14.582: International Trade II
— Lecture 2: Monopolistic Competition (Empirics) —

Plan of Today's Lecture

1. Introduction

2. Discussion of various pieces of evidence for (the importance of) increasing returns in explaining aggregate trade flows:

    1. Intra-industry trade.

    2. Preponderance of North-North trade.

    3. The impressive fit of the gravity equation.

    4. The importance of market access for determining living standards.

    5. The home market effect.

    6. Path dependence.

3. Ideas for future work

4. Appendix material

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④ Appendix material

The Big Question

- As discussed in Lecture 1, there are two fundamental reasons for why regions trade:

    1. Countries are *ex ante* different (in terms of technologies, tastes, and/or endowments). They therefore trade according to the traditional theory of comparative advantage.

    2. Countries are *ex ante* identical, but due to increasing returns to scale (ITRS) they specialize and become different *ex post*. (One could actually think of this as a particularly extreme form of comparative advantage, and one that is endogenously-driven.)

- It is important to know (for both positive and normative reasons) how relatively important these two forces of trade are in the real world.
    - For example: presence of IRTS could justify industrial policy, "infant industry" argument, import protection as export promotion, etc.

- NB: Nothing in this discussion (or this lecture) distinguishes the particular source of IRTS that is stressed in monopolistic competition models (love-of-variety + entry) from wider sources of IRTS.

Attempts to Answer This Question

- We will review 6 different types of empirical predictions that show some promise for testing between CA and IRTS:
  1. The existence of Intra-industry trade (IIT).
  2. Most trade is between similar-looking countries.
  3. The gravity equation fits well.
  4. "Market access" matters for standards of living.
  5. The home market effect.
  6. Path dependence (in response to shocks).

- It is often claimed that IRTS-based trade models were needed because neoclassical trade models couldn't explain 1-4.
  - Unfortunately, this is not true, as we'll discuss. (But of course IRTS-based models have attractions even absent the question of whether it is the only explanation for 1-4.)
  - So we need better tests/measurement devices. Findings 5-6 offer more hope.

- NB: more details on 1-4 and 6 in the Appendix slides.

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Finding 1: Intra-Industry Trade

- Grubel and Lloyd (1975 book) famously characterized IIT systematically.
    - Grubel-Lloyd index (for country i in industry k): $GL_i^k \equiv 1 - \frac{|X_i^k - M_i^k|}{X_i^k + M_i^k}$.

    - Typically takes values higher than 0.5, and this has been growing since 1975 (see, eg, Helpman (JEP, 1998)).

- Bhagwati and Davis (1993) discuss the issues involved in inferring what IIT implies for the importance of IRTS.

- Basic problem is that neoclassical models are about homogeneous goods (perfect substitutes in consumption), and our datasets are nowhere close to that.
    - Modern view is that it is very likely that we are seeing aggregates over truly homogenous goods any time we look at trade data (with possible exception of firm-product-level data, but then there is rarely any attempt made to test the perfect substitutes requirement).

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Finding 2: Most trade is between similar countries ("North-North").

- Basic idea behind this claim: the spirit of a CA-based model is that countries trade because they are different, so it is therefore surprising that trade is predominantly between rich countries (whose technologies and endowments are presumably quite similar).

- One simple difficulty with assessing this claim in a many-country HO model (with FPE) is that the model doesn't make predictions about who trades what with whom (consumers are indifferent about where to source any good in equilibrium).

- Davis (JPE, 1997) offered a set of examples for how endowment differences translate into trade flow differences:
  - Conditions under which, even in a pure HO model, similarly-endowed countries trade less with one another than do differently-endowed countries.
  - But Helpman (JEP, 1998) views these as more possibility results than truly likely scenarios. I don't know of empirical work that dug deeper.

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Finding 3: The Gravity Equation

- The gravity equation is one of the best fitting and most established empirical relationships in all of Trade (and migration, K flows, phone calls, commuting, bee pollination...).

  - Though as an aside, Trefler and Lai (2002) demonstrate how the segments of the variation that the gravity equation fits particularly well require only assumptions that virtually any economic model would maintain (eg market clearing).

- For a long time, the impressive fit of the gravity equation was seen as evidence for the importance of IRTS in trade.

  - This is partly because Helpman (1987) and Bergstrand (REStat, 1989) showed how elegantly the monopolistic competition theory of trade could be manipulated into a gravity equation form.

  - But really, the field had known since at least Anderson (AER, 1979) that the so-called "Armington" (1969) model could deliver a gravity equation, and the Armington model is really just an extreme Ricardian model.

More on the Gravity Equation

- It is now widely recognized that the key to a gravity equation-style relationship is just specialization.
  - This point was very nicely made in Deardorff (1998).

- We will see examples of models that deliver gravity equations later in the course (summarized in Costinot and Rodriguez-Clare (Handbook, 2013)). This will include:
  - Armington (i.e. Anderson, 1979).
  - Krugman (1980).
  - Ricardian model as in Eaton and Kortum (2002).
  - Special case of Melitz (2003).

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Finding 4: "Market Access" Matters

- "Market access" typically defined as something like:

$$\ln w_i = \ln \alpha + \ln \left(\sum_{j \neq i} L_j \tau_{ji}^{-\theta} \right) \equiv \ln \alpha + \ln MA_i \qquad (1)$$

- Easy to manipulate most gravity equation models into something <u>approximately</u> like this.
  - Full derivation involves more GE terms inside MA definition, but these may be unlikely to matter much in may settings.

Finding 4: "Market Access" Matters

- Plenty of evidence for behavior like equation (1) in many settings:

    - Redding and Venables (JIE, 2004): Measured "market access" (as measured poperly, from the fixed effects in a gravity equation) predicts Y/L across countries.

    - Redding and Sturm (AER, 2008): When Germany was partitioned, cities on the Eastern edge of West Germany (who lost market access) suffered and then recovered when Germany was re-unified. MA predicts magnitude of these effects pretty well.

    - Donaldson and Hornbeck (QJE, 2016): US railroads affected agricultural land values in a way consistent with MA model.

    - Faber (REStud, 2016): Chinese highways (built to connect big cities) actually *harmed* rural counties that they penetrated along the way.

- But, unfortunately, MA is an implication of any gravity model. So comments earlier about gravity models mean that, similarly, MA findings don't discriminate between IRTS vs. other models that predict gravity trade.

MA ("Market access") is constructed using an inverse trade-cost weighted sum of gravity equation fixed effects.
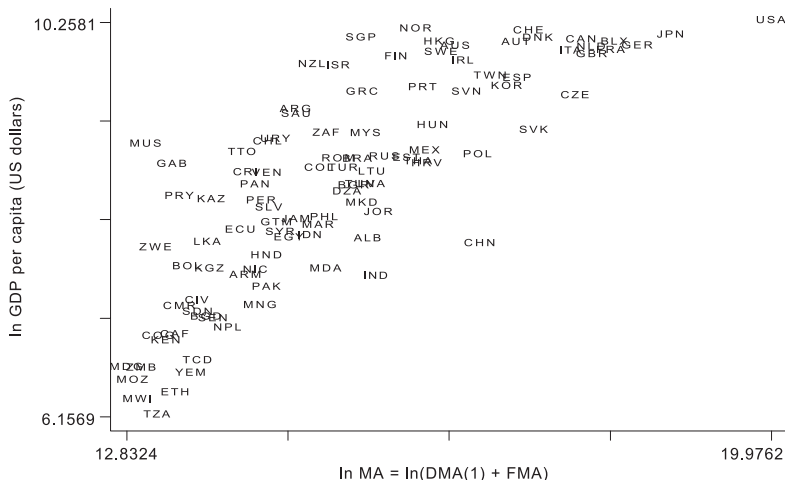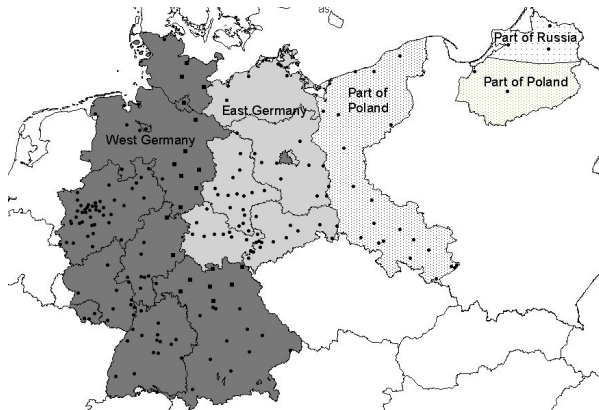

Fig. 2. GDP per capita and MA=DMA(1)+FMA.

