Lecture 7: Empirical Tests of the Heckscher-Ohlin Model

14.581: International Economics I

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Plan of the Lecture

- Properly testing the Heckscher-Ohlin theory requires information on three objects:
  - Trade flow data (to compute M^k)
  - Factor endowment data (to compute V^k)
  - Technology data to compute the matrix (A)
- We will first briefly discuss papers that have used a subset of these objects to test the model
- We will then proceed to study "complete tests" of the theory

Baldwin (1971)

- Baldwin (1971) used cross-industry U.S. data on net exports for 1960 and correlated them with a few measures of factor intensity (e.g., physical capital per worker, scientists per worker, farmers per worker, unskilled employed per worker...).
- He expected (and confirmed) that the U.S. is a net exporter of goods that use intensively scientists, craftsmen, and farmers. Surprisingly, he recorded a negative significant coefficient on K/L.
- What can we infer from these results. Suppose that $I = J$ (which is not quite the case in his study). Then as we saw in the last lecture, we can invert the factor market conditions and obtain:

$$\left(X^k - C^k\right) = A^{-1}\left(V^k - s^k\bar{V}\right). \quad (1)$$

- So in some sense, Baldwin (1971) estimated relative factor abundance $(V^k - s^k\bar{V})$.
- Is the U.S. capital-scarce? Not clear because he ran it on A rather than A^{-1}. Also, other studies found a positive sign on K/L.

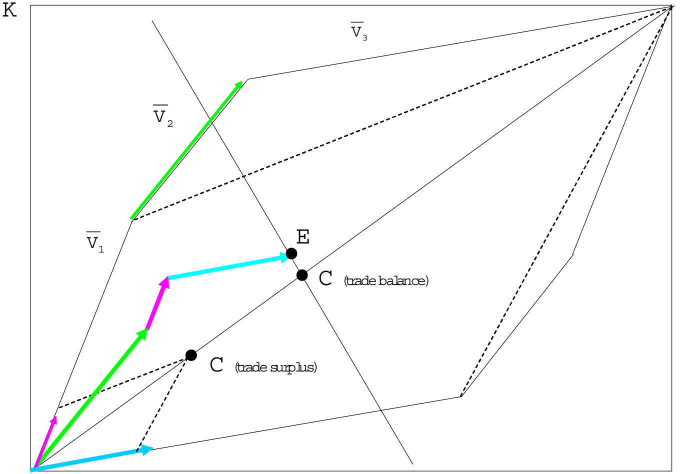
Leamer (1984)

- Leamer (1984) also made use of equation (1), but instead of using data on A, he used cross-country data on relative factor endowments (V^k) for both 1958 and 1975.
- In particular, he organized the data so as to have 11 sectors and 11 factors (even case), and then regressed net exports in each sector on the measures of factor abundance.
- His estimates deliver straightforward results (such that countries with lots of oil tend to export petroleum). But also more interesting ones:
  - for instance, a larger amount of capital raises net exports of all types of manufacturing goods.
  - net exports of labor intensive products is enhanced by abundance of non-professional and illiterate workers, but reduced (though not significantly) by abundance of technical workers
- The R^2 of the regressions are in general quite large, but not clear he is *testing* the model.

The Leontief (1954) Paradox

- We will next discuss the more promising approach of testing the factor content of trade.
- Leontieff (1953) was the first researcher to investigate the factor content of U.S. trade.
- Using U.S. input-output tables he computed the amount of capital and labor embodied in U.S. exports and U.S. imports. Surprisingly, he found that U.S. imports were more capital intensive than U.S. exports.
- Does that imply that the U.S. is capital scarce relative to the world?
  - Leamer (1980) noted that in 1947, U.S. was exporting both capital as well as labor services
  - Furthermore, the capital-labor in production was found to be higher than that in consumption
  - One can show that the HOV equations then imply that capital was relatively abundant in the U.S. (see graph below).
- How can we have net exports in both factors? In a two-factor world with trade balance, Leontief's conclusion would have been valid. But U.S. was running a large trade surplus (also $J > 2$).

The Leontief (1954) Paradox: A Graphical Illustration



Home imports capital-intensive good 1, and exports the other two goods

The Leontief (1954) Paradox (cted.)

