

Evidence-Based Trade Policymaking Capacity Building Programme

ARTNeT Interactive Gravity Modeling Tool

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Outline

- Background on gravity model of trade and their applications
- Theoretical gravity and fixed effect issues
- ARTNeT Interactive gravity model database
- Demonstration and exercises
- Conclusions



Part I

Background on gravity model of trade and their applications



What is 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).



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.



Trade Gravity: Basic

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

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

C = constant,

Y = economic mass (\approx GDP),

t = trade costs between two countries

\approx distance, adjacency, ..., "policy factors".

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



Basic gravity model of trade:

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

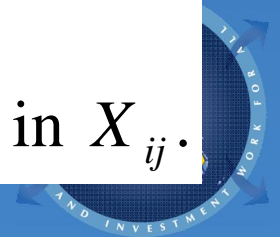
- Larger countries trade more than smaller ones
- Trade costs between two trade partners reduce trade between them.

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 % change 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 we are interested in.
- Estimation using OLS



Examples of Applications

- Effects of regional integration on trade

Do RTAs boost trade between members?

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

Do RTAs reduce exports from non - members?

$$\begin{aligned} \ln X_{ij} = & b_0 + b_1 \ln(Y_i) + b_2 \ln(Y_j) + b_3 \ln(t_{ij}) + \dots \\ & + b_4 (\text{dummy BothInRTA}_{ij}) + b_5 (\text{dummy OneInRTA}_{ij}) + e_{ij} \end{aligned}$$

See, World Bank (2005) for example.



Examples of Applications

- Effects of trade facilitation on trade

How much can trade facilitation boost bilateral trade?

$$\ln X_{ij} = b_0 + b_1 \ln(Y_i) + b_2 \ln(Y_j) + b_3 \ln(t_{ij}) + b_4 \ln(\text{time}_i^X) + e_{ij}$$

See, Djankov et al.(2010) for example.



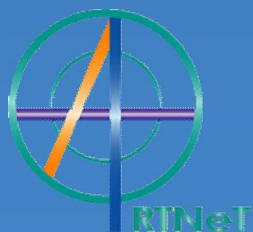
Examples of Applications

- Effects of institutional weakness on trade

How does corruption affect trade?

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

See, Anderson & Marcouiller(2002) for example.



Examples of Applications

- Estimating trade potential

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

First step: estimate the model to get estimated coefficients

Second step: Use estimated coefficients give predicted X_{ij}

$$\hat{X}_{ij} = \hat{b}_0 + \hat{b}_1 \ln(Y_i) + \hat{b}_2 \ln(Y_j) + \hat{b}_3 \ln(t_{ij}) + \dots$$

Third: Trade potential is the gap between predicted and actual X_{ij}



Part II

Theoretical gravity and Fixed effect issues



Why do we need theoretical gravity?

Major weaknesses of basic gravity:

- No theoretical background
- Failure to take into account of GE effects
 - Nothing from the third party can affect trade between the two partners
 - Cannot say about welfare effects
 - Cannot say about resource allocations within an economy



A brief introduction to theoretical gravity

- Enormous literature has laid theoretical foundations to gravity model
 - Ex. Anderson (1979), Bergstrand (1990), Anderson & Van Wincoop (2003), Helpman et al (2008).
- Some of them have strong implications on the data and estimation method
 - Complex empirical issues that OLS cannot handle
 - For ex. see the gravity course on Ben Shepherd website at <http://www.developing-trade.com/>



AvW (2003)

- The most formal benchmark for theoretical gravity model so far
 - Bringing the gravity model a step closer to GE effects
 - Accounting for “relative price effects” on trade flow

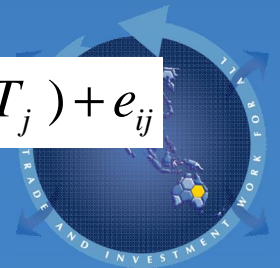
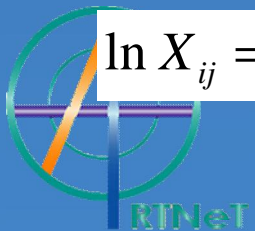
*Things affecting “**relative price**” can influence bilateral trade flow. No matter the “things” happen between the two trading partners or happen with third parties.*



AvW (2003): Empirical implications

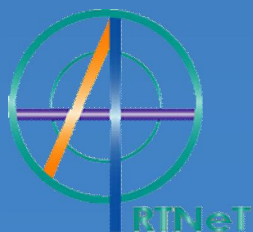
- **“Relative trade costs”** matter, not only absolute trade costs,
 - **Not only distance between countries, but also their distance from RoW** matter for their bilateral trade
- Two types of trade costs have to be taken into account
 - Trade costs between i and j
 - Trade costs of i and j with third parties
- This idea introduces a **“multilateral trade resistance (MTR)”** term to the gravity regression
 - MTR terms are empirically unobservable
 - One approach to take into account MTR in the regression is using **“Fixed Effects”** Dummies.

$$\ln X_{ij} = b_0 + b_1 \ln(Y_i) + b_2 \ln(Y_j) + b_3 \ln(t_{ij}) + b_4 \ln(MRT_i) + b_5 \ln(MRT_j) + e_{ij}$$



Using fixed Effects Dummies

- An approach to (partly) take into account MTR in the regression, while using OLS
- Fixed effects dummies
 - Exporter & Importer dummies
 - Year dummies
 - Sector dummies



With fixed effects dummies :

$$\ln X_{ij} = b_0 + b_1 \ln(GDP_i) + b_2 \ln(GDP_j) + b_3 \ln(t_{ij}) + \dots \\ b_4 dummy_country_i + b_5 dummy_country_j + e_{ij}$$