Redding and Sturm (2008): Results

The Partition of Germany: some Western Germany cities (i.e. those near the E-W border) lost a great deal of market access

**Map 1: The Division of Germany after the Second World War**

Notes: The map shows Germany in its borders prior to the Second World War (usually referred to as the 1937 borders) and the division of Germany into an area that became part of Russia, an area that became part of Poland, East Germany and West Germany. The West German cities in our sample which were within 75 kilometers of the East-West German border are denoted by squares, all other cities by circles.

Figure 3: Indices of Treatment & Control City Population
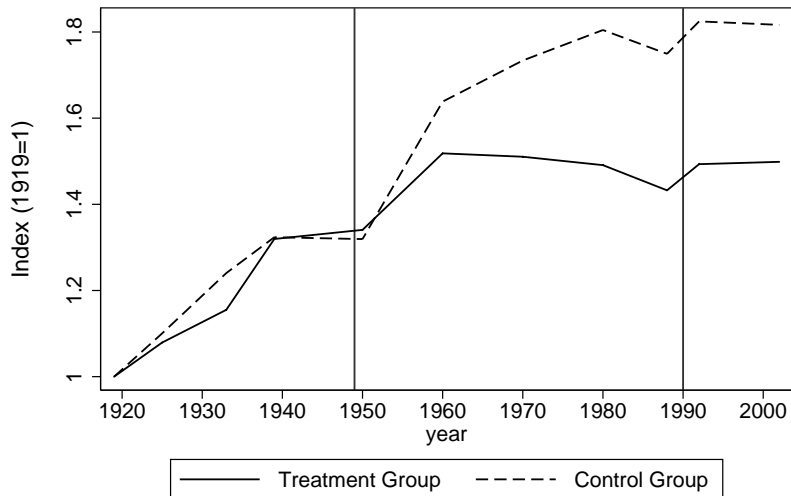
C. Natural Waterways, Canals, and 1870 Railroads

D. Natural Waterways, Canals, and 1890 Railroads
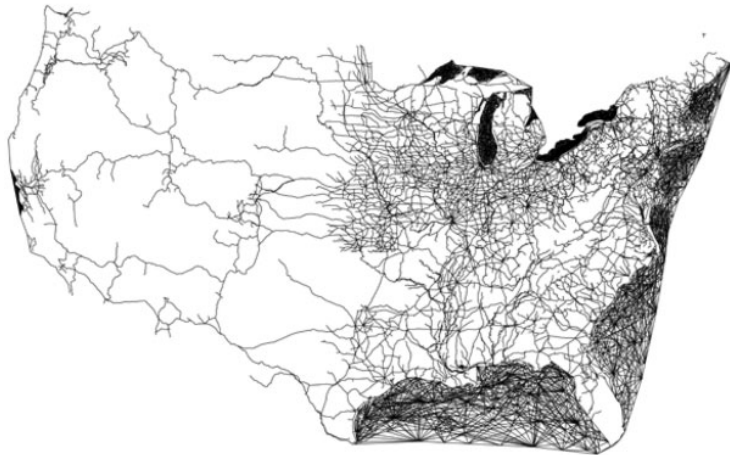
FIGURE II

Effect of MA on land value
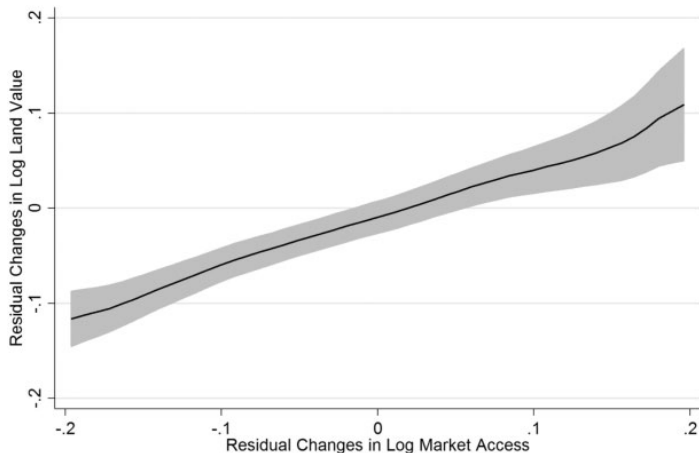
FIGURE IV

Local Polynomial Relationship between Changes in Log Land Value and Log Market Access, 1870 to 1890

Figure 3: **Euclidean Spanning Tree Network**
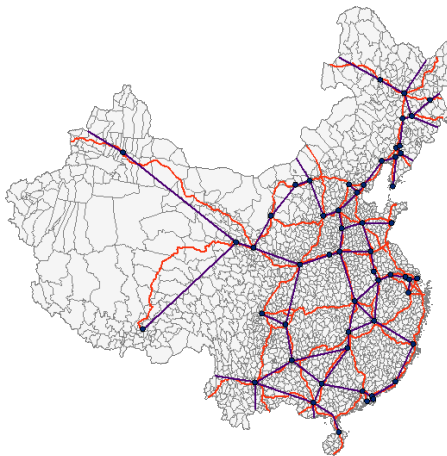
The network in red color depicts the completed NTHS network in 2007. The network in darker color depicts the Euclidean spanning tree network. The routes are the result of applying Kruskal's (1956) minimum spanning tree algorithm to bilateral Euclidean distances between targeted destinations. This algorithm is first run for the all-China network, and then repeated within North-Center-South and East-Center-West divisions of China. These regional repetitions add 9 routes to the original minimum spanning tree.

Faber (2014): Results

Proximity to new highways was (relatively) bad among sample of rural counties

Figure 4: **Estimated Effect of Peripheral Connections over Distance to the Nearest NTHS Route**
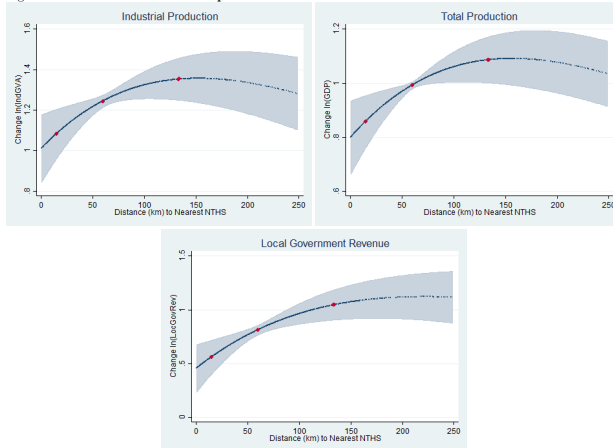
The graphs depict the flexibly estimated relationships between distance to the nearest NTHS route and peripheral county growth in industrial value added, total GDP, and local government revenue. The plots correspond to the best fitting polynomial functional form according to the Akaike Information Criterion (AIC). The functions and confidence intervals are based on IV estimates holding covariates at their mean. County distance to the NTHS and its polynomial terms are instrumented with distances to the LCP and Euclidean spanning trees and their polynomials. The red dots indicate median county distances to the nearest NTHS route among connected peripheral counties (left), peripheral counties neighboring a connected county (center), and the remaining peripheral counties farther away (right). The shaded areas indicate 90% confidence intervals. Standard errors are clustered at the province level.

