.

The traditional gravity model

- Concepts and stylized facts of the gravity approach
- Example of applications
- Identifying (“trade potentials”) using gravity approach

Gravity force in Physics



$$F_{ij} = G\frac{M_i M_j}{d_{ij}^2}$$

The gravitational force between two objects (apple, head) is directly proportional to each of their masses, and inversely proportional to the square of the distance between them.

Gravity Analogy

Gravity force equation

$$F_{ij} = G\frac{M_i M_j}{D_{ij}^2}$$

Gravity force between two objects depends on their masses and inversely proportional to the square of distance between them.

Intuitive gravity for trade

$$X_{ij} = C\frac{Y_i\, Y_j}{t_{ij}}$$

$X_{ij} = \text{exports (or trade) from i to j},$

$C = \text{contstant},$

$Y = \text{economic mass} (\approx \text{GDP}),$

$t = \text{trade costs between two countries}$

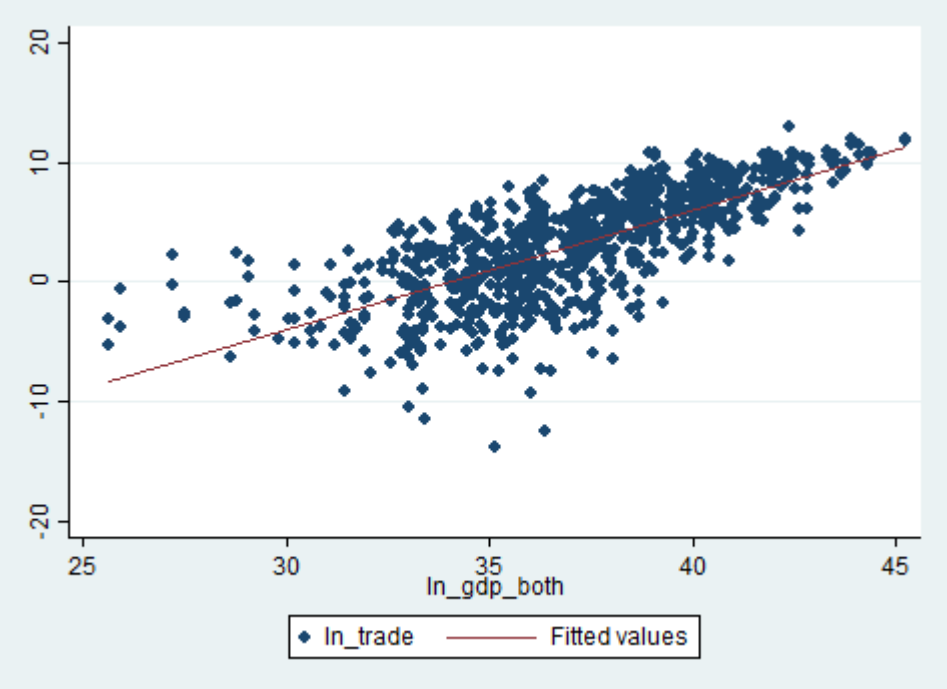
$\approx \text{distance, adjacency, .., "policy factors".}$

Export (or trade) between two countries depends on their economic masses and negatively related to trade costs between them.

Trade and combined GDP

gen ln_gdp_both = ln(gdp_exp*gdp_imp)

