International Economics: Lecture 9
Testing Trade Theories & HOV Model

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ATC, February 27, 2017
Leontief Paradox

- In 1953 Leontief published the results of HO theorem test.
- These results became so famous, that were dubbed as “Leontief Paradox”.

- Leontief test was based on Input-Output Tables, which was pioneered by him.

Wassily Leontief (1906-1999)
Leontief Paradox

- **Hypothesis**: The U.S. was assumed to be the most K-abundant country in the world. So based on HO theorem it was expected that the U.S. exported K-intensive goods and imported L-intensive goods.
- **Test method**: Leontief calculated the U.S. capital and labor requirements per $1 million of U.S. exports and of import substitutes for 1947.
- **Result**: U.S. exports were more L-intensive than U.S. import substitutes.

<table>
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<tr>
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<th>Imports Substitutes</th>
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<tbody>
<tr>
<td>Capital (mln. dollars in 1947 prices)</td>
<td>2.6</td>
<td>3.1</td>
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<td>170</td>
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# Leontief Paradox

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<td>18.2</td>
</tr>
<tr>
<td><strong>Leontief</strong> (1947 input req. 1951 trade, 192 sectors)</td>
<td>K/L ($1000 / man-year)</td>
<td>13</td>
<td>13.7</td>
</tr>
<tr>
<td></td>
<td>K/L, excluding natural resources</td>
<td>0.88</td>
<td></td>
</tr>
<tr>
<td><strong>Baldwin</strong> (1958 input req. 1962 trade)</td>
<td>K/L</td>
<td>1.27</td>
<td></td>
</tr>
<tr>
<td></td>
<td>K/L, excluding natural resources</td>
<td>1.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td>K/L, excluding natural resources &amp; human capital</td>
<td>0.92</td>
<td></td>
</tr>
</tbody>
</table>
### Input – Output tables

show intersectoral flows

<table>
<thead>
<tr>
<th>from</th>
<th>into</th>
<th>Agriculture</th>
<th>Manufacture</th>
<th>Households</th>
<th>Total Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>25</td>
<td>20</td>
<td>55</td>
<td>100</td>
<td>100 bushels of wheat</td>
</tr>
<tr>
<td>Manufacture</td>
<td>14</td>
<td>6</td>
<td>30</td>
<td>50</td>
<td>50 yards of cloth</td>
</tr>
<tr>
<td>Households</td>
<td>80</td>
<td>180</td>
<td>40</td>
<td>300</td>
<td>300 man-years of labor</td>
</tr>
</tbody>
</table>

Rows show output distribution:
e.g. of 100 units of Agri. output 25 are used by Agri. itself, 20 by Manu., 55 by Households.

Columns show input structure:
To produce 100 units of wheat 25 wheat, 14 cloth, 80 labor are used.

Input – Output tables
show intersectoral flows

<table>
<thead>
<tr>
<th>from</th>
<th>Agriculture ($)</th>
<th>Manufacture ($)</th>
<th>Households ($)</th>
<th>Total Output ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>50</td>
<td>40</td>
<td>110</td>
<td>200</td>
</tr>
<tr>
<td>Manufacture</td>
<td>70</td>
<td>30</td>
<td>150</td>
<td>250</td>
</tr>
<tr>
<td>Households</td>
<td>80</td>
<td>180</td>
<td>40</td>
<td>300</td>
</tr>
<tr>
<td>Total Input ($)</td>
<td>220</td>
<td>250</td>
<td>300</td>
<td></td>
</tr>
</tbody>
</table>

IO table in value terms, when P(wheat)=$2, P(cloth)=$5, P(labor)=$1

$300 is value of services supplied by households. It is national income, which equals to sum of payments made by each sector to households (3rd row).

Total value of inputs used by each sector
Total value of output
Input – Output tables

*input coefficients*

<table>
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<th>Manufacture</th>
<th>Households</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>0.25=25/100</td>
<td>0.40</td>
<td>0.133</td>
<td></td>
</tr>
<tr>
<td>Manufacture</td>
<td>0.14</td>
<td>0.12</td>
<td>0.10=30/300</td>
<td></td>
</tr>
<tr>
<td>Households</td>
<td>0.80</td>
<td>3.6=180/50</td>
<td>0.133</td>
<td></td>
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</tbody>
</table>

Input coefficients of one sector product into another sector.

e.g. to produce 1 unit of manufacturing output
  0.4 units of agricultural output
  0.12 units of manufacturing output, and
  3.6 units of household services are needed.
Input – Output tables

Capital and labor requirements for $1mln worth of cars

<table>
<thead>
<tr>
<th>Industry</th>
<th>Output requirements ($1000)</th>
<th>Requirements per $1mln of output of industry listed on left</th>
<th>Requirements per $1mln of final output of cars</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capital ($1000)</td>
<td>Labor (man-years)</td>
<td>Capital ($1000)</td>
</tr>
<tr>
<td>Cars</td>
<td>1,457</td>
<td>566</td>
<td>60</td>
</tr>
<tr>
<td>Iron &amp; steel</td>
<td>235</td>
<td>1,026</td>
<td>78</td>
</tr>
<tr>
<td>Nonferrous metals</td>
<td>79</td>
<td>1,002</td>
<td>56</td>
</tr>
<tr>
<td>Chemicals</td>
<td>58</td>
<td>593</td>
<td>50</td>
</tr>
<tr>
<td>Textile</td>
<td>39</td>
<td>494</td>
<td>111</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td>2,105</td>
</tr>
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</table>
### Input – Output tables