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The Home-Market Effect

- **Key idea:** Countries with larger markets for a product at home will tend to sell relatively more of that product abroad.

  [Linder 1961, Krugman 1980]

- **Implications:**
  - Key to New Trade Theory/ New Economic Geography [Helpman-Krugman 1985, Fujita, Krugman, and Venables 1999]
  - Key to quantitative predictions of (multi-sector) gravity models [Costinot and Rodriguez Clare 2014]
  - "Import protection as export promotion" [Krugman 1984]

- **Challenge in testing for HME:** simultaneity bias (size of local market determined by both supply and demand conditions)

- We will focus on one recent attempt (Costinot, Donaldson, Kyle and Williams, 2016) but see below for discussion of other directions.

CDKW (2016): Two Contributions

1 Theory:

(a) Develop a simple test for two different notions of the HME:

- *Weak HME*: (à la Linder 1961) home demand $\nearrow$ exports
- *Strong HME*: (à la Krugman 1980) home demand $\nearrow$ *net* exports

(b) Q: What can we learn from HME tests?

A1: Positive test $\iff$ industry supply curve is downward-sloping

A2: Weak vs strong HME $\iff$ weak vs strong IRTS

2 Empirics:

(a) Unique data on global pharmaceutical sales

$+$ Variation from demographic-driven demand

$\implies$ *Both strong and weak HMEs at work*

(b) Estimation of demand and supply parameters

$\implies$ IRTS about 25% weaker than in Krugman (1980)

Demand

- Aggregate demand in country j for drugs targeting disease n (e.g. cardiovascular disease):

$$D_j^n = \theta_j^n D(P_j^n/P_j)D_j$$

- Demand in country j for varieties from country i for disease n:

$$d_{ij}^n = d(p_{ij}^n/P_j^n)D_j^n$$

with country-disease price index implicitly defined by

$$P_j^n = \sum_i p_{ij}^n d(p_{ij}^n/P_j^n)$$

Supply, Trade Costs and Equilibrium

- **Supply:**

$$s_i^n = \eta_i^n s(p_i^n)$$

- **Trading Frictions:**

$$p_{ij}^n = \tau_{ij}^n p_i^n$$

- **Equilibrium:**

$$s_i^n = \sum_j \tau_{ij}^n d_{ij}^n$$

A Simple Test of the Home-Market Effect

- Consider first-order approximation around symmetric equilibrium (with identical trade costs, $\tau_{ij}^n = \tau$ for all $i \neq j$ and n)

- Then bilateral foreign sales ($x_{ij}^n \equiv p_{ij}^n d_{ij}^n$, for any $i \neq j$) given by:

$$\ln x_{ij}^n = \delta_{ij} + \delta^n + \beta_M \ln \theta_j^n + \beta_X \ln \theta_i^n + \varepsilon_{ij}^n$$

where:
  - δ_{ij}: all terms common to country i, country j or country pair ij
  - δ^n: all terms common to disease n
  - ε_{ij}^n: all other variation in trade costs $+$ supply conditions (note: ε_{ij}^n not a function of θ in any country)

A Simple Test of the Home-Market Effect

$$\ln x_{ij}^n = \delta_{ij} + \delta^n + \beta_M \ln \theta_j^n + \beta_X \ln \theta_i^n + \varepsilon_{ij}^n$$

- Total sales abroad ($X_i^n \equiv \sum_{j \neq i} x_{ij}^n$)
- Total purchases from abroad ($M_i^n \equiv \sum_{j \neq i} x_{ji}^n$)

- **Definition:**

  Weak HME: $\qquad \dfrac{d \ln X_i^n}{d \ln \theta_i^n} > 0 \qquad \Longleftrightarrow \quad \beta_X > 0$

  Strong HME: $\qquad \dfrac{d \ln X_i^n}{d \ln \theta_i^n} > \dfrac{d \ln M_i^n}{d \ln \theta_i^n} \quad \Longleftrightarrow \quad \beta_X > \beta_M$

Economic Interpretation of HME Tests

- Consider world with a large number of small open economies:
  - Each too small to affect price of foreign varieties, but large enough to affect price of own varieties [Gali Monacelli 2005]
  - $\epsilon^d, \epsilon^x > 1$ (empirically relevant case)
  - $\epsilon^x \geq \epsilon^D$ (more substitution within than across diseases)

- Then:

  Weak HME: $\qquad \dfrac{d \ln X_i^n}{d \ln \theta_i^n} > 0 \qquad\qquad \Longleftrightarrow \quad -\infty < \epsilon^s < 0$

  Strong HME: $\qquad \dfrac{d \ln X_i^n}{d \ln \theta_i^n} > \dfrac{d \ln M_i^n}{d \ln \theta_i^n} \quad \Longleftrightarrow \quad -\infty < -\rho < \epsilon^s < 0$

$\Rightarrow$ Weak HME implies IRTS; Strong HME implies strong IRTS

Neoclassical case (no IRTS)
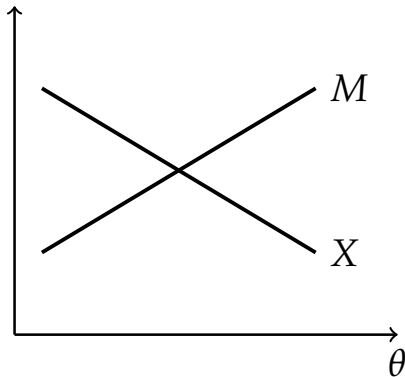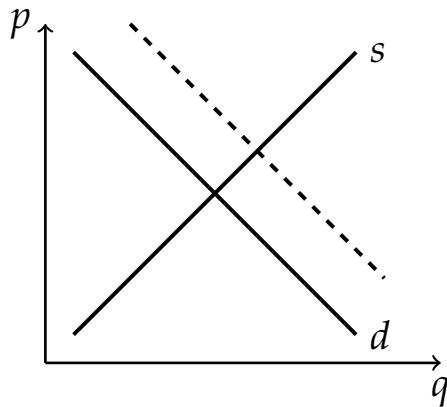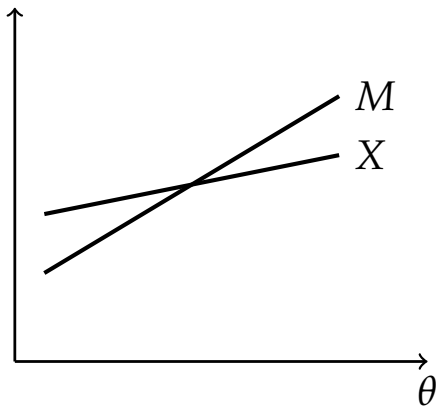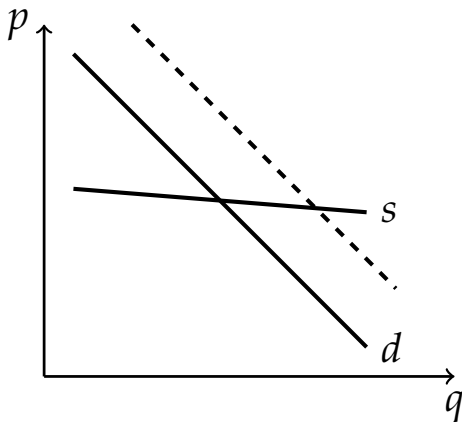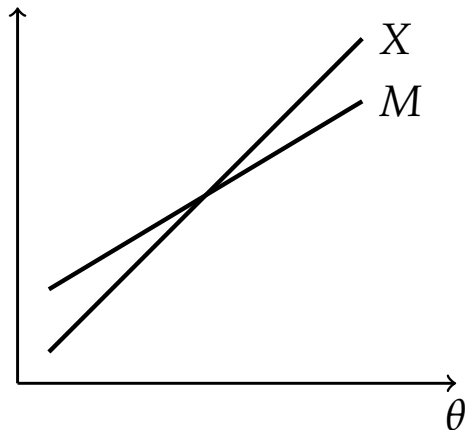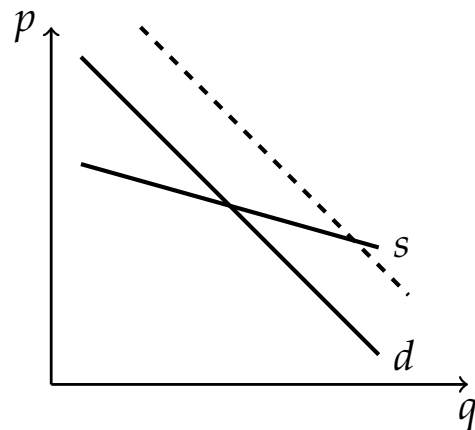
Beyond Perfect Competition

