

Session 1: Introduction to Gravity Modeling

Ben Shepherd

Principal, Developing Trade Consultants Ltd.

ARTNeT Capacity Building Workshop for Trade Research:
Gravity Modeling

Monday, August 23, 2010

Outline

- 1 Introduction and Workshop Overview
 - Introduction
 - Overview of the Workshop
- 2 The Basic Gravity Model
 - The Gravity Analogy
 - Stylized Facts: Trade, GDP, and Distance
- 3 Assessing Trade Policies Using Gravity
 - Example 1: Trade Facilitation
 - Example 2: Trade Effects of Corruption
- 4 Summary

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Introduction

- “Gravity” is the workhorse of empirical 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)

Introduction

- Numerous applications looking at different types of 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, though, gravity has become a complex business:
 - Intuition is not enough: 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.

Key Messages

- The gravity model accords well with basic intuition about the drivers of international trade.
- It does a good job of explaining some important stylized facts about international trade.
- In more recent times, gravity has been given a range of rigorous theoretical foundations.
- 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.

Key Messages

- Gravity modeling can be a useful input into the policy process, but only if it is done well:
 - It asks a question that gravity can answer relatively well.
 - It uses up-to-date models and techniques.
 - Conclusions are presented modestly, with attention to robustness and uncertainty issues.
 - Synergies with other approaches are exploited.

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Overview of the Workshop

General Objectives

- Help boost knowledge and capacity for policy-relevant trade research in the Asia-Pacific.
- Promote network effects through the exchange of ideas, questions, sources, etc.
- Particular focus on trade costs, trade facilitation, and behind the border (BTB) barriers.
- Provide a thorough overview of the gravity model, both theory and estimation techniques, to act as a springboard to individual and joint research projects.
- Present and compare data sources, empirical strategies, estimation methods, and results.

Overview of the Workshop

Methodology and Approach

- 1 Intuitive presentation of basic ideas.
Introduction to simple data manipulation.
Estimation of traditional gravity models using real data.
- 2 Intuitive presentation of recent gravity theory.
Estimation of the “theoretical” gravity model using panel data techniques.
- 3 Econometric difficulties facing gravity modelers.
Estimation in the presence of zero trade flows.
Estimation in the presence of endogenous policies.
- 4 Complements to gravity modeling.
Inverse gravity, and trade costs indices.
Firm-level data.

Overview of the Workshop

Monday, August 23

Morning Sessions

- Introduction to the course.
- Presentation of the basic gravity model.
- Estimation by OLS, testing hypotheses, and interpreting results.

Afternoon Sessions

- Using the ARTNeT online gravity interface.

Overview of the Workshop

Tuesday, August 24

Morning Sessions

- The theoretical gravity model.
- Estimation using fixed and random effects.
- Implementation in Stata

Afternoon Sessions

- Introduction to Stata.
- Using Stata and the ARTNeT online gravity interface to estimate the “theoretical” gravity model.

Overview of the Workshop

Wednesday, August 25

Morning Sessions

- Performing counterfactual simulations with gravity models.
- Creating gravity model indicators (using principal components analysis).

Afternoon Sessions

- Research presentations.

Overview of the Workshop

Thursday, August 26

Morning Sessions

- Export diversification and gravity.

Afternoon Sessions

- Dealing with reverse causality in the gravity model.

Overview of the Workshop

Friday, August 27

Morning Sessions

- Measuring trade costs using inverse gravity.
- Consolidation: current best practice.

Afternoon Sessions

- Consolidation exercise.

Overview of the Workshop

Course Materials

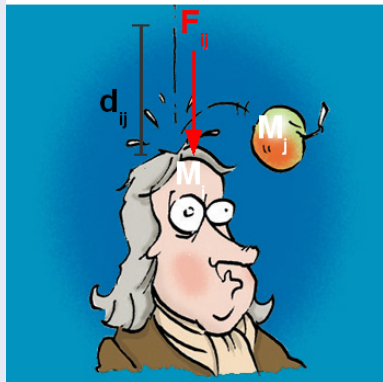
- All materials are available from www.developing-trade.com.
- Some of the suggested readings are technical. Focus on the logic and implications, which are intuitive, rather than the math.
- Datasets are mostly drawn from published research. Make sure you can reproduce their results, then experiment with different specifications.

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The Gravity Analogy

Before: "Ouch!"



After: " $F_{ij} = G \frac{M_i M_j}{D_{ij}^2}$!"

