Heckscher-Ohlin: Empirical Applications

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Leontief paradox

- Leontief (1953) used input-output matrix of the US to compute the capital and labor used in US exports and US imports.
- Used the same input-output matrix for imports and exports. This is consistent with the basic H-O model that assumes identical technologies across countries.
- Capital/labor (expressed in terms of $ per worker) in exports: $13,700.
- Capital/labor (expressed in terms of $ per worker) in imports: $18,200.
- The finding that US imports are relatively capital-intensive, compared to US exports, was unexpected, and became referred to as the 'Leontief paradox'.

Leontief paradox

- Possible explanations for the Leontief paradox:
  - Technologies are different across countries.
  - Labor should be disaggregated into different skill classes.
  - There are more factors of production than just labor and capital. For example: land.
- Leamer (1980) used the 'factor content' version of the H-O model, known as the Heckscher-Ohlin-Vanek model, to come up with an alternative test.

Heckscher-Ohlin-Vanek model

- Countries $i = 1, ..., C$.
- Industries $j = 1, ..., N$.
- Factors of production $k, \ell = 1, ..., M$.
- Assumptions: (i) identical technologies across countries; (ii) identical homothetic preferences across countries; (iii) factor price equalization (FPE) holds.
- Assumptions (i) and (iii) allow us to use the same technology matrix. Assumption (ii) implies that the share of income spent on good j in each country is the same as the share of world income that goes to good j.

Heckscher-Ohlin-Vanek model

- **Technology:** $A = [a_{kj}]$.
  M x N matrix (rows are factors, columns are industries). Element a_{kj} measures the amount of factor k needed to produce one unit of good j. Identical technologies across countries, in addition to FPE, imply that the technology matrix A is identical across countries.
- **Output:** Y^i.
  N x 1 matrix (rows are industries) for each country i.
- **Demand:** D^i.
  N x 1 matrix (rows are industries) for each country i.
- **Net exports:** $T^i = Y^i - D^i$.
  N x 1 matrix (rows are industries) for each country i.

Heckscher-Ohlin-Vanek model

- **Factor content of trade:** $F^i = AT^i$.
  M x 1 matrix (rows are factors). Measures for each country i the net amount of factors exported.

- **Endowments:** $V^i = AY^i$.
  M x 1 matrix (rows are factors). Measures the endowments for each country i.

- **Demand (again):** $D^i = s^i D^w$.
  N x 1 matrix (rows are industries) for each country i. Demand in country i is a fraction s^i of world demand, D^w, where $s^i = Y^i / Y^w$. This is a result of homothetic identical preferences across countries. Pre-multiply above expression by A. Expresses demand for goods in terms of demand for factors.

$$AD^i = s^i AD^w = s^i AY^w = s^i V^w$$

Heckscher-Ohlin-Vanek model

- **Factor content of trade (again):**
  $F^i = AT^i = A(Y^i - D^i) = V^i - s^i V^w$.
  N x 1 matrix (rows are industries) for each country i.

- **H-O-V Theorem:** *If endowment of country i in factor k relative to world endowment of factor k is greater than the share of country i in world GDP, i.e., if $\frac{V_k^i}{V_k^w} > s^i$, then country i is abundant in factor k.*

Leamer (1980)

- With two factors of production, H-O-V implies that:

$$F_K^i = K^i - s^i K^w$$
$$F_L^i = L^i - s^i L^w$$

- Country i is capital abundant if

$$\frac{K^i}{K^w} > \frac{L^i}{L^w} \equiv \frac{K^i}{L^i} > \frac{K^w}{L^w}$$

where, according to H-O-V, $K^w = \frac{1}{s^i}(K^i - F_K^i)$ and $L^w = \frac{1}{s^i}(L^i - F_L^i)$

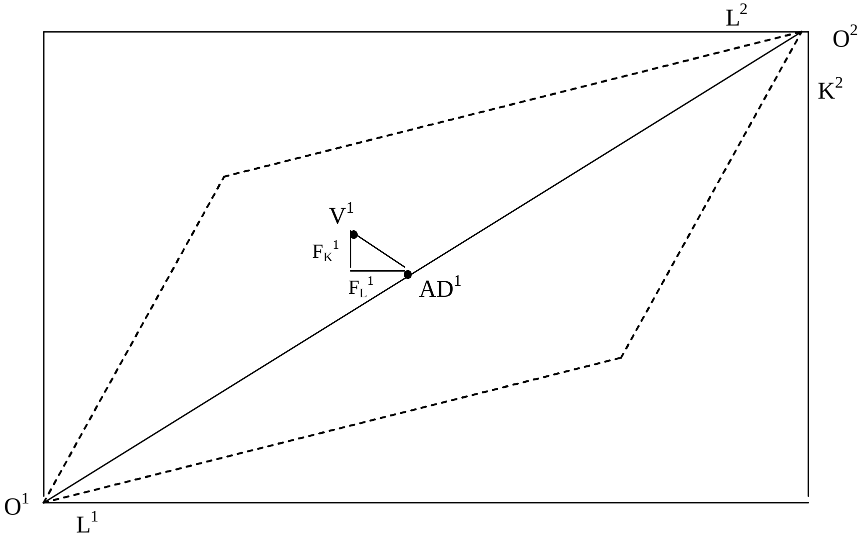
Leamer (1980)

- *If country i is capital abundant, then H-O-V implies*

$$\frac{K^i}{L^i} > \frac{K^i - F_K^i}{L^i - F_L^i}$$

- In other words, a country is capital-abundant if the capital-labor ratio embodied in *production* is greater than the capital-labor ratio embodied in *consumption*.
- Using the same data as Leontief, Leamer (1980) found that the U.S. was capital-abundant. He therefore concluded that there was no Leontief paradox. Instead, Leontief had performed the wrong test.