- Previous derivations valid for any supply-side featuring:

$$
\begin{aligned}
s_i^n &= \eta_i^n s(p_i^n), \\
p_{ij}^n &= \tau_{ij}^n p_i^n
\end{aligned}
$$

1. **Monopolistic competition** [Krugman 1980]
   - Aggregate supply slopes down because of love of variety:

   $$
   \epsilon^s = -\sigma,
   $$

   - $\sigma \equiv$ elasticity of substitution between domestic varieties

Beyond Perfect Competition

- Previous derivations valid for any supply-side featuring:

$$
\begin{aligned}
s_i^n &= \eta_i^n s(p_i^n), \\
p_{ij}^n &= \tau_{ij}^n p_i^n
\end{aligned}
$$

2. Bertrand oligopoly

- Aggregate supply slopes down (also) because of variable markups:

$$
\epsilon^s = -\sigma \times \frac{(\mu - 1)^2 + (1 - 1/\sigma)(d \ln \mu / d \ln N)}{(\mu - 1)^2 (1 - (\sigma - 1)(d \ln \mu / d \ln N))}
$$

- $\mu \equiv$ the markup and $N \equiv$ the number of firms

Beyond Perfect Competition

- Previous derivations valid for any supply-side featuring:

$$s_i^n = \eta_i^n s(p_i^n),$$
$$p_{ij}^n = \tau_{ij}^n p_i^n$$

3. **Monopoly**
   - Supply slopes down because of endogenous innovation:

   $$\epsilon^s = d\ln(-f'(c))/d\ln c,$$

   - $f(c) \equiv$ investment required to achieve marginal cost c

Data

- **Broad goal:**

  1. Data on $\{x_{ij}^n\}$: e.g. sales from France to Germany of drugs that treat cardiovascular disease

  2. Data on proxy for $\{\theta_i^n\}$: e.g. exogenous shifter of French demand for drugs that treat cardiovascular disease

- Use data from 2012 cross-section—HME is inherently a cross-sectional prediction about the pattern of trade

Data on $\{x_{ij}^n\}$: IMS MIDAS

- Unique dataset capturing $\sim 70\%$ of global pharmaceutical sales
  - Sourced from audits of retail pharmacies, hospitals, and other sales channels; includes both public and private purchasers
  - Record quarterly revenues and unit sales by country at "package" level, e.g. bottle of 30 10mg tablets of Lipitor (atorvastatin)

- Our data include:
  1. 56 destination country j markets
  2. $\sim 33,000$ unique molecules in ~ 600 ATC classes
     - e.g. A02B: drugs for peptic ulcer and gastro-esophageal reflux disease
  3. $\sim 14,000$ firms selling these molecules $\Rightarrow$ we hand-match these firms to origin countries i based on the firm's HQ location

Top 10 Countries in Terms of Global Sales

The very largest pharmaceutical firms are clustered geographically, but firms in our data are HQ'd in 55 (of 56) origin countries.

Table 1: Top 10 countries in terms of sales

Country	Share of world sales (%)	Share of world expenditures (%)	Number of firms headquartered
	(1)	(2)	(3)
USA	37.12	42.10	356
Switzerland	12.68	0.61	35
Japan	11.62	12.67	53
United Kingdom	10.67	2.67	80
Germany	6.77	4.68	94
France	6.51	4.34	58
India	2.29	1.61	292
China, Mainland	2.18	3.74	524
Canada	1.36	2.57	46
Italy	1.35	3.35	68

Data on proxy for $\{\theta_i^n\}$: Disease Burdens

Building on Acemoglu and Linn (2004): use demographic data to construct a predictor of country-disease demand. Draw on:

1. World Health Organization Global Burden of Disease data:
   - Disability-adjusted life-years (DALYs)
   - Available by age (0-14, 15-59, 60+)-gender-disease-country
   - Hand-coded crosswalk of ~ 600 ATC codes to 60 WHO diseases
     - e.g. A02B linked to "peptic ulcer disease"
     - 60 WHO diseases are empirical counterpart of diseases n in our model

2. US Census Bureau International Database:
   - Country-level data on the size of each demographic group

Predicted Disease Burden (Demand-shifter)

We generate "predicted disease burden" (PDB) as follows:

$$(PDB)_i^n = \sum_{a,g} \left[\text{population}_{iag} \times \left(\frac{\sum_{j \neq i} \text{disease burden}_{jag}^n}{\sum_{j \neq i} \text{population}_{jag}} \right) \right]$$

where:

- $a =$ age groups (0-14, 15-59, 60+)
- $g =$ gender

Does PDB predict actual disease burdens?

Table E.1: Predicting disease burden using demographic variation

	log(disease burden)	
	(1)	(2)
log(predicted disease burden)	1.820	1.545
	(0.370)	(0.290)
Sample of origin countries (i, n such that $\sum_{j \neq i} X_{ij}^n > 0$)	✓	
Sample of destination countries (j, n such that $\sum_{i \neq j} X_{ij}^n > 0$)		✓
Adjusted R^2	0.905	0.910
Observations	2,878	1,750

Notes: For details on construction of variables, sample restrictions see notes to Table 3. Standard errors in parentheses are two-way clustered at country and disease levels. All specifications control for country and disease fixed-effects.

Testing for the HME

- Use PDB as an empirical proxy for demand-shifter θ. That is, up to a first-order approximation, assume that (with $\gamma > 0$):

$$\ln \theta_i^n = \gamma \ln(PDB)_i^n + \gamma_i^n$$

- This implies:

$$\ln x_{ij}^n = \delta_{ij} + \delta^n + \tilde{\beta}_M \ln(PDB)_j^n + \tilde{\beta}_X \ln(PDB)_i^n + \tilde{\varepsilon}_{ij}^n$$

- So we have:

$$\textbf{Weak HME:} \qquad \frac{d \ln X_i^n}{d \ln \theta_i^n} > 0 \qquad \Longleftrightarrow \qquad \tilde{\beta}_X > 0$$

$$\textbf{Strong HME:} \qquad \frac{d \ln X_i^n}{d \ln \theta_i^n} > \frac{d \ln M_i^n}{d \ln \theta_i^n} \qquad \Longleftrightarrow \qquad \tilde{\beta}_X > \tilde{\beta}_M$$

Test of the Home-Market Effect

$$\ln x_{ij}^n = \delta_{ij} + \delta^n + \tilde{\beta}_M \ln(PDB)_j^n + \tilde{\beta}_X \ln(PDB)_i^n + \tilde{\varepsilon}_{ij}^n$$

Table 3: Test of the Home-Market Effect (baseline)

	log(bilateral sales)		
	(1)	(2)	(3)
log(PDB, destination)	0.520		0.545
	(0.097)		(0.107)
log(PDB, origin)		0.947	0.928
		(0.174)	(0.123)
p-value for $H_0 : \tilde{\beta}_X \leq 0$		0.000***	0.000***
p-value for $H_0 : \tilde{\beta}_X \leq \tilde{\beta}_M$			0.018**
Origin $\times$ disease FE	✓		
Destination $\times$ disease FE		✓	
Disease FE			✓
Adjusted R^2	0.630	0.563	0.540
Observations	18,756	18,905	19,150

Notes: OLS estimates of equation (16). Predicted disease burden (PDB_i^n) is constructed from an interaction between the global (leaving out country i) disease burden by demographic group in disease n, and the size of each demographic group in country i. All regressions omit the bilateral sales observation for home sales (i.e. where $i = j$) and control for origin-times-destination fixed-effects. The number of observations differs across columns due to omission of observations that are completely accounted for by the included fixed-effects. Standard errors in parentheses are two-way clustered at origin and destination country levels. p-values are based on F-test of the stated H_0. *** p<0.01, ** p<0.05. A p-value of "0.000" refers to one below 0.0005.