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.

The Gravity Analogy

- Newton's theory of gravity postulates that the gravitational force between two objects is directly proportional to each of their masses, and inversely proportional to the square of the distance between them.

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

- G here is a gravitational constant, supposed universal.
- This is fine for planets, apples, etc. But what is the connection with trade?

The Gravity Analogy

Physics

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

Economics

$$X_{ij} = c \frac{Y_i Y_j}{d_{ij}}$$

- Economic “mass” is proxied by a country’s GDP.
- The distance between countries is taken as an indication of the level of trade costs they face.
- Think of a larger economy pulling more goods from its trading partners; similarly, a larger economy pushes more goods towards its trading partners.
- But this process is impeded by trade costs (e.g., transport, tariffs, etc.)

The Gravity Analogy

Physics

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

Economics

$$X_{ij} = c \frac{Y_i Y_j}{d_{ij}}$$

- Take logs, add some reduced form coefficients, and include an error term to get the familiar empirical gravity model:

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

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

- It is intuitively appealing, and also happens to have very strong explanatory power.
- To get a feel for just what a good job it can do, let's have a look at some stylized facts.

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Stylized Facts: Trade, GDP, and Distance

- Using some basic data, we can quickly get a sense of just what the gravity model is picking up.
 - Bilateral trade: 2005, nominal USD.
 - Source: Comtrade via WITS.
 - Export and importer GDP: 2005, nominal USD
 - Source: World Development Indicators.
 - Bilateral distance.
 - Source: CEPII distance dataset.

Stylized Facts: Trade, GDP, and Distance

Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
trade_value	23411	1880230	7.11E+07	0	1.03E+10
gdp05_exp	20355	3.34E+11	1.22E+12	6.64E+07	1.24E+13
gdp05_imp	21666	4.21E+11	1.38E+12	6.64E+07	1.24E+13
dist	22174	7564.114	4540.373	9.342786	19951.16

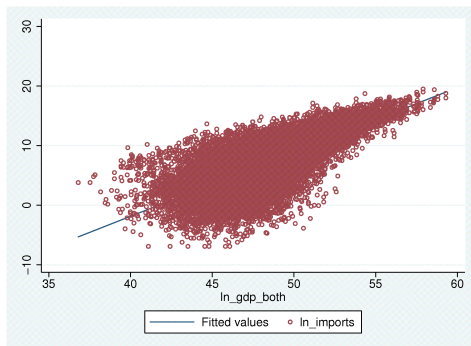
Stylized Facts: Trade, GDP, and Distance

Bivariate Correlations

	ln_imports	ln_gdp_exp	ln_gdp_imp	ln_gdp_both
ln_imports	1			
ln_gdp_exp	0.56	1		
ln_gdp_imp	0.41	-0.17	1	
ln_gdp_both	0.75	0.65	0.64	1
ln_dist	-0.26	0	0.04	0.03

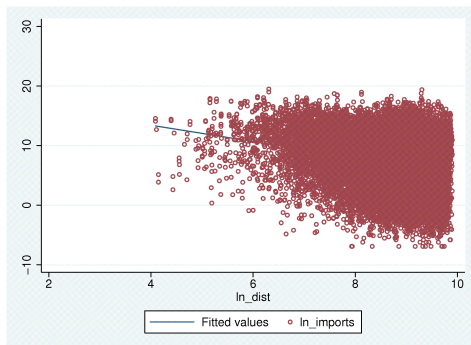
Stylized Facts: Trade, GDP, and Distance

$\ln(\text{Imports})$ vs. $\ln(\text{GDP}_i \cdot \text{GDP}_j)$



Stylized Facts: Trade, GDP, and Distance

Ln(Imports) vs. Ln(Distance)



Stylized Facts: Trade, GDP, and Distance

Consolidation

- Some evidence of a positive relationship between the GDP of trading partners, and bilateral trade.
- Some evidence of a negative relationship between international distance, and bilateral trade.
- But these correlations:
 - Do not control for other potential influences;
 - Do not equate to causation;
 - Are subject to considerable deviations, in particular at low GDP and high distance.

Assessing Trade Policies Using Gravity

- The proof of the pudding is in the eating...
- There are literally thousands of gravity models in the trade literature, but we can get a good feel for current best practice by focusing on just a couple of examples.
- The best analytical work using gravity:
 - Asks a question that gravity can answer relatively well.
 - Combines current best practice on theory and econometrics.
 - Takes care to interpret results modestly.
 - Looks for ways of interacting with other approaches to trade modeling.

