Factor Proportion Empirics

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Today's lecture

Tests of the Heckscher-Ohlin model

- Leontief (1953) and Leamer (1980)
- Bowen, Leamer and Sveikauskas (1987)
- Trefler (1993)
- Trefler (1995)

The factor content of trade

Recall: the Heckscher-Ohlin-Vanek Theorem

- Vector of net export flows: $t^c = y^c - d^c$
- Net factor content of trade: $F^c = A^c t^c$, which implies

$$A^c(w^c)t^c = v^c - A^c(w^c)\alpha^c(p^c)Y^c$$

- Where $\alpha^c(p^c)$ is the expenditure share on each good
- If we have free trade ($p^c = p$), identical technology ($A^c = A$), indentical test ($\alpha^c = \alpha$), and factor endowments inside the FPE set so FPE holds ($w^c = w$), then HOV equalition simplify to:

$$F^c \equiv A(w)t^c = v^c - s^c v^w$$

Test of HO model: An side

To perform a complete test need data on

- trade (t^i)
- technology (A)
- endowment (v^i)

Not available until quite recently, so a lot of tests were "incomplete"

Test of HO model: An side

In reality, production uses intermediates:

- This means (for example) that the capital content of shoe production includes not only the direct use of capital in making shoes, but also the indirect use of capital in making all upstream inputs to shoes (like rubber).
- Let A(w) be the input-output matrix for commodity production. And let $B(w)$ be the matrix of direct factor inputs.
- Then, if we assume that only final goods are traded (it takes some algebra, due to Leontief, to show that) the only change we have to make to the HOV theorem is to use $\bar{B}(w) \equiv B(w)(I - A(w))^{-1}$ in place of $A(w)$ above.

Test on HOV equations

How do we test $\bar{B}(w)t^c = v^c - s^c v^w$?

- This is really a set of vector equations (one element per factor k).
- So there is one of these predictions per country c and factor k.
- There are of course many things one can do with these predictions, so many different tests have been performed.

Leontief (1953) and Leamer (1980)

Leontief's Paradox

- The firrst work based on the NFCT was in Leontief (1953)
- Circa 1953, Leontief had just computed (for the first time), the input-output table (which delivers $A_{US}(w_{US})$ and $B_{US}(w_{US})$) for the 1947 US economy.

Leontief's Paradox

Leontief then argued as follows:

- Leontief's table only had k and l inputs (and 2 factors was the bare minimum needed to test the HOV equations).
- He used $\bar{B}^{US}(w^{US})$ to compute the k/l ratio of US exports: $F^{US}_{k/l,t} \equiv \bar{B}(w)_{k/l} t^{US} = 13{,}700$ per worker.
- He didn't have $\bar{B}^{c}(w^{c})$ for all (or any!) countries that export to the US (to compute the factor content of US imports), so he applied the standard HO assumption that all countries have the same technology and face the same prices and that FPE and FPI hold. Hence: $\bar{B}^{US}(w^{US}) = \bar{B}^{c}(w^{c}), \forall c$
- He then used $\bar{B}^{US}(w^{US})$ to compute the k/l ratio of US imports: $F^{US}_{k/l,m} \equiv \bar{B}(w)_{k/l} m^{US} = 18{,}200$ per worker.

The fact that $F^{US}_{k/l,m} > F^{US}_{k/l,t}$ was a bit surprise, as everyone assumed the US was relatively K-endowed relative to the world as a whole.

Leamer (JPE, 1980)

Leamer (1980) pointed out that Leontief's application of HO theory, while intuitive, was wrong if either trade is unbalanced, or there are more than 2 factors in the world.

- Either of these conditions can lead to a setting where the US exports both k and l services—which is impossible in a balanced trade, 2-factor world. It turns out that this is exactly what the US was doing in 1947.

In particular, Leamer (1980) showed that the intuitive content of HO theory really says that:

- $\frac{K^{US}}{L^{US}} > \frac{K^{US}-F_k^{US}}{L^{US}-F_l^{US}}$, where $F_i^{US} \equiv \bar{B}(w)_i t^{US}$ is the factor content of US net exports in factor i.
- This just takes a ratio of HOV equations, for two factors (k and l). HOV equations just say that, for any factor, the factor content of production has to be greater than the factor content of consumption.
- But HOV does not necessarily say that the factor content of exports should exceed the factor content of imports, as Leontief (1953) had tested.