Disentangling Demand and Supply Elasticities

- **Recap:**
  1. Both weak and strong HMEs seem to be key features of the data in the global pharmaceutical industry
  2. This implies (at least in the SOE limit) that sector-level supply curves slope downwards (i.e. $\epsilon^s < 0$).

- **Next:**
  - Go beyond the bounds on IRTS implied by HME tests
    $\implies$ obtain *point estimate* for ϵ^s

Demand Elasticity Estimation

- **Step 1:** Estimate distance elasticity of trade costs ("α"):
  - Suppose that (up to first-order approximation):

$$\ln \tau_{ij}^n = \alpha \ln dist_{ij} + \nu_{ij}^n \qquad (2)$$

  - Then prices of each variety ω then satisfy:

$$\ln p_{ij}^n(\omega) = \alpha \ln dist_{ij} + \ln p_i^n(\omega) + \nu_{ij}^n$$

- **Step 2:** Estimate distance elasticity of bilateral sales ("ρ"):
  - Local approximation around symmetric equilibrium implies:

$$\ln x_{ij}^n = \delta_j^n + (1 - \epsilon^x) \ln p_i^n + (1 - \epsilon^x) \ln \tau_{ij}^n$$

  - So using (2) we have:

$$\ln x_{ij}^n = \delta_j^n + \delta_i^n + \rho \ln dist_{ij} + \chi_{ij}^n$$

  - Hence $\epsilon^x = 1 - \rho/\alpha$

Demand Elasticity Estimates

Column 1: $\ln p_{ij}^n(\omega) = \delta_i^n(\omega) + \alpha \ln dist_{ij} + \nu_{ij}^n(\omega)$

Column 2: $\ln x_{ij}^n = \delta_j^n + \delta_i^n + \rho \ln dist_{ij} + \chi_{ij}^n$

Table 9: Demand elasticity estimates

	log(price)	log(bilateral sales)
	(1)	(2)
log (bilateral distance)	0.062	−0.324
	(0.031)	(0.075)
Variety FE	✓	
Origin × disease FE		✓
Destination × disease FE		✓
Adjusted R^2	0.881	0.578
Observations	64,396	18,638

Notes: Column (1) reports OLS estimates of equation (20); variety fixed-effects control for interactions between all combinations of active molecules, corporations, and disease classes; standard errors (in parentheses) clustered by destination country; sample is based on all MIDAS observations for which prices are reported. Column (2) reports OLS estimates of equation (21). Standard errors in parentheses are two-way clustered at origin and destination country levels. All regressions omit the bilateral sales observation for home sales (i.e where $i = j$).

Supply Elasticity Estimation

- Let $r_i^n \equiv p_i^n s_i^n = \sum_j x_{ij}^n$ denote total value of sales by country i in disease n

- Local approximation of supply curve (i.e. $s_i^n = \eta_i^n s(p_i^n)$) around symmetric equilibrium implies:

$$\ln r_i^n = (1 + \epsilon^s) \ln p_i^n + \ln \eta_i^n$$

- Substituting this into bilateral sales equation yields (for $i \neq j$):

$$\ln x_{ij}^n = \delta_j^n + \delta_{ij} + \left(\frac{1 - \epsilon^x}{1 + \epsilon^s} \right) \ln r_i^n + \phi_{ij}^n \qquad (3)$$

- Estimation:
  - OLS estimation of equation (3) would be biased
  - But $\ln(PDB_i^n)$ is a valid (demand-side) IV for $\ln r_i^n$
  - Estimate of $\left(\frac{1 - \epsilon^x}{1 + \epsilon^s} \right)$, together with ϵ^x, allows estimation of ϵ^s

Supply Elasticity Estimates

Column 3: $\ln x_{ij}^n = \delta_j^n + \delta_{ij} + \left(\frac{1-\epsilon^x}{1+\epsilon^s} \right) \ln r_i^n + \phi_{ij}^n$

Table 10: Supply elasticity estimates

	log(total sales)	log(bilateral sales)	
	OLS (1)	OLS (2)	IV (3)
log (PDB)	1.241 (0.110)		
log (total sales)		0.669 (0.052)	0.764 (0.116)
p-value for $H_0 : \left(\frac{1-\epsilon^x}{1+\epsilon^s} \right) = 1$			0.048**
Adjusted R^2	0.789	0.629	0.627
Observations	18,905	18,905	18,905

Notes: Column (2) reports the OLS estimate, and column (3) the IV estimate, of equation (22). Column (1) reports the corresponding first-stage specification. The instrumental variable is log(PDB) in the origin country. All regressions omit the bilateral sales observation for home sales (i.e where $i = j$) and control for orign-destination and destination-disease fixed-effects. Standard errors in parentheses are two-way clustered at origin and destination country levels. p-value is based on F-test of H_0. ** p<0.05.

IRTS: Comparison with Values in Prior Work

(Recall: our point estimate is $\epsilon^s = -7.06$)

- **Empirical literature:**
    - Plant-level production function estimation [Basu-Fernald 1997]: $\epsilon^s = -4.45$ on all of U.S. manufacturing
    - Relative costs inferred from comparative advantage (HOV) model [Antweiler-Trefler 2002]: ϵ^s = -4.27 for global pharmaceutical industry
    - But neither study estimates supply elasticity ϵ^s by isolating purely demand-side variation, as in our approach

- **Theoretical literature:**
    - Krugman (1980): $\epsilon^s = -\epsilon^x$
    - $\implies$ IV coefficient $\left(\frac{1-\epsilon^x}{1+\epsilon^s}\right) = 1$
    - We can reject this at the 10% confidence level.
    - Preferred estimate is $\simeq$ 25% weaker IRTS than in Krugman (1980)

Other work on the HME

- Davis and Weinstein (JIE, 2003):
  - Clever way of nesting an HO and IRTS model

- Hanson and Xiang (AER, 2004):
  - Test more in spirit of Helpman-Krugman (1985) version of HME: do large countries specialize relatively more in high-IRTS industries?

- Head and Ries (AER, 2001):
  - Studying which firms expanded and contracted in Canada around NAFTA.

- Behrens, Lamorgese, Ottaviano and Tabuchi (JIE, 2009):
  - Point out that extending Krugman (1980) from 2 to N countries is hard, and that the simple HME doesn't survive (what is "home" demand when $N > 2$?)

Plan of Today's Lecture

1. Introduction

2. **Discussion of various pieces of evidence for (the importance of) increasing returns in explaining aggregate trade flows:**
   1. Intra-industry trade.
   2. Preponderance of North-North trade.
   3. The impressive fit of the gravity equation.
   4. The importance of market access for determining living standards.
   5. The home market effect.
   6. **Path dependence.**

3. Ideas for future work

4. Appendix material

Test 6: Path Dependence

- Under certain conditions, models of IRTS can generate path dependence: initial, random advantage can become permanent.
  - This is what happens when the HME (in Krugman 1980) is combined with factor mobility (as Krugman (JPE, 1991) did to great effect).