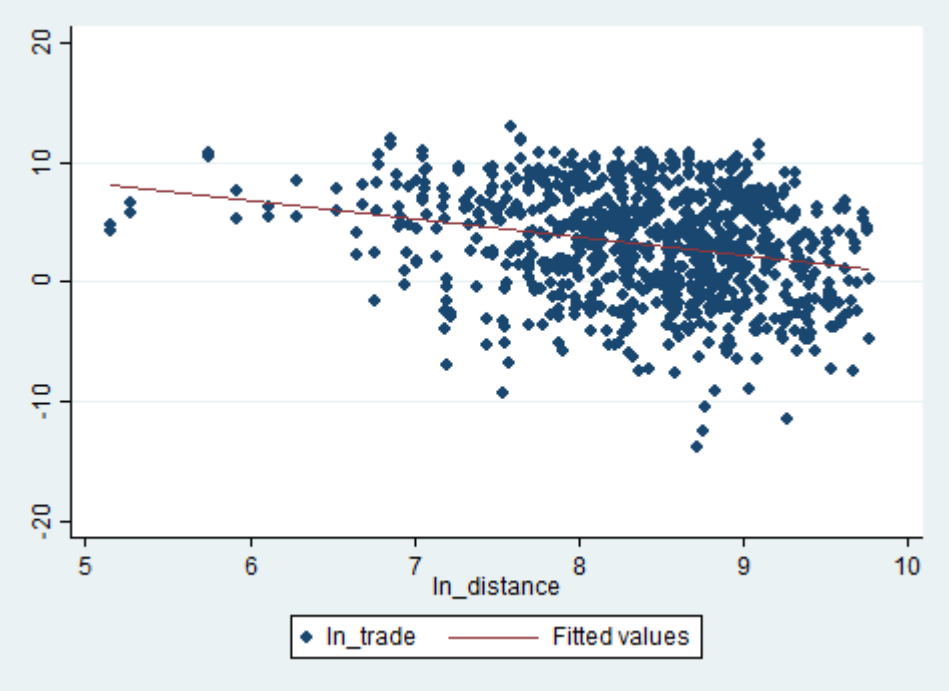
twoway (scatter ln_trade ln_gdp_both) (lfit ln_trade ln_gdp_both)



Based on AP export data 2013 provided in WITS

Trade and distance

twoway (scatter ln_trade ln_distance) (lfit ln_trade ln_distance)



Based on AP export data 2013 provided in WITS

What is the gravity model?

- Gravity model is a very popular econometric model in international trade
- The name came from its utilizing the gravitational force concept as an analogy to explain the volume of bilateral trade flows
  - Proposed by Tinbergen (1962)
- Initially, it was not based on theoretical model, but just intuition only
- Later on, a range of rigorous theoretical foundation has been given.
  - The most well-known benchmark so far is Anderson and van Wincoop (2003).

Intuitive gravity model of trade:

$$X_{ij} = C\frac{Y_i\ Y_j}{t_{ij}}$$

- Larger countries trade more than smaller ones
- Trade costs between two trade partners reduce trade between them.

Empirical equation for basic gravity model:

$$\ln X_{ij} = b_0 + b_1 \ln(Y_i) + b_2 \ln(Y_j) + b_3 \ln(t_{ij}) + e_{ij}$$

$$b_1, b_2 > 0; \quad b_3 < 0$$

A 1% change in Y_i is associated with a b_1% chage in X_{ij}.

Proxies for trade costs

- Distance
- Adjacency
- Common language
- Colonial links
- Common currency
- Island, landlocked
- Institutions, infrastructures, migration flows,..
- Bilateral tariff barriers

Why is it so popular?

- Intuitively appealing
- Fits with some important stylized facts
- Easily to use real data to explain trade flows with respect to policy factors.
- Estimation using OLS

Applications of gravity models

- Analysis of elasticities of trade volumes
  - Regional Trade Agreements (RTA), "natural regionalism" (Frankel & Wei, 1993, Baier & Bergstrand 2005)
  - WTO membership
  - Impact of NTBs on trade (Fontagné et al. 2005)
  - Cost of the border (Mac Callum, Anderson & van Wincoop 2003)
  - Impact of conflicts on trade
  - FDI & trade: complements or substitute (Eaton & Tamura, 1994; Fontagné, 2000)
  - Effect of single currency on trade (Rose, 2000)
  - Trade patterns: inter and intra-industry trade (Fontagné, Freudenberg & Péridy, 1998)
  - Diasporas (community of immigrants)
  - Internet

Applications of gravity models

- Analyse predicted trade flows and observe differences between predicted and observed flows (analysis of residuals)
  - Trade potentials of economies in transition (out-of sample predictions)
  - Identify the natural markets and markets with an untapped trade potential
  - Predicted values are used in some cases as an input for CGE modeling (Kuiper and van Tongeren, 2006)
  - Use of confidence intervals in addition to predicted values, in order to take into account the residual variance

Examples of Applications

- Effects of regional integration on trade

Do RTAs boost trade between members?

$$\ln X_{ij} = b_0 + b_1 \ln(Y_i) + b_2 \ln(Y_j) + b_3 \ln(t_{ij}) + b_4 (dummyRTA_{ij}) + e_{ij}$$