*Capital and labor requirements per $1mln worth of U.S. exports & import substitutes*

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U.S. imports were about 30% more K-intensive than U.S. exports.
Possible Explanation #1

Data validity

- Boris Swerling (1953) criticized that 1947 was not a typical year: the postwar recovery was not yet finished.
- That is why in 1956 Leontief repeated the test for U.S. 1951 trade data. This time imports were just 6% more K-intensive than exports \( (K/L_M = 1.06 K/L_X) \). But the Paradox still existed.

‘... exports from Europe was still 1/3 below, that from North America ... more than 100% above, the prewar level. ... close to half of [U.S. exports] were financed by grants and credits under various foreign aid programs. Surely any conclusions about the structure of [U.S. trade] based on 1947 trade data can be accepted only with reservations’.

B. Swerling (1954)
Possible Explanation #2

**U.S. Labor’s higher efficiency**

- Leontief himself explained the Paradox by claiming that U.S. labor is 3 times more efficient.
- In that case U.S. is labor (not capital) abundant and Leontief findings are consistent with HO predictions.
- Note: This higher efficiency should be due not to higher K/L ratio, because, as per HO assumptions, countries share the same technologies.

... one man-year of American labor is equivalent to, say, three man-years of foreign labor. Leontief (1953)
According to Leontief, higher efficiency was due to ‘entrepreneurship, superior organization, and favorable environment’, i.e. economic incentives available in the U.S.

But, if economic incentives increased the productivity of U.S. labor, they should have increased also the productivity of U.S. capital.

It is reasonable to argue, that U.S. labor efficiency is higher, but data is not supporting so much difference.

Reasonable difference is estimated to be between 20% to 25%, not 3 times (Kreinin, 1965).

"Leontief paradox“ cannot be explained by reference to the relative superiority of U.S. labor.          Kreinin (1965)
Possible Explanation #3

*Demand reversal*

- When the K-abundant country strongly prefers K-intensive good, then the K-abundant country will export the L-intensive good because it has relative cost advantage in it.
- But studies suggest that international consumption patterns are similar (at least in developed world).
- Besides, when income increases, demand rises more for L-intensive (e.g. services), than for K-intensive goods.

*Data do seem to indicate that there are more similarities than differences in tastes across countries.*

Selvanathan (2012)
Possible Explanation #4

**Factor intensity reversal**

- FIR occurs when a good is K-intensive in one country, but L-intensive in another.
- When relative factor prices are drastically different, then a good may be produced by a L-intensive process in the L-rich country and by a K-intensive process in the K-rich country.
- E.g. cotton production is L-intensive in Uzbekistan, but K-intensive in the U.S.
Possible Explanation #4

*Factor intensity reversal*

- So, when U.S. imports cotton, as per Leontief’s test method, it seems the import is K-intensive, though actually it is L-intensive.
- If FIR is commonplace, then the Paradox always occurs in at least one of two trading countries.
- But empirical studies don’t show strong evidence for FIR (Kurokawa, 2011).

*FIR is* much less important empirically than it is interesting theoretically.  
*Samuelson (1951)*
Definite critique of the Paradox

*Leontief’s test was wrong!!!*

- In 1980 Edward Leamer showed that K/L ratios not in exports & imports but in production and consumption should be compared.

- Leamer’s critique was based on Heckscher-Ohlin-Vanek model.
Heckscher-Ohlin-Vanek Model

*The central point: Not trade in goods, but trade in factor services.*

- Many countries (i=1,...,C), goods (j=1,...,G), factors (k=1,...,F).
- Technologies are identical, CRS.
- Factor prices are equalized under free trade.
- Tastes are identical and homothetic.

- Matrix $A = [a_{jk}]'$ (F×G) denotes unit input requirements:

$$A = \begin{bmatrix}
a_{L1} & a_{L2} & a_{L3} \\
a_{K1} & a_{K2} & a_{K3} \\
a_{T1} & a_{T2} & a_{T3}
\end{bmatrix} \quad A = \begin{bmatrix}1.5 & 2 & 0.5 \\
3 & 1.3 & 8 \\
6 & 4.3 & 0.2\end{bmatrix}$$

*Homothetic preferences – when relative prices are constant, the consumption of each good changes by the same rate as income, i.e. consumption shares do not change.*
Heckscher-Ohlin-Vanek Model

The central point: Not trade in goods, but trade in factor services.