- Tests of path dependence (have been contradictory!):
  - Davis and Weinstein (AER, 2002): Did city population shares in Japan return to normal after WWII bombing? Yes.
  - Davis and Weinstein (JRS, 2008): Did city-by-industry manufacturing output/employment shares do the same? Yes.
  - Bleakley and Lin (QJE, 2012): Is current US population clustered in places that have natural resources that were *previously* productive, but are no longer of any productive use? Yes.

- We will discuss these papers in more detail in Lectures 15-19 (on Economic Geography).

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3. **Ideas for future work**

4. Appendix material

Ideas for Future Work

- Are there better ways to distinguish IRTS motives for trade from CA-based motives? Is there a way to do so that focuses in exactly on the distinction that matters for policy questions?

- Other areas where sources of exogenous demand variation could measure the strength of the HME?

- Measure empirically the role of trade costs in generating the strength of the HME.

- What are the policy implications of the HME? Could we create an empirical sufficient statistic for such policy implications?

Appendix Slide Material

- More detail on four of the six findings discussed above...
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Aggregation

- GL (1975) noted that IIT is clearly very sensitive to aggregation.

- Aggregation at what level?

    - Most obvious issue is aggregation over goods (see below).

    - But can also have aggregation over time ("seasonal trade"—where trade goes from country A to B in one season, but from B to A in another season) or over space ("border trade"; hypothetical example would be where Seattle sells cars to Vancouver, but Toronto sells cars to Detroit).

- Chipman (1992) has looked at the extent of IIT over different levels of SITC groupings.

    - Fitting an equation and extrapolating it, he finds that all IIT would disappear by 18-digit goods. (But note that the finest international trade data is at the 10-digit level.)

    - But if the existing industry categories are not appropriately defined in the context of a given theory, then it is hard to know what to make of these results.

An Aggregation Theorem I

- Chipman (1991) proved an 'Aggregation theorem' about IIT:

  - In a conventional HO economy with G goods, F factors and N countries, with $G = F$,

  - And with the world economy inside the FPE set,

  - Given *any* aggregation of the G goods into $\bar{G} < G$ groupings,

  - There exists an allocation of world endowments such that any given share of trade is intra-industry trade.

- Note that the aggregation scheme here is unspecified.

  - So it could be based on consumption similarity, production similarity, or any other dimension of similarity (eg, ease of data collection, idiosyncratic whims of the person who created SITC classifications...) you want.

An Aggregation Theorem II

- The intuition behind this result:
  - Imagine a perfectly symmetric world in which there is no trade.
  - Now let the countries exchange some of their relative endowments such that incomes (and hence consumption patterns) remain unchanged. Production, however, will change.

  - If the endowment change promotes production of good X in one country and good Y in the other country, and if goods X and Y are 2 goods that we've chosen to be inside the same 'industry' grouping, then the only trade that emerges is 'intra-industry'.

- Note that 'inside the FPE set' is not innocuous here.
  - It requires that the $A(w)$ matrix is non-singular, which requires that each good G is using (even slightly) different factor intensities at w.

  - So the two goods aggregated together into an industry can have 'similar', but not identical, factor intensities.

Chipman (1992)

- Chipman (1991) said that it is *possible* to get IIT in an HO model. But how much IIT should we expect in a 'typical' HO model?

- Chipman (1992) works with a simple example, but the intuition that emerges is, 'a lot'.

  - That is, IIT is likely to be the rule rather than the exception in an HO-style model.

  - The basic intuition is that as the technologies for making 2 goods become more similar, the PPF becomes flatter, which gives rise to more specialization.

  - So if we group goods into 'industries' based on production similarity, there will be lots of scope for intra-industry specialization within these groupings, and hence lots of scope for IIT.

- Rodgers (1988) extended this in a more formal direction, defining production similarity on a Euclidian norm operating on Cobb-Douglas elasticities.

Davis (JIE, 1995)

- Davis (1995) provides what is probably the best-known result about IIT in neoclassical settings.

- The above examples suggested that intra-industry specialization (IIS) is the key to generating IIT.
  - Scale economies generate IIS, but so too can Ricardian forces of differential technologies (in a simple Ricardian model, if we define the entire economy as one 'industry' then there is clearly both IIS and IIT).

- So Davis develops a HO-Ricardian model in which there is an arbitrary amount of IIT.
  - This is true even though the aggregation of goods into industries is based on *identical* factor intensities.
  - This is different from Chipman's (1991, 1992) pure-HO cases in which the aggregation had to be over 'similar', but non-identical, factor intensities.

Davis (1995): Minimal working example

- 3 goods: X_1, X_2, and Y.
  - X_1 and X_2 are the 2 goods in an 'industry', with identical factor intensities.

- 2 countries:
  - Country 1: $X_1 = AF(K_{X1}, L_{X1})$, $X_2 = F(K_{X2}, L_{X2})$ and $Y = G(K_Y, L_Y)$.
  - Country 2: $X_1 = F(K_{X1}, L_{X1})$, $X_2 = F(K_{X2}, L_{X2})$ and $Y = G(K_Y, L_Y)$.

  - So $A > 1$ is the essential Ricardian element of this otherwise HO model.

- Davis solves for the Integrated Equilibrium (IE):
  - And shows that it will always involve techniques such that country 1 is capable of producing the entire world supply of good X_1.

The FPE set

Point $V(1)$ is the vector of factors the IE would use to make good 1, which is then the new origin for country 1.
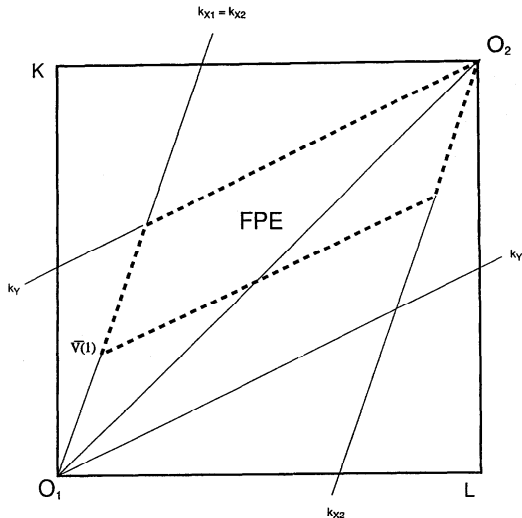
Fig. 1. The integrated equilibrium.

Generating Arbitrary Amounts of IIT

Consider moving from endowments at A, B, C and D. The slope of the A-D line is $-w/r$, so incomes (and hence the factor content of consumption) are constant. As we move from A to D, country 2 produces less Y and more X_2.
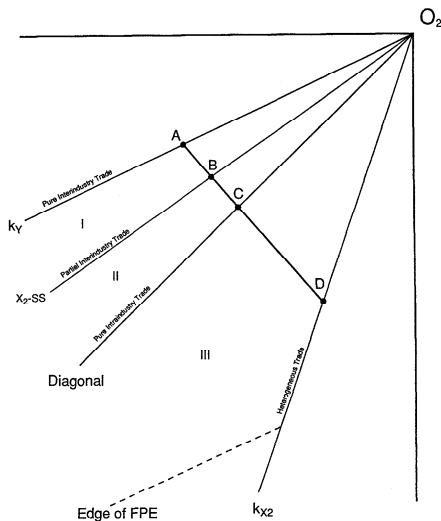
Davis (1995): A final point

- It has often been argued that product differentiation and IIT go hand in hand.
  - Eg: Grubel-Lloyd (1975) subtitle: *The theory and measurement of international trade in differentiated products.*

- And product differentiation and IRTS are often argued to go hand in hand.

