The Gravity Model
Exchange Rates and Agricultural Trade

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Post-Bretton Woods

- Foreign exchange rates highly volatile after collapse of Bretton Woods system in 1973
- Despite view that volatility would diminish as agents gained experience with flexible exchange rates, fluctuations increased after 1980 (Hakkio, 1984)
- By end of 1980s, growth rate of international trade among industrial countries had declined by more than 50 percent (De Grauwe, 1988)
Exchange Rate Volatility and Trade

- Exchange rate volatility has potential to undermine proper functioning of world economy (Maskus, 1986):
  - uncertainty about profits from trade
  - may restrict international capital flows
  - agents add a risk premium, thereby raising prices of traded goods

- Notion that exchange rate volatility has negative effect on international trade due to agents’ risk-aversion is intuitively-appealing, and has some grounds in theory
Exchange Rate Volatility and Trade

• Absent insurance, exchange rate volatility may reduce volume of trade e.g., Ethier (1973), Baron (1976), Hooper and Kohlhagen (1978)

• Empirical work, has found conflicting results for sign on volatility (Bahmani-Oskooee and Hegerty, 2007) – also reflected in research on agricultural trade:

  (i) Anderson and Garcia (1989-US bilateral soybean trade), and (ii) Pick (1990-US bilateral agricultural trade), find evidence for negative effect, (iii) Langley et al. (2000-Thai agricultural trade) find evidence for positive effect
Exchange Rate Volatility and Trade

● What might explain these contradictory findings?

● de Grauwe (1988) shows impact of mean-preserving spread in exchange rate, $\epsilon$, on expected marginal utility of trade, $U'_f \tilde{e}$, depends on relative risk aversion, $R = \frac{U'_f \tilde{Y}_f}{U'_f}$

● Assuming constant relative risk aversion, if $R>1$ ($R<1$), $d^2U'_f \tilde{e} / de^2 > 0$ ($d^2U'_f \tilde{e} / de^2 < 0$), i.e., greater exchange rate risk $\tilde{e}$ increases (decreases) trade

● Intuition – increase in risk has income and substitution effects

● Not unsurprising, therefore, empirical literature is ambiguous on effects of exchange rate volatility
Exchange Rate Uncertainty

- A priori, flexible exchange rates take care of external imbalances, macroeconomic policy being targeted at domestic objectives (Obstfeld, 1998)
- If PPP holds, real exchange rates should be mean-reverting (MacDonald, 1989)
- Speed of convergence very slow (Rogoff, 1996) – exposing agents to uncertainty that is difficult to hedge
- De Grauwe (1988) and Perée and Steinherr (1989), early studies finding medium term exchange rate uncertainty adversely affects trade flows
Agricultural Trade and Uncertainty

- Using panel data for 10 developed countries over period 1974-95, Cho, Sheldon and McCorriston (2002) found exchange rate uncertainty had largest negative impact on agricultural trade.

- Kandilov (2008), using different index of uncertainty, and data over period 1974 to 1997 replicated these results, but also found negative effect is larger for developing country agricultural exporters.

- Confirms prescience of Schuh’s (1974) view that an over-valued dollar in post-WWII period may have acted as a disincentive to US agricultural exports.
Gravity Model

- Cho et al. (2002), and Sheldon, et al. (2012) use so-called gravity equation to test effect of exchange rate uncertainty.

- Gravity model of trade predicts volume of trade between two countries proportional to their GDPs and inversely related to any trade barriers between them.

- Typically, bilateral trade flows between country j and country k explained by:

\[ V_{jk} = \beta_0 (Y_j)^{\beta_1} (Y_k)^{\beta_2} (D_{jk})^{\beta_3} (A_{jk})^{\beta_4} \mu_{jk} \]
Gravity Model

- Specification in (1) used originally by Tinbergen (1962), and probably one of the great success stories in applied economics (Leamer and Levinsohn, 1995)

- Theoretical foundations of gravity equation less well understood – but it has become popular again, and used extensively in exchange rate literature

- It turns out that gravity equation can be derived from quite different theoretical models, Grossman (1998) noting, “…Specialization – and not new trade theory or old trade theory – generates the force of gravity…”
Does Gravity Carry any Weight?

- Cho et al. (2002): in gravity-type model significance of income variable varied across sectors and countries
- Feenstra et al. (2001): ‘home-market’ effect for differentiated goods, reverse ‘home-market’ effect for homogeneous goods
- Helpman (1987): volume of trade as share of GDP is larger, the more similar income levels for sample of OECD countries
- Hummels and Levinsohn (1995): similar result for sample of non-OECD countries
- **Identification problem:** gravity model works well for differentiated and homogeneous goods
Outline

- Empirical phenomenon of intra-industry trade (IIT)
- Monopolistic competition and trade
- Empirical strategies for testing the monopolistic competition story
- Possible application to food and agricultural trade
Empirical Phenomenon of Intra-Industry trade

- Early work focused on measurement, Balassa (1965), Grubel and Lloyd (1975)
- Overlap in trade flows, i.e., Grubel and Lloyd index:
  \[
  \text{GL}^j = 1 - \frac{|X^j - M^j|}{(X^j + M^j)}
  \]
  \(0 \leq \text{GL}^j \leq 1\)
- Problems: aggregation (Finger, 1975), static nature of index (Brülhart, 2000)
- Found in food industry trade data by McCorriston and Sheldon (1991), and Hirschberg et al. (1994)
Monopolistic Competition and Trade