DON'T make these MISTAKES:

- X_{ij} = trade between ij (wrong!)
 - We need a clear distinction between exporter effects and importer effects
- USE GDP per capita rather than GDP (wrong!)
 - Price Index has already been included in MTR terms



Part III

ARTNeT Interactive gravity model database



ARTNet online gravity

- ARTNet has developed an online gravity interface to make it easier for policy researcher to get started with gravity
- Available online and FREE at
<http://www.unescap.org/tid/artnet/gravity.asp>
- Can be used for
 - Estimate basic gravity models using a wide variety of policy data
 - Analyze trade potentials
 - Download pre-formatted data that can be plugged into statistical software for more extensive analysis



Data and sources

- Cover various countries and time periods
- Exports and imports
- GDP, GDP per cap, growth, population
- Geographical, historical , and cultural links
- Cover trade policy data:
 - trade credits, trade facilitation, logistics, infrastructure
 - Behind the border barriers
 - Aid for trade



Current datasets

- General trade dataset: 1994-2007
 - Use for general analysis and for calculate trade potential
- Trade facilitation dataset: 2006
 - Use for analysis focusing trade effects of trade facilitation, customs and border procedures, and behind the border barriers
- Aid for trade dataset: 2002-2007
 - Use for analysis of trade effects of aid flows



Example 1: Basic Regression

- Select “ARTNeT data on trade dataset”
 - Use for general analysis and for calculate trade potential
- Set the dependent (LHS) variable to $\log(\text{exports})$
- Standard independent (RHS) variables
 - Partner and reporter GDP
 - Distance
 - Common language, geographical contiguity, colony, common colonizer
- Run the regressions and interpret the results



Part IV

Demonstration and Exercises



Example 1: Trade potential

- Calculate estimated to actual trade ratios for the following country pairs:
 - Exports from Thailand to USA for 2007, and averaged over 1994-2007
 - Exports from USA to Thailand for 2007, and averaged over 1994-2007



Example 1: Trade projection

- Using 2007 as the base year, calculate trade projections for:
 - Thailand's exports to Cambodia, China, Indonesia, India, and Japan, based on an expected 2% fall in reporter and partner GDP
 - Thailand's exports to USA, Canada, Germany and Japan, based on expected 1% fall in international transport costs



Example 2: Trade Effects of Tariffs

- Select “trade facilitation dataset”
 - Use for general analysis and for calculate trade potential
- Set the dependent (LHS) variable to $\log(\text{exports})$
- Independent (RHS) variables
 - Partner and reporter GDP per capita
 - Partner and reporter populations
 - Distance
 - Common language, geographical contiguity, colony, common colonizer
 - Simple avg tariffs in the partner (importing) country
- Run the regressions and interpret the results
- Analyze trade impact of a 5% cut in tariffs



Part V

Conclusions



Value of the interactive database

- A wide variety of trade-related data, in particular on trade facilitation
- Additional data can easily be plugged in
- Saves researchers a lot of time and resources in terms of data collection and preliminary analysis
- Extensions from basic models are possible such as fixed effects
- ARTNet has developed an online gravity interface to make it easier for policy researcher to get started with gravity
- Available online and FREE
- Can be used for
 - Estimate basic gravity models using a wide variety of policy data
 - Analyze trade potentials
 - Download pre-formatted data that can be plugged into statistical software for more extensive analysis



Things to aware

- Can't say about welfare / resource allocation
 - It is not based on general equilibrium
 - It is based on historical data
- Can't be a primary tool for forecast / counterfactuals
 - It is purely based on historical data
- Other tools (ex. CGE) have to use in conjunction to handle these issues
- OLS may not give an efficient estimates if
 - if there is zero trade flow.
 - Reverse causality exist (endogeneity problems)
 - Multi-dimension data



Suggestions

- Robustness check
 - Whether model specification and estimation techniques used are appropriate
- Being modest when using the gravity results in your analysis
 - the gravity results give ideas about the relationship, but do not expect precise \$ figure
- If an analysis really need \$ number, do it for a range rather than a single number (ex. Between $-SD$ and $+SD$)
- Asking questions that gravity can answer well
 - Ex. Trade potential based on 2007 data does not say about current/future potential
- If there are serious doubts about reverse causality, treat the conclusions as association, not causal links
- Apply gravity analysis in conjunction with other approaches such as CGE.
- Keep updating the up-to-date model and techniques



References

Tinbergen, J. (1962). *Shaping the World Economy: Suggestions for an International Economic Policy*: 20th Century Fund, NY.

Anderson, J. and E. Van Wincoop (2003). "Gravity with Gravitas: A solution to the Border Puzzle", *AER*, 93: 170-192.

World Bank (2005). *Global Economic Prospect: Trade, Regionalism, and Development*.

Djankov, S., C. Freund & C. S. Pham (2010). "Trading on Time," *The Review of Economics and Statistics*, 92(1):166-173.

Anderson, J. E. and D. Marcouiller (2002). "Insecurity and the Pattern of Trade: An Empirical Investigation." *Review of Economics and Statistics*, 84(2), 342-52.

Anderson, J. E. (1979). "A theoretical foundation for the gravity equation." *AER*, 69(1), 106-116.

Bergstarnd, J.H. (1990). "The H-O-S model, the Linder Hypothesis, and the determinants of bilateral intra-industry trade." *Economic Journal*, 11(4):1216-1229.

Helpman, E., Melitz, M. and Rubinstein, Y. (2008), "Estimating trade flows: Trading partners and trading volumes," *Quarterly Journal of Economics*, 123, 441-487.