- But Davis (1995) points out that a rise in the number of products G relative to factors F (ie the presence of $G > F$, which we might think of as 'product differentiation') also makes any technology differences across countries *more* likely to generate IIT (even with CRTS).

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Davis (JPE, 1997)

- Consider a $4 \times 4 \times 4$ framework:

  - 2 Northern countries, 2 Southern countries.

  - Northern countries relatively endowed with 'North-type' factors. Endowments inside FPE set.

  - 2 'North-type' industries (to be defined shortly), and 2 'South-type' industries.

- Let technology-techniques matrix, $A(w)$ be given by:

$$A(w) = B + \delta \underbrace{\begin{bmatrix} 1 & 1 & -1 & -1 \\ 1 & 1 & -1 & -1 \\ -1 & -1 & 1 & 1 \\ -1 & -1 & 1 & 1 \end{bmatrix}}_{\equiv D} + \epsilon \underbrace{\begin{bmatrix} e_1 & -e_1 & e_2 & -e_2 \\ -e_1 & e_1 & -e_2 & e_2 \\ e_2 & -e_2 & e_1 & -e_1 \\ -e_2 & e_2 & -e_1 & e_1 \end{bmatrix}}_{\equiv E}$$

- Here, first 2 columns are goods in North-type industries; first 2 rows are North-type factors.

$A = B + \delta D + \epsilon E$

- So the B matrix represents 'average' input coefficients.

- The D matrix represents technological dispersion between industries.

- The E matrix represents technological dispersion within industries

- And then the notion of an 'industry' (based on technological similarity) comes from conditions which (are not unambiguous but) generally require δ to exceed a mixture of ϵ and e_1 and e_2.
  - That is, there is more dispersion in A between industries than within.

Davis (1997): Results

- From this, Davis (1997) shows that the HOV equations imply the following:
  1. $V^N - V^S = 2t^{NS}\delta D_1$ (where t^{NS} is the total trade volume of the North with the South, and D_1 is the first row of D).
  2. $V^N - V^N = 2t^{NN}\epsilon E_1$ (defined similarly).

- Hence, for fixed endowment differences, the volumes of trade depend critically on δ and ϵ.
  1. If the goods in which N and S specialize are very different in their input intensities (high δ) then only a small amount of trade (low t^{NS}) is needed to accomplish the required amount of factor trade.

  2. If the goods in which N and N' specialize are very similar (low ε) then even though the *net* content of factor services traded will be small, there is lots of back-and-forth factor services trade, which is accomplished by lots of goods trade (high t^{NN}).

Davis (1997): Another Result

- From this framework, Davis (1997) constructs an example in which $t^{NN} > t^{NS} > t^{SS}$, which is roughly what we see in the world today.

- But note how this was achieved without allowing for:

    - Higher levels of trade protection in the South (leading to little N-S or S-S trade).

    - Non-homothetic tastes (which might make consumption patterns in the North relatively similar, promoting N-N trade).

    - The North to be richer, and hence to trade more with anyone (leading to more N-N trade).

    - Trade costs that are proportional to distance (to allow for the fact that, in the real world, 'N' countries are probably closer to other 'N' countries than 'S' countries.)

Davis and Weinstein (2003)

- DW (2003) explore the factor content of N-N trade empirically.

- They use the data (from DW (AER, 2001)) on *actual, reported* $\bar{B}^c(w^c)$ matrices in each country.

    - So there is no real HO model content here. (This is not a test of HO.)

    - Their interest here is in how to decompose *entirely, tautologically, accurate* measures of $F_c \equiv \bar{B}^c(w^c)E_c - \sum_{c'} \bar{B}^{c'}(w^{c'})M_{cc'}$, where E_c is net exports from country c, and $M_{cc'}$ is net imports into country c from country c'.

DW (2003) Results

1. The pure intra-industry component of F_c is significant (42 % of all F_c).

   - In a conventional HO model (with FPE) there is no IIT FCT.

   - In fact, as discussed above, the existence of IIT has been taken as evidence against the HO model.

   - But in this setting, where the $\bar{B}^c(w^c)$ matrices are allowed to differ (and, strikingly, do differ) we see that, even within the richest countries in the OECD, IIT is a conduit for much factor services trade.

2. For the median G10 country, lots of factor services trade is within the North.

   - For K: 48 % is within North.
   - For L: 37 % is within North.

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The Gravity Equation III

- Deardorff (1998) also discusses how the HO model has gravity-like features to it.

    - At first glance this is surprising, since bilateral trade isn't pinned down in the HO model.

    - But Deardorff points out that bilateral trade isn't determined because buyers are indifferent about where they buy from.

    - So if buyers (somewhat plausibly?) settled this indifference randomly, and in proportion to the 'number' of sellers offering them goods from each country, the resulting bilateral trades would be gravity-like.

Evenett and Keller (JPE, 2002)

- EK (2002) go beyond simply estimating a gravity equation across all country pairs.

- Instead, they note that:
  - While both IRTS and HO *can* predict gravity, they have different predictions on where (ie for which country pairs) we're likely to see it at work.

- The EK (2002) argument:
  - IRTS (a la Krugman (1980)) always predicts gravity. And IRTS predicts high IIT. So in country pairs with 'high IIT', we should see gravity holding well.

  - HO (simple 2×2) predicts gravity only to the extent there is specialization. Specialization rises in the difference between the 2 countries' endowments. So in country pairs with wide endowment differences, we should also see gravity holding. But HO does not predict IIT, so this should be true even in the 'low IIT' country pairs.

Evenett and Keller: 4 Models

- They compare 4 models:

  1. Pure-IRTS: Complete specialization, so $M_{ij} = \alpha \frac{Y_i Y_j}{Y^W}$ with $\alpha = 1$. This is true in high-IIT samples, and more true as IIT rises.

  2. Pure-HO with complete specialization ('multicone HO'): so again $\alpha = 1$. But this is in low-IIT samples, and more true as endowment differences ('FDIF') rise.

  3. Mix HO-IRTS (a la Helpman and Krugman (1985)): now $\alpha = 1 - \gamma^i$, and γ^i being the share of GDP that is in the CRTS sector. This is true in high-IIT samples, and more true as IIT rises.

  4. Pure HO with incomplete specialization ('unicone HO'): now $\alpha = \gamma^i - \gamma^j$, with γ^i being the share of GDP in one of the 2 sectors. This is in low-IIT samples, and more true as endowment differences ('FDIF') rise.

TABLE 3
BENCHMARK CASE

	IRS/HECKSCHER-OHLIN MODEL: HIGH-GRUBEL-LLOYD SAMPLE ($GL > .05$)				HECKSCHER-OHLIN MODEL: LOW-GRUBEL-LLOYD SAMPLE ($GL < .05$)			
	IRS Model (IRS/IRS Goods)		IRS/Unicone Heckscher-Ohlin Model (IRS/CRS Goods)		Multicone Heckscher-Ohlin Model (CRS/CRS Goods)		Unicone Heckscher-Ohlin Model (CRS/CRS Goods)	
	α_v	5% 95%	α_v	5% 95%	α_v	5% 95%	α_v	5% 95%
	Ranked by Grubel-Lloyd Index				Ranked by FDIF			
$v=1$	.016	.012	.078	.072	.039	.030	.021	.012
	(.012)	.044	(.005)	.087	(.007)	.049	(.004)	.026
$v=2$	.044	.036	.053	.047	.111	.087	.027	.025
	(.005)	.052	(.005)	.060	(.014)	.132	(.008)	.043
$v=3$	.139	.120	.117	.112	.047	.040	.058	.039
	(.013)	.164	(.009)	.141	(.005)	.056	(.008)	.066
$v=4$	.069	.049	.123	.109	.039	.034	.048	.046
	(.017)	.097	(.005)	.124	(.003)	.044	(.006)	.064
$v=5$	.099	.083	.128	.119	.039	.033	.080	.069
	(.015)	.125	(.006)	.134	(.004)	.045	(.007)	.101
All observations	.087	.076	.086	.079	.052	.047	.040	.034
	(.009)	.104	(.004)	.092	(.003)	.056	(.003)	.044
Only perfect specialization of production	yes		no		yes		no	
$H_0: \alpha_i = \alpha \; \forall i$	reject		reject		reject		reject	
$H_0: \alpha_1 = \alpha_5$	reject		reject		do not reject		reject	
Share of bilateral comparisons correct	N.A.		9/10		N.A.		9/10	

NOTE.—Standard errors are in parentheses.