- Observed IIT a key challenge to neoclassical orthodoxy (Leamer, 1992)
- Monopolistic competition has become standard model for rationalizing IIT
- Different models of monopolistic competition developed based on preference structure:
- General equilibrium model developed by Helpman and Krugman (1985)
Figure 1: Trade Equilibrium
Monopolistic Competition and Trade

- **Key empirical prediction**: share of IIT larger between countries that are similar in terms of factor endowments and relative size

- Helpman’s (1987) results support prediction using 4-digit SITC data for 14 OECD countries over period 1970-81:

\[
GL_{jk} = \alpha + \beta_1 \log \left( \frac{Y_j}{N_j} \right) - \left( \frac{Y_k}{N_k} \right) + \beta_2 \min(\log Y_j, \log Y_k) + \beta_3 \max(\log Y_j, \log Y_k) + \mu_{jk}, \quad \beta_1 < 0, \beta_2 > 0, \beta_3 < 0
\]

- Hummels and Levinsohn show results not robust when using country fixed-effects
Monopolistic Competition and Trade

- **Key empirical prediction**: volume of trade as share of GDP increases as countries become more similar in size – assuming structure of monopolistic competition

- Helpman’s (1987) results support prediction data for 14 OECD countries over period 1956-81:

  \[
  \frac{V^A}{Y^A} = e_A \left[ 1 - \sum_{j \in A} (e_j^A)^2 \right]
  \]

  (4)

- Hummels and Levinsohn found similar results for sample of 14 non-OECD countries over period 1962-77

- Debaere (2005) re-estimated (4) for 1970-89, confirming Helpman’s (1987) result for OECD sample, and finding a negative sign on income dispersion for non-OECD sample
Empirical Evaluation of Monopolistic Competition Story

- (4) is a form of gravity model – but it seems to fit trade in both differentiated and homogeneous goods

- Empirical issue becomes one of determining which theoretical model works best in a given data sample (Evenett and Keller, 1998; 2002)
  
  - Evenett and Keller (2002) derive theoretical restrictions on country income parameters that form basis of hypothesis testing
  
  - Feenstra et al. derive additional theoretical restrictions allowing broader test of trade theories
Empirical Evaluation of Monopolistic Competition Story

- Evenett and Keller tested 4 versions of the gravity model based on classifying 1985 4-digit SITC data for 58 countries into differentiated vs. homogeneous goods.
- Perfect specialization:

\[ M_{jk} = \alpha_v \frac{Y_j Y_k}{Y_{vw}} + \mu_{jk} \quad , \quad \alpha_v = 1 \]

Sample split into high and low IIT samples:
- high IIT sample, \( \alpha_v = 0.087 \)
- low IIT sample, \( \alpha_v = 0.052 \)

i.e., perfect specialization in either differentiated or homogeneous goods over-predicts bilateral trade.
Empirical Evaluation of Monopolistic Competition Story

- Imperfect specialization with differentiated and homogeneous goods:

\[
M_{jk}^{iv} = (1 - \psi_{v}^{j}) \frac{Y_{v}^{j}Y_{v}^{k}}{Y_{w}} + \mu_{v}^{jk}, \quad (1 - \psi_{v}^{j}) < 1
\]

Estimated for cases where j(k) is capital-abundant, median value of \((1 - \psi_{v}^{j}) = 0.086\)

- Imperfect specialization with homogeneous goods:

\[
M_{jk}^{iv} = (\psi_{v}^{j} - \psi_{v}^{k}) \frac{Y_{v}^{j}Y_{v}^{k}}{Y_{w}} + \mu_{v}^{jk}, \quad (\psi_{v}^{j} - \psi_{v}^{k}) < 1
\]

Estimated for cases where j(k) is capital-abundant, median value of \((\psi_{v}^{j} - \psi_{v}^{k}) = 0.04\)
Empirical Evaluation of Monopolistic Competition Story


\[ \ln M_{jk}^{ik} = -\beta_0 Y^w + \beta_1 \ln Y^j + \beta_2 \ln Y^k \]  

- \( \beta_1 > \beta_2 \) monopolistic competition or ‘reciprocal dumping’ with entry (Brander and Krugman, 1983)

- \( \beta_1 < \beta_2 \) Armington (Head and Ries, 2001) or ‘reciprocal dumping’ with no entry
Empirical Evaluation of Monopolistic Competition Story

● (7) tested for complete sample of countries:
  ■ Differentiated goods, $\beta_1 = 1.09$ and $\beta_2 = 0.65$
  ■ Homogeneous goods, $\beta_1 = 0.51$ and $\beta_2 = 0.82$

● Results hold for sub-samples of countries, OECD and OPEC/non-OPEC

● Conclude that there is a ‘home-market’ effect in differentiated goods case (monopolistic competition) and reverse ‘home-market’ effect for homogeneous goods case (reciprocal dumping)

● “…theoretical foundations for gravity equation are actually quite general, but the empirical performance is quite specific…”
Application to Food and Agricultural Trade

- With appropriate data and econometric methods, ought to be able to test which trade theory best explains bilateral food and agricultural trade

- Observed IIT differs substantially between commodities and processed foods, and by country (McCorriston and Sheldon, 1991)

- Rauch (1999) approach to classification is appealing

- Feenstra et al. model captures different theories, and Evenett and Keller (2002) approach can be nested by appropriate restrictions on $\beta_1$ and $\beta_2$