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Example 1: Trade Facilitation

- 1 To what extent can streamlined customs procedures and faster border crossing times boost bilateral trade?
- 2 How does the impact of trade facilitation vary across different countries and product groups?

Example 1: Trade Facilitation

By How Much can Trade Facilitation Boost Bilateral Trade?

$$\log \left(X_{ij}^k \right) = b_0 + b_1 \log \left(Y_i \right) + b_2 \log \left(Y_j \right) + b_3 \log \left(d_{ij} \right) + e_{ij} \dots \\ + b_4 \log \left(\mathbf{time}_i^x \right) + \dots$$

- 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%.
 - Using their numbers, an extra day's delay is equivalent to moving a country 70km further away from its trading partners.

Example 1: Trade Facilitation

Does Trade Facilitation Affect All Countries and Products Equally?

- Djankov Freund & Pham (2010) find that:
 - Landlocked countries are particularly sensitive to border crossing times: One extra day reduces exports by as much as 4%.
 - For landlocked countries, it is often border crossing times in neighboring (transit) countries that constrain exports more than border crossing times at home.
 - Time-critical agricultural and manufactured goods are particularly sensitive to border crossing times:
 - Agriculture: Fresh fruits and vegetables.
 - Manufactures: Electronic goods; parts and components.

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Example 2: Trade Effects of Corruption

- 1 How does corruption affect international trade flows?
- 2 How do other trade costs such as tariffs and border crossing times interact with corruption to affect trade?

Example 2: Trade Effects of Corruption

How Does Corruption Affect Trade Flows?

$$\log \left(X_{ij}^k \right) = b_0 + b_1 \log \left(Y_i \right) + b_2 \log \left(Y_j \right) + b_3 \log \left(d_{ij} \right) + e_{ij} \dots \\ + b_4 \log \left(\mathbf{corr}_{ij} \right) + \dots$$

- 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.

Example 2: Trade Effects of Corruption

How Do Trade Costs and Corruption Interact to Affect Trade?

- Trade costs are in fact an important determinant of trade-related corruption, since businesses may be willing to pay “speed money” or “facilitation charges” to get around them:
 - Fisman and Wei (2004) show that higher tariffs are associated with higher rates of customs “misclassification” or “under-reporting”.
 - Djankov and Sequiera (2009) and Shepherd (2009) show that time spent at ports and border crossings is also associated with higher rates of corruption.

Example 2: Trade Effects of Corruption

How Do Trade Costs and Corruption Interact to Affect Trade?

$$\log \left(X_{ij}^k \right) = b_0 + b_1 \log \left(Y_i \right) + b_2 \log \left(Y_j \right) + b_3 \log \left(d_{ij} \right) + e_{ij} \dots \\ + b_4 \log \left(\mathbf{corr}_{ij} \right) + b_5 \log \left(\mathbf{corr}_{ij} \right) \times \log \left(\mathbf{time}_{ij}^x \right) \dots$$

- Shepherd (2009) uses a gravity model to show that trade is more sensitive to corruption in countries with long border crossing times.

Example 2: Trade Effects of Corruption

How Do Trade Costs and Corruption Interact to Affect Trade?

$$\begin{aligned}\log \left(X_{ij}^k \right) &= b_0 + b_1 \log \left(Y_i \right) + b_2 \log \left(Y_j \right) + b_3 \log \left(d_{ij} \right) + e_{ij} \dots \\ &+ b_4 \log \left(\mathbf{corr}_{ij} \right) + b_5 \log \left(\mathbf{corr}_{ij} \right) \times \log \left(\mathbf{tariff}_{ij}^x \right) \dots \\ &+ b_5 \log \left(\mathbf{corr}_{ij} \right) \times \left[\log \left(\mathbf{tariff}_{ij}^x \right) \right]^2 \dots\end{aligned}$$

- Dutt and Traca (2009) use a gravity model to show that:
 - Corruption is usually trade restricting, but...
 - When tariffs are very high (5%-14% of their sample), it can actually be trade promoting: it is a way for business to avoid bad regulation.

Summary

- The gravity model accords well with basic intuition about the drivers of international trade.
- Its structure fits with some important stylized facts.
- It has been used to say interesting and useful things about the interactions between at-, between-, and behind-the-border policies and trade flows.
- In the next session, we will look at how to bring it more seriously into contact with the data.