Evenett and Keller: Results II

Model comparisons

TABLE 4
MEASURES OF FIT FOR THE BENCHMARK CASE

| | IRS/HECKSCHER-OHLIN MODEL: HIGH-GRUBEL-LLOYD SAMPLE ($GL > .05$) | | | | | | HECKSCHER-OHLIN MODEL: LOW-GRUBEL-LLOYD SAMPLE ($GL < .05$) | | | | | |
| | IRS Model (IRS/IRS Goods) | | | IRS/Unicone Heckscher-Ohlin Model (IRS/CRS Goods) | | | Multicone Heckscher-Ohlin Model (CRS/CRS Goods) | | | Unicone Heckscher-Ohlin Model (CRS/CRS Goods) | | |
	ln ($e'e$)	AIC	R^2	ln ($e'e$)	AIC	R^2	ln ($e'e$)	AIC	R^2	ln ($e'e$)	AIC	R^2
	Ranked by Grubel-Lloyd Index						Ranked by FDIF					
$v=1$	44.61	39.79	1.083	43.74	39.30	.832	43.36	37.26	.238	43.24	37.37	.712
$v=2$	45.21	40.39	.456	44.93	40.46	.619	45.61	39.51	.455	45.25	39.38	.605
$v=3$	48.81	43.99	.958	48.75	44.26	.674	44.72	38.62	.417	44.24	38.38	.484
$v=4$	47.17	42.34	.917	46.45	41.93	.869	44.45	38.35	1.963	43.88	38.03	.793
$v=5$	50.61	45.79	.214	49.61	45.04	.934	44.32	38.22	.596	43.84	37.95	.690
All observations	50.91	44.46	.280	51.03	44.69	.105	46.74	39.03	.451	46.96	39.30	.195
Only perfect specialization of production		yes			no			yes			no	

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Davis and Weinstein (2003)

- NB: A lengthier discussion can be found in DW (1996, working paper).

- DW (2003) use data on OECD manufacturing and try to nest H-O with a version of Krugman (1980) that delivers an HME.

- They focus on the implications of the HME for *production* rather than exporting behavior, but the same intuition goes through for exporting.

DW (2003): 2 Nested Models

- Model 1: Pure HO:
  - HO working at the 4-digit industry level, with $G = F$.
  - Let n index 'industries', which DW take to be 3-digit industries.
  - And let g index 'goods' within these 3-digit industries, which are then 4-digit industries.
  - A result from HO theory (that you will see next quarter with Kyle) establishes that when $F = G$, we can write: $X_{ngc} = R_{ng} V_c$, where:
    - R_{ng} is the (row corresponding to good g in industry n of the) what is often called "the Rybczinski matrix."
    - X_{ngc} refers to output in country c of good g in industry n.
    - V_c is the vector of factor endowments in country c.

DW (2003): 2 Nested Models

- Model 2: Krugman-HO:
  - HO now is assumed to work at the 3-digit level.
  - And (with CES preferences, iceberg trade costs, and the assumption that both fixed and marginal production costs use the same bundle of factors), all goods g inside an industry n will use the same factor bundles, so R_{ng} continues to convert factors into production.
  - But production within industries is indeterminate. So DW assume that, absent idiosyncratic demand differences, each country will allocate factors across goods within an industry in the same proportion as all other countries: $X_{ngc} = \frac{X_{ng,ROW}}{X_{n,ROW}} \times X_{nc}$. Define $SHARE_{ngc} \equiv \frac{X_{ng,ROW}}{X_{n,ROW}} \times X_{nc}$.
  - Idiosyncratic demand differences will tilt this. A country that has higher demand for a good will produce more of the good (how much more depends on whether we have a HME or not).
  - Define this 'tilt' as $IDIODEM_{ngc} = (\frac{\widetilde{D}_{ngc}}{\widetilde{D}_{nc}} - \frac{\widetilde{D}_{ng,ROW}}{\widetilde{D}_{n,ROW}})X_{nc}$, where $\widetilde{D}$ is absorption, to be defined shortly.

DW (2003): The Test

- Based on the above logic, DW (2003) argue that:
  - Production (X_{ngc}) should depend on fundamental HO forces (ie $X_{ngc} = R_{ng} V_c$).
  - But we should also allow for a potential adjustment to this that is increasing in $SHARE_{ngc}$ and $IDIODEM_{ngc}$.
  - So assume that production is simply linear in these last 2 terms and estimate:

  $$X_{ngc} = \alpha_{ng} + \beta_1 SHARE_{ngc} + \beta_2 IDIODEM_{ngc} + R_{ng} V_c + \varepsilon_{ngc}.$$

- We expect the following:
  - $\beta_2 = 0$: zero-trade costs world (IRTS or CRTS).
  - $\beta_2 \in (0, 1]$: CRTS with trade costs.
  - $\beta_2 > 1$: IRTS (HME).

DW (2003): Constructing $SHARE_{ngc}$

- How do we measure a country's total 'demand' (really, absorption—i.e. final plus intermediate demand) for a good, ie $\widetilde{D}_{ngc}$?
  - DW (1996) used simply the amount of local demand in country c for this good g in industry n.
  - DW (2003) instead use the derived demand for country c's goods both at home and in its trading partners as well. To measure this they first regress, industry-by-industry, a gravity equation to get the effect of distance on demand. From this they can sum over all trade partners, down-weighting by distance, to get a sense of the 'market size' for g, n faced by country c.
  - This distinction turns out to have big effects.

- An important concern is simultaneity bias: do un-modeled production differences drive idiosyncratic demand differences (for example, by changing prices, or even tastes?)
  - DW use lagged (by 15 years) demand data to try to mitigate this.
  - Various other discussions in text.

DW (2003): Results
Estimates pooled across all industries

Table 1
Pooled runs (Dependent variable is 4-digit output; standard errors below estimates)

	1	2	3	4
IDIODEM	1.67	1.67	1.57	1.57
	0.05	0.05	0.10	0.10
SHARE	0.96	0.92		
	0.01	0.02		
EXPORTD		0.07		0.01
		0.02		0.04
FACTORS	No	No	Yes	Yes
Observations	650	650	650	650

IDIODEM is idiosyncratic demand, SHARE is the share of 4-digit output in 3-digit output in the rest of the world, EXPORTD is a dummy variable that is one if the country is a net exporter of the good, and FACTORS indicates whether the coefficients on factor endowments were allowed to differ across 4-digit sectors. No indicates that the coefficients on factor endowments were constrained to be the same for every 3-digit sector; Yes means they varied by 4-digit sector.

DW (2003): Interpretation

- Strong evidence for $\beta_2 > 1$, so an HME.

  - Endowments account for around 50 % of production variation, and CRTS around 30 %.

  - Running this regression industry-by-industry reveals that $\beta_2 > 1$ in around half of the industries.

- This contrasts starkly with DW (1996), which used only local demand to construct D, where $\beta_2 = 0.3$.

- In parallel work, DW (EER, 1999) did a similar exercise to DW (1996) on Japanese regions and estimated $\beta_2 = 0.9$, which suggests greater scope for an HME within countries.

  - Though these results are hard to compare with DW (1996, 2003) since the Japanese data are at a coarser level of industry aggregation.