- With a trade surplus, to get at the issue of relative factor abundance one needs to replace $s^k = GDP^k / GDP^{World}$ with $\tilde{s}^k = \left(GDP^k - TradeSurplus^k\right) / GDP^{World}$ in the standard HOV formulas.
- Leamer essentially found

$$\frac{K^{US}}{K^{World}} > \tilde{s}^k > \frac{L^{US}}{L^{World}},$$

  which indicates that U.S. was capital abundant.
- But Brecher and Choudhri (1982) point that the net positive exports of both factors requires

$$\frac{K^{US}}{K^{World}} > \frac{L^{US}}{L^{World}} > s^k,$$

  and the latter is clearly counterfactual since U.S. GDP per capita is above the world average one.
- These paradoxes seem to have vanished through time as net exports of labor services have become negative.

Bowen, Leamer and Sveikauskas (1987)

- Bowen et al. (1987) should be credited for conducting the first complete test of the HOV predictions on the factor content of trade.
- In particular, they rewrote the set of Vanek equations as follows:

$$\frac{F_j^k}{s^k \bar{V}_j} = \frac{V_j^k}{s^k \bar{V}_j} - 1 \text{ for all } j \text{ and } k,$$

  and computed both the LHS and RHS of the equation with data on trade flows, factor endowments and the U.S. technology matrix.
- Bowen et al. used data on 12 factors and 27 countries in 1967
- They perfomed two types of tests:
  - Sign tests: for which fraction of all (j, k) is *sign(LHS)=sign(RHS)*?
  - Rank tests: how often do we confirm that if $\frac{F_j^k}{s^k \bar{V}_j} > \frac{F_{j'}^k}{s^k \bar{V}_{j'}}$ then $\frac{V_j^k}{s^k \bar{V}_j} > \frac{V_{j'}^k}{s^k \bar{V}_{j'}}$? (same varying k rather than j).
- Bowen et al. found that sign tests are correct about 60% of times, while rank tests only 49% of times.

Conditional FPE: Trefler (1993)

- The results by Bowen et al. show that the stripped down HOV model performs poorly. They attempted to salvage it introducing Hicks-neutral technology differences and nonhomothetic preferences, but did not help (note Trefler, 1995, p. 1038).
- Trefler (1993) pushed forward the notion that technology differences might be important, but allowed for factor-augmenting technology differences across countries.
- Perhaps tests fail because a worker (or a machine) in the U.S. embodies more "effective" units of labor (or capital) than one in another country. Effective endowment of factor j in country k is then

$$\widetilde{V}_j^k = \pi_j^k V_j^k.$$

- These productivity differences will rule out FPE, but not "conditional FPE" or FPE in effective units of factors.
- Can we find a vector of π_j^k's such that the HOV tests perform better?

Conditional FPE: Trefler (1993) cted.

- Note that the HOV equations are now

$$F_j^k = \pi_j^k V_j^k - s_k \left(\sum_{k'} \pi_j^{k'} V_j^{k'} \right) \text{ for all } j \text{ and } k \tag{2}$$

- For each factor j, we have a system of $K-1$ independent equations and K "free parameters" (the π_j^k's).
- So up to a normalization ($\pi_j^{US} = 1$) not only can we make the model perform better, we can make it fit the data exactly!
- Trefler (1993) backs out the efficiency parameters π_j^k from (2) and checks whether they seem reasonable (33 countries, 2 factors in 1983):
  - first, he shows that they are all positive (not in Bowen at al.)
  - for each $J = K, L$, he plots a cross-section of π_j^k against w_j^k; it looks like conditional FPE approximately holds! (see his Figure 1).

The Case of Missing Trade: Trefler (1995)

- Trefler (1995) studies systematic deviations of the data from the theoretical predictions of HOV equations.
- In particular, for 33 countries (accounting for about 80% of world income) and 9 inputs, he constructs (1983 data):

$$\varepsilon_j^k = F_j^k - \left(V_j^k - s^k \bar{V}_j \right).$$

- His main findings are as follows:
  1. ε_j^k is approximately equal to $-\left(V_j^k - s^k \bar{V}_j \right)$, which of course implies $F_j^k \approx 0$ ("Missing Trade");
  2. Poor countries tend to have a predominance of $\varepsilon_j^k < 0$, while rich countries tend to feature $\varepsilon_j^k > 0$;
  3. The two above imply that poor countries tend to be abundant in most factors, while rich countries tend to be scarce in most factors ("Endowments Paradox"). Puzzling since rich countries tend to run trade surpluses.

