The Gravity Model
Exchange Rates and Agricultural Trade

Ian Sheldon

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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, $\tilde{e}$, on expected marginal utility of trade, $U_f'\tilde{e}$, depends on *relative* risk aversion, $R = U_f''\tilde{Y}_f / U_f'$
- 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:**

$$(1) \qquad V^{jk} = \beta_0 (Y^j)^{\beta_1} (Y^k)^{\beta_2} (D^{jk})^{\beta_3} (A^{jk})^{\beta_4} \mu^{jk}$$

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**
- **<u>Identification problem</u>: gravity model works well for differentiated and homogeneous goods**

Outline

- Empirical phenomenon of intra-industry trade (IIT)
- Monopolistic competition and trade
- Resolution of contradiction in Helpman (1987), Hummels and Levinsohn (1995) – theoretical foundations of gravity model
- 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:

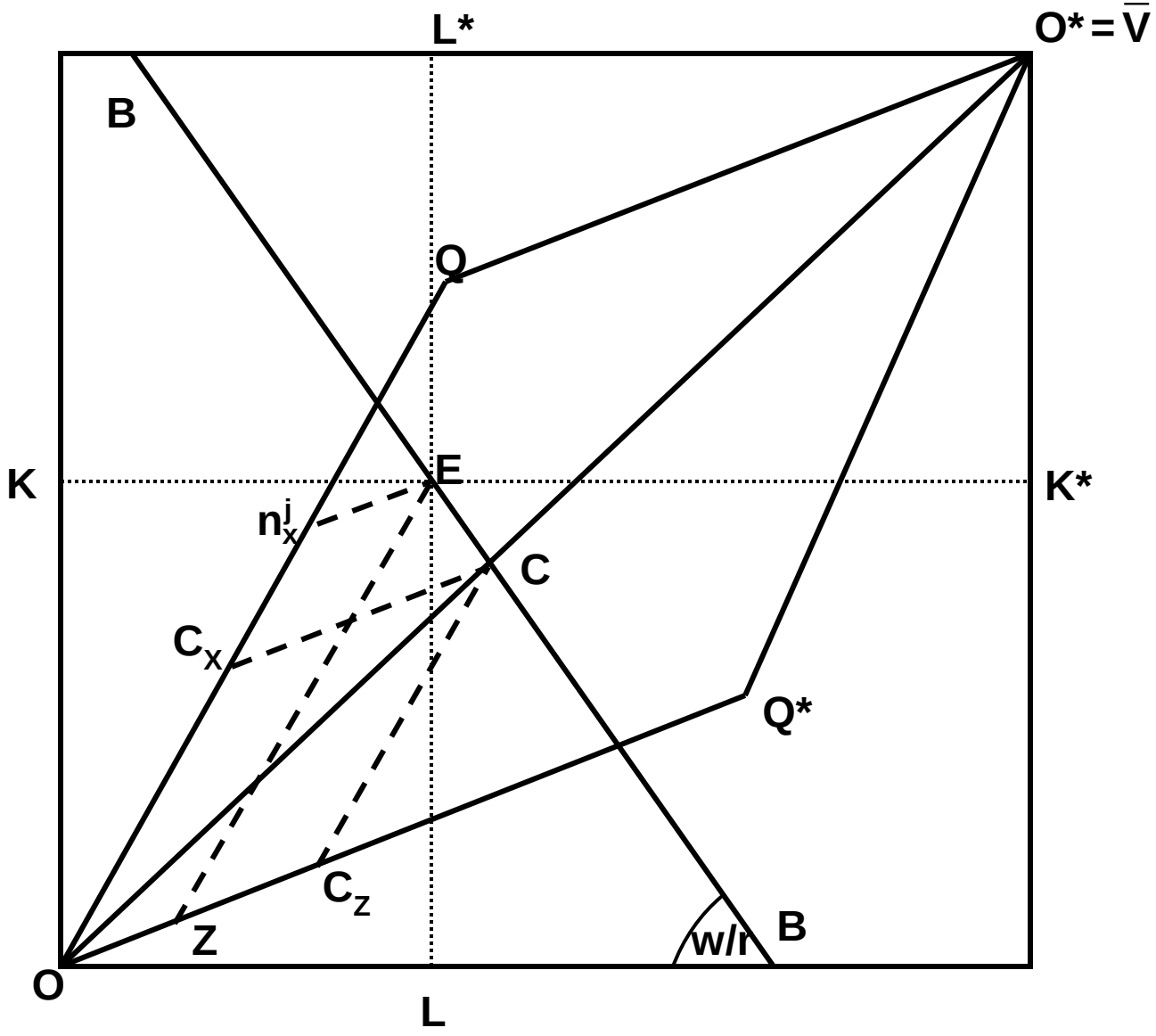
$$(2) \qquad GL^j = 1 - \frac{\left|X^j - M^j\right|}{(X^j + M^j)} \qquad 0 \leq GL^j \leq 1$$

- 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:
  - Krugman (1979;1980) ⟶ Dixit and Stiglitz (1977)
  - Helpman (1981) ⟶ Lancaster (1977)
- 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:**

$$(3) \qquad GL^{jk} = \alpha + \beta_1 \log\left[\frac{Y^j}{N^j}\right] - \left[\frac{Y^k}{N^k}\right] + \beta_2 \min(\log Y^j, \log Y^k)$$

$$+ \beta_3 \max(\log Y^j, \log Y^k) + \mu^{jk}, \quad \beta_1 < 0, \beta_2 > 0, \beta_3 < 0$$

- **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:**

$$\frac{V^A}{Y^A} = e_A \left[1 - \sum_{j \in A} (e_A^j)^2 \right] \quad (4)$$

- **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:

(5) $$M_v^{jk} = \alpha_v \frac{Y_v^j Y_v^k}{Y^w} + \mu_v^{jk} \quad , \quad \alpha_v = 1$$

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:**

$$(6) \quad M_v^{jk} = (1-\psi_v^j)\frac{Y_v^j Y_v^k}{Y^w} + \mu_v^{jk}, \quad (1-\psi_v^j) < 1$$

Estimated for cases where j(k) is capital-abundant, median value of $(1-\psi_v^j) = 0.086$

- **Imperfect specialization with homogeneous goods:**

$$(7) \quad M_v^{jk} = (\psi_v^j - \psi_v^k)\frac{Y_v^j Y_v^k}{Y^w} + \mu_v^{jk}, \quad (\psi_v^j - \psi_v^k) < 1$$

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

- **Feenstra *et al*. test for 'home-market' effect in 110 country data set for 1970, 1975, 1985, 1990, splitting 4-digit SITC data into differentiated and homogeneous goods based on Rauch (1999) classification**

$$(8) \qquad \ln M^{jk} = -\beta_0 Y^w + \beta_1 \ln Y^j + \beta_2 \ln Y^k$$

  - **$\beta_1 > \beta_2$ 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 β_1 and β_2**