Leamer (1980)



Leamer (1980)

- If preferences are homothetic and identical across countries, the factor content of consumption, AD^i, must lie on the diagonal. Reason: consumption in country 1 is proportional to world consumption, so that the factor content of consumption in country 1 is proportional to the world factor endowments.
- The position of V^1 implies that country 1 is capital-abundant, i.e., the capital-labor ratio in production is greater than the capital-labor ratio in consumption.
- If trade is balanced, slope of line connecting V^1 and AD^1 gives price of L relative to K.
- Note: trade need not be balanced. Keeping V^1 where it is, moving AD^1 down the diagonal leads to a trade surplus, and moving it up the diagonal a trade deficit.

Leamer (1980)

- The reason for the difference between Leontief and Leamer is that Leontief did not allow for trade to be unbalanced.
- Consider a simple numerical example: $K^{US} = 1000$, $L^{US} = 1000$, and relative price of capital and labor is 1. In addition, $K^{EXP} = 200$ and $L^{EXP} = 190$. As in Leontief, assume that $K^{EXP}/L^{EXP} < K^{IMP}/L^{IMP}$.
- Assume balanced trade. Example: $K^{EXP} = 200$, $L^{EXP} = 190$, $K^{IMP} = 210$ and $L^{IMP} = 180$. Then, using Leamer's definition, we find that

$$\frac{K}{L} = 1 < \frac{K - K^{EXP} + K^{IMP}}{L - L^{EXP} + L^{IMP}} = \frac{1000 - 200 + 210}{1000 - 190 + 180} = \frac{1010}{990}$$

so that the US would be labor abundant, confirming Leontief's finding.

Leamer (1980)

- Instead, assume US runs trade surplus: $K^{EXP} = 200$, $L^{EXP} = 190$, $K^{IMP} = 20$ and $L^{IMP} = 18$. Leontief still holds: the capital/labor ratio of exports is less than the capital/labor ratio of imports. However:

$$\frac{K}{L} = 1 > \frac{K - K^{EXP} + K^{IMP}}{L - L^{EXP} + L^{IMP}} = \frac{1000 - 200 + 20}{1000 - 190 + 18} = \frac{820}{828}$$

  so that according to Leamer the US would actually be capital-abundant.

- Since the US was running a trade surplus in the decade following WWII, this explains the difference between Leontief and Leamer.

Empirical tests following Leamer

Bowen, Leamer and Sveikauskas (1987)

Test the relation $F^i = V^i - s^i V^w$, i.e., if a country has a greater share of factor k than its share of world GDP, then it should export that factor k.

- *Sign test*: $\text{sign}(F_k^i) = \text{sign}(V_k^i - s^i V_k^w)$.
- *Rank test*: $F_k^i > F_\ell^i \equiv (V_k^i - s^i V_k^w) > (V_\ell^i - s^i V_\ell^w)$

Using 27 countries and 12 factors, test failed miserably. Sign test satisfied in 61% of cases, and rank test satisfied in 49% of cases. Remember: flipping a coin would give us 50%!

Trefler (1993)

- Allow for technological differences across countries.
- π_k^i: productivity of factor k in country i relative to US.
- $\pi_k^i V_k^i$: effective endowment of factor k in country i, the endowment it would have if its productivity were the same as in the US.
- A: US technology.
- Factor content of trade, $F^i = AT^i$, measured in terms of effective factors.

Trefler (1993)

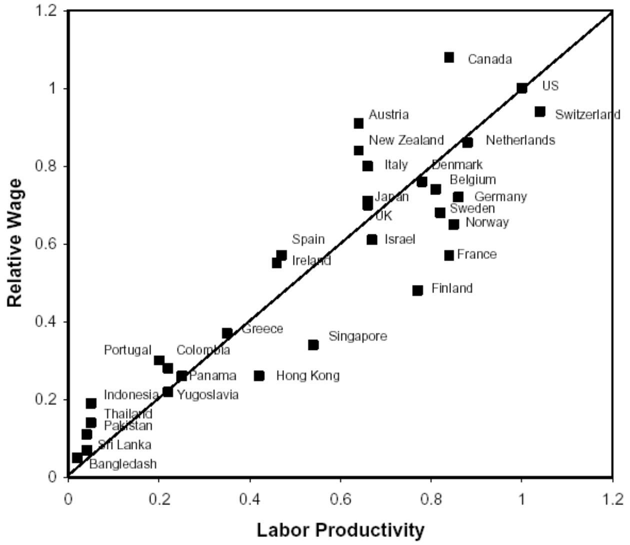
- Therefore,

$$F_k^i = A_k T^i = \pi_k^i V_k^i - s^i \sum_{j=1}^{C} \pi_k^j V_k^j$$

where $i = 1, ..., C$ (countries) and $k = 1, ..., M$ (factors).

- This gives us M x C equations. Given that there are M market clearing conditions (one for each factor), this gives us M x (C-1) independent equations.
- Trefler gets data for T^i and V_k^i, and then solves for π_k^i. (Note: A normalized to 1.)
- In this case, H-O-V holds by construction. However, he can compare π_k^i with some other reasonable productivity numbers.

Trefler (1993)



Trefler (1993)

- Horizontal axis gives labor productivity relative to the US, as computed by Trefler, and vertical axis gives wages, relative to the US.
- Correlation between both is 0.9!