The Case of Missing Trade: Trefler (1995) cted.

- Trefler (1995) then modifies the model to try to fit the data better.
- He first adds cross-country Hicks neutral technological differences:

$$F_j^k = \delta^k V_j^k - s^k \left(\sum_{k'} \delta^{k'} V_j^{k'} \right) \qquad (3)$$

- This helps because it increases the effective supply of factors in rich countries;
    - but this is different from his (1993) exercise, because equation (3) need not hold exactly and can thus be estimated
- Trefler estimates sensible δ's and shows that this simple modification increases the success rate of the sign test to 62%.
- Trefler also allows a set of poor countries to have a common factor-bias efficiency parameter ϕ_j on top of their individual Hicks-neutral term. Using a model-selection criterion he concludes however that the Hicks-neutral specification performs better.
- Finally, he models Home bias in consumption and shows that the data prefers this more general model.
    - The success rate of the sign test goes up to 72% (93% when weighting by size), while the correlation between actual F_j^k and predicted $\hat{F}_j^k$ goes up to 0.67 (from 0.28).

No Conditional FPE: Davis and Weinstein (2001)

- Davis and Weinstein consider the case in which (large enough) factor endowment differences lead to a failure of FPE.
- In Lecture 6 we showed that in such a case, we will have (non-efficiency related) cross-country variation in the technology matrix A. And standard measures of the factor content of trade will underestimate trade flows!
- DW estimate technology matrices for 10 OECD countries. They run:

$$a_{ji}^{k} = \alpha^{k} + \beta_{ji} + \gamma_{j}\left(K^{k}/L^{k}\right) + \varepsilon_{ji}^{k}$$

  and confirm that $\gamma_K > 0$ and $\gamma_L < 0$.
- They then construct the factor content of trade with these estimated input requirements
- They also allow for Hicks-neutral technological differences, nontradable goods, and relax the standard HOV assumptions on the demand side by using gravity equations to better predict consumption.
- DW find that when plotting F_j^k against $\hat{F}_j^k$, they now obtain a slope of 0.82 (as opposed to 0 as in Trefler), and the success rate of the sign test is around 90%.

Other HOV Tests

- A couple of studies have shown that leaving aside technological differences and home bias in consumption, the HOV model performs quite well when:
  - focusing on the net factor content of regional trade flows (see Davis, Weinstein, Bradford and Shimpo, 1997) – where FPE and common A seem valid assumptions;
  - when focusing on bilateral comparisons of the factor content of trade between countries with very large differences in factor endowments (Debaere, 2003).
- Choi and Krishna (2004) have tested Helpman's (1984) bilateral predictions under no FPE,

$$\left(w^k - w^\ell\right) \cdot \left(F_{IMP}^{k,\ell} - F_{IMP}^{\ell,k}\right) \geq 0,$$

  for a sample of eight developed countries and have found that it holds (though not by much) for 72 to 75% of the cases.
- Zhu and Trefler (2006) discuss how to properly test the factor content of trade predictions in a world with no FPE and international trade in intermediate inputs (need to compute worldwide factor usage embodied in net trade).

Rybczynski Tests: Harrigan (1995, 1997), Schott (2003)

- Harrigan (1995) estimates Rybczynski effects for 20 OECD countries in 1970-85 (similar to Leamer 1984, but no consumption and longer time-series).
    - He finds that every industry has an "enemy" factor endowment;
    - but has trouble explaining cross-country variation (technology?).
- Harrigan (1997) incorporates technological differences into his previous work. Specifies a translog GDP function which relates, for each sector i, the sector's output share in GDP to a vector of factor endowments and to a vector of sector-specific productivity measures:

$$\frac{X_i^k}{GDP^k} = \alpha_i + \sum_k \gamma_{ij} \ln V_j^k + \sum_{i'} \delta_{ii'} \ln \left(A_{i'}^k p_{i'} \right)$$

    - Harrigan finds that, for 10 OECD countries in 1970-1990, both endowments and technology are important in shaping international specialization.
- Schott (2003) argues that in a world with multiple cones of diversification, there is no longer a linear relationship between industry output and factor endowments (e.g., produce textiles only if have $K/L \in \left(\underline{K/L}, \overline{K/L} \right)$). Finds support for nonlinear specification (see his Figure 3).