Do RTAs reduce exports from non-members?

$$\ln X_{ij} = b_0 + b_1 \ln(Y_i) + b_2 \ln(Y_j) + b_3 \ln(t_{ij}) + \ldots$$
$$+ b_4 (dummy\ BothInRTA_{ij}) + b_5 (dummy\ OneInRTA_{ij}) + e_{ij}$$

- By using dummy variables, gravity models provide a crude measure of RTA impact on trade but cannot distinguish the precise mechanisms.
- Both b4 > 0 and b5>0 implies trade creating RTA.
- Only b4> 0 while b5<0 implies trade diverting RTA

See, World Bank (2005) for survey.

- Two important limitations related to using gravity models for estimating the impact of a RTA:

1. RTAs may be endogenous variables (ie. the causal link between the formation of a RTA and trade flows). This endogeneity affects gravity-based estimates.
2. Recent literature is replete with models in which regional integration agreements are formed in the pursuit of other, non-trade goals (see, for instance, Limao, 2006) or in which they have "non-traditional" gains (see Ethier, 1998).
   - South–South agreements have been rather more successful in non-trade dimensions like the management of common resources than in the dimension of pure trade-liberalization.

- The analysis of RTAs should avoid limiting itself to measuring trade diversion and creation, although these are important issues for the welfare of member countries.

Examples of Applications

- Effects of institutional weakness on trade

  How does corruption affect trade?

$$\ln X_{ij} = b_0 + b_1 \ln(Y_i) + b_2 \ln(Y_j) + b_3 \ln(t_{ij}) + b_4 \ln(corruption_i) + e_{ij}$$

Anderson and Marcouiller use a 58-country gravity model and corruption data from the World Economic Forum to 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.

Examples of Applications

- Effects of trade facilitation on trade

  How much can trade facilitation boost bilateral trade?

$$\ln X_{ij} = b_0 + b_1 \ln(Y_i) + b_2 \ln(Y_j) + b_3 \ln(d_{ij}) + b_4 \ln(time_i^X) + e_{ij}$$

- Djankov Freund & Pham (2010) use a gravity model with 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%.
  - Time-critical agricultural and manufactured goods are particularly sensitive to border crossing times:
    - Agriculture: Fresh fruits and vegetables.
    - Manufactures: Electronic goods; parts and components.
- **Landlocked countries** are particularly sensitive to border crossing times: One extra day reduces exports by as much as 4%.

Examples of Applications for landlocked countries

- Effects of being landlocked countries on trade

How much does being lancdlocked reduce trade?

$$\ln X_{ij} = b_0 + b_1 \ln(Y_i) + b_2 \ln(Y_j) + b_3 \ln(d_{ij}) + b_4 \ln(landlocked_{ij}) + \ldots + e_{ij}$$

Raballand (2003) applies a gravity approach to (46 countries of which 18 are landlocked) show that being landlocked country would reduce trade by 80% (when measured by a dummy variable).

- Determinants of trade costs

An example of trade-cost regressions, (See, Moïsé and Sorescu, 2013, etc.)

Without landlocked

$$\ln(\tau_{ij}^k) = \beta_0^k + \beta_1^k \ln(\text{distance}_{ij}) + \beta_2^k \text{contiguity}_{ij} + \beta_3^k \text{language}_{ij} + \beta_4^k \text{colony}_{ij} + \beta_5^k \text{rta}_{ij} + \beta_6^k \text{avg\_applied\_tariff}_{ij*ji}^k + \beta_7^k \text{TFI}_*^c + D_i + D_j + D_k + \varepsilon_{ij}^k$$

With landlocked

$$\ln(\tau_{ij}^k) = \beta_0^k + \beta_1^k \ln(\text{distance}_{ij}) + \beta_2^k \text{contiguity}_{ij} + \beta_3^k \text{language}_{ij} + \beta_4^k \text{colony}_{ij} + \beta_5^k \text{rta}_{ij} + \beta_6^k \text{avg\_applied\_tariff}_{ij*ji}^k + \beta_7^k \text{TFI}_*^c + \beta_8^k \text{TFI}_i^{\text{transit}} * (1 - \text{contiguity}_{ij}) + D_j + D_k + \varepsilon_{ij}^k$$