Session 1: Introduction to Gravity Modeling

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ARTNeT Capacity Building Workshop for Trade Research:
“Behind the Border” Gravity Modeling

Monday, September 21, 2009
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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4. Summary
“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)
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.
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.
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.
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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4. **Summary**
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.

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Overview of the Workshop
Monday, September 21

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

Afternoon Sessions
- Revision of Stata basics and “tricks”.
- Setting up a gravity dataset in Stata, and performing simple manipulations.
- Using Stata to estimate a gravity model.
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Introduction and Workshop Overview
The Basic Gravity Model
Assessing Trade Policies Using Gravity
Summary

Overview of the Workshop
Tuesday, September 22

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

### Afternoon Sessions
- Dealing with endogeneity of policies via instrumental variables.
- Estimating and testing IV models in Stata.
### Morning Sessions
- The theoretical gravity model.
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Overview of the Workshop

Wednesday, September 23

Morning Sessions
- Estimating gravity models when zero trade flows are important.
- Estimating trade propensity models
- Using Stata to estimate Poisson and Probit/Logit/Heckit models.

Afternoon Sessions
- Data sources for gravity modeling.
- Using principal components analysis to summarize data.
- Implementation of PCA in Stata.
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**Afternoon Sessions**
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Overview of the Workshop
Thursday, September 24

Morning Sessions
- Inferring trade costs using “inverse gravity”.
- Implementing the “levity” model in Stata.

Afternoon Sessions
- Using firm-level data to complement gravity.
- Estimating firm-level models using Stata.
Overview of the Workshop
Thursday, September 24

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- Inferring trade costs using “inverse gravity”.
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Afternoon Sessions
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Overview of the Workshop
Friday, September 25

Morning Sessions
- Consolidation exercise: using gravity to investigate logistics and production networking in APEC.

Afternoon Sessions
- Research design workshop / brainstorming.
- Research presentations by participants.
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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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4. Summary
The Gravity Analogy

Before: “Ouch!”

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.

After: “\(F_{ij} = GM_{ij}M_{ij}D_{ij}^{-2}!\)”

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

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

- 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.

Economics

\[ X_{ij} = c \frac{Y_i Y_j}{d_{ij}} \]
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4. **Summary**
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

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### Stylized Facts: Trade, GDP, and Distance

**Bivariate Correlations**

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</table>
Stylized Facts: Trade, GDP, and Distance

\[ \text{Ln(Imports)} \text{ vs. Ln(GDPI*GDPj)} \]
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.
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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4. Summary
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?
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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?

$$\log \left( X_{ij}^k \right) = b_0 + b_1 \log (Y_i) + b_2 \log (Y_j) + b_3 \log (d_{ij}) + e_{ij} \ldots$$

$$+ b_4 \log (\text{time}_i^x) + \ldots$$

- Djankov Freund & Pham (2009) 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 (2009) 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

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Example 2: Trade Effects of Corruption

How Does Corruption Affect Trade Flows?

\[
\log \left( X_{ij}^k \right) = b_0 + b_1 \log (Y_i) + b_2 \log (Y_j) + b_3 \log (d_{ij}) + e_{ij} + b_4 \log (\text{corr}_{ij}) + \ldots
\]

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?

\[
\log \left( X_{ij}^k \right) = b_0 + b_1 \log (Y_i) + b_2 \log (Y_j) + b_3 \log (d_{ij}) + e_{ij} \ldots \\
+ b_4 \log (\text{corr}_{ij}) + b_5 \log (\text{corr}_{ij}) \times \log (\text{time}_{ij}) \ldots
\]

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?

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

- 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.