- Output vector: \( Y^i \) (G×1).
- Demand vector: \( D^i \) (G×1).
- Net exports vector: \( T^i = Y^i - D^i \)

\[
Y^i = \begin{bmatrix} 100 \\ 50 \\ 80 \end{bmatrix}, \quad D^i = \begin{bmatrix} 70 \\ 110 \\ 70 \end{bmatrix} \quad \Rightarrow T^i = \begin{bmatrix} 30 \\ -60 \\ 10 \end{bmatrix}
\]

- **Factor content of trade:** \( F^i = AT^i \) (F×1 vector)

\[
F^i = AT^i = \begin{bmatrix} 1.5 & 2 & 0.5 \\ 3 & 1.3 & 8 \\ 6 & 4.3 & 0.2 \end{bmatrix} \times \begin{bmatrix} 30 \\ -60 \\ 10 \end{bmatrix} = \begin{bmatrix} -70 \\ 92 \\ -76 \end{bmatrix}
\]

Country i imports labor and land services, exports capital services.

\[
AT^i = \begin{bmatrix} \frac{F^L_i}{F^i} \\ \frac{F^K_i}{F^i} \\ \frac{F^T_i}{F^i} \end{bmatrix}
\]

if \( F^K_i > 0 \), then country i exports resource K.
Heckscher-Ohlin-Vanek Model

*The central point: Not trade in goods, but trade in factor services.*

- Our goal is to explain

how the factor content of trade relates to factor endowment.
Heckscher-Ohlin-Vanek Model

*The central point: Not trade in goods, but trade in factor services.*

\[
T^t = Y^t - D^t \quad \text{and} \quad AT^t = AY^t - AD^t
\]

- \(AY^t\) - Demand for factors

As Full Employment, then \(AY^i\) = Endowment: \(V^i\)

\[
AY^i = V^i
\]

\[
AY^i = \begin{bmatrix} 1.5 & 2 & 0.5 \\ 3 & 1.3 & 8 \\ 6 & 4.3 & 0.2 \end{bmatrix} \times \begin{bmatrix} 100 \\ 50 \\ 80 \end{bmatrix} = \begin{bmatrix} 290 \\ 1005 \\ 831 \end{bmatrix} = V^i
\]

The country is endowed with 290 units of labor, and that much labor is needed to produce 100, 50, 80 units of goods 1, 2, 3.
Heckscher-Ohlin-Vanek Model

*The central point: Not trade in goods, but trade in factor services.*

\[ T^i = Y^i - D^i \quad AT^i = AY^i - AD^i \quad AY^i = V^i \]

- As tastes are identical and homothetic, and
- Factor prices are equalized,
  
  *consumption vectors* of all countries are *proportional*.

\[ D^i = s^i D^W \quad s^i \text{ – share of country } i \text{ in world consumption.} \]
\[ D^W \text{ – world consumption vector.} \]

\[ AD^i = s^i AD^W \quad D^W = Y^W \quad \text{world consumption is necessarily equal to world production.} \]
\[ s^i AD^W = s^i AY^W \text{ as Full Employment} \]
\[ AY^W = V^W \quad V^W \text{ world endowment.} \]
\[ AD^i = s^i V^W \]
\[ F^i = V^i - s^i V^W \]
Heckscher-Ohlin-Vanek Model

The central point: Not trade in goods, but trade in factor services.

\[ F_i = V_i - s_i V^W \]

- for individual factors \[ R_k^i = V_k^i - s_i V^W \]
- **country is k-abundant** if \( R_k^i > 0 \) that is \( V_k^i / V^W_k > s_i \)
- **country is k-abundant** if country i’s endowment with factor k relative to the world endowment is higher than country i’s share in world consumption.
- if country is k-abundant, then **factor content of trade is positive** \( (R_k^i > 0) \).
Heckscher-Ohlin-Vanek Model

The central point: Not trade in goods, but trade in factor services.

\[ F_H^i = K^t - s^t K^W \]
\[ F_L^i = L^t - s^t L^W \]
\[ \frac{K^t}{K^W} > \frac{L^t}{L^W} \]

**Leamer's theorem**

\[ \frac{K^i}{L^i} \geq \frac{(K^i - F_H^i)}{(L^i - F_L^i)} \]

\[ K^W = (K^t - F_H^i)/s^t \]
\[ L^W = (L^t - F_L^i)/s^t \]
\[ K^t/K^W = s^t K^i/(K^t - F_H^i) \]
\[ L^t/L^W = s^t L^i/(L^t - F_L^i) \]

China population: 1.357 billion
World population: 7.137 billion
China’s share: 19%

China GNI: 10.8 T
World GNI: 73.4 T
China’s share: 14.7%
Heckscher-Ohlin-Vanek Model

The central point: Not trade in goods, but trade in factor services.

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Leamer's theorem

\[
\frac{K^i}{L^i} > \frac{(K^i - F^i_K)}{(L^i - F^i_L)}
\]

<table>
<thead>
<tr>
<th></th>
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<th>Consumption</th>
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<tbody>
<tr>
<td>Capital ($ bln.)</td>
<td>327</td>
<td>305</td>
</tr>
<tr>
<td>Labor (mln. man-years)</td>
<td>47</td>
<td>45</td>
</tr>
<tr>
<td>K/L ($1000 / man-year)</td>
<td>6.946</td>
<td>6.737</td>
</tr>
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References


Thank you and take care,

but remember

The roots of education are bitter, but the fruit is sweet.

Aristotle