Bowen, Leamer and Sveikauskas (1987)

Bowen, Leamer and Sveikauskas (1987)

"**Sign test**"

$$\text{sign}(F_f^c) = \text{sign}(v_f^c - s^c v_f^w)$$

"**Rank test**"

$$F_k^c > F_l^c \Rightarrow v_k^c - s^c v_k^w > v_l^c - s^c v_l^w$$

Bowen, Leamer and Sveikauskas (1987)

Data for 27 countries, 12 factors

Sign test: ok in about 61 % of the cases

Rank test... 49 % of the cases

$\rightarrow$ Very disappointing... purely random pattern of trade would give you 50 % of good matches...

Why such a failure?

Bowen, Leamer and Sveikauskas (1987)

TABLE 2—SIGN AND RANK TESTS, FACTOR BY FACTOR

Factor	Sign Test[a]	Rank Tests[b]	
Capital	.52	0.140	.45
Labor	.67	0.185	.46
Prof/Tech	.78	0.123	.33
Managerial	.22	−0.254	.34
Clerical	.59	0.134	.48
Sales	.67	0.225	.47
Service	.67	0.282[c]	.44
Agricultural	.63	0.202	.47
Production	.70	0.345[c]	.48
Arable	.70	0.561[c]	.73
Pasture	.52	0.197	.61
Forest	.70	0.356[c]	.65

[a] Proportion of 27 countries for which the sign of net trade in factor matched the sign of the corresponding factor abundance.

[b] The first column is the Kendall rank correlation among 27 countries; the second column is the proportion of correct rankings out of 351 possible pairwise

Bowen, Leamer and Sveikauskas (1987)

TABLE 3—SIGN AND RANK TESTS, COUNTRY BY COUNTRY

Country	Sign Tests[a]	Rank Tests[b]	
Argentina	.33	0.164	.58
Australia	.33	−0.127	.44
Austria	.67	0.091	.56
Belgium-Luxembourg	.50	0.273	.64
Brazil	.17	0.673[c]	.86
Canada	.75	0.236	.64
Denmark	.42	−0.418	.29
Finland	.67	0.164	.60
France	.25	0.418	.71
Germany	.67	0.527[c]	.76
Greece	.92	0.564[c]	.80
Hong Kong	1.00	0.745[c]	.89
Ireland	.92	0.491[c]	.76
Italy	.58	0.345	.69
Japan	.67	0.382	.71
Korea	.75	0.345	.69
Mexico	.92	0.673[c]	.86
Netherlands	.58	−0.236	.38
Norway	.25	−0.236	.38
Philippines	.50	0.527[c]	.78
Portugal	.67	0.091	.56
Spain	.67	0.200	.62
Sweden	.42	0.200	.62
Switzerland	.67	0.382	.69
United Kingdom	.92	0.527[c]	.78
United States	.58	0.309	.67
Yugoslavia	.83	−0.055	.49

[a]Proportion of 12 factors for which the sign of net trade in factor matched the sign of the corresponding excess supply of factor.

[b]The first column is the Kendall rank correlation among 11 factors (total labor excluded); the second column is the proportion of correct rankings out of 55 possible pairwise comparisons.

[c]Statistically significant at the 5 percent level.

Trefler (1993)

Trefler (1993)

- Starting point: HOV assumptions are violated
  - no FPE (at all!)
  - Different technologies across countries
- Leontieff himself suggested that his "paradox" could be explained by productivity differences
- Not strictly speaking a test of HOV, but shows that Leontieff may be right: productivity differences can explain the failure of the empirical tests of HOV

Trefler (1993)

- All factors can differ in their productivity (USA is chosen as a benchmark; productivity 1 for all factors)

- **Effective endowment** of factor f in country c is therefore:

  $\widetilde{v}_f^c = \pi_f^c v_f^c$ where π_f^c is the productivity of factor f

- No more FPE equalization but "conditional FPE"

- Let $\widetilde{F}^c \equiv \widetilde{A} t^c$, $\widetilde{A}$ is the effective factor adjusted technology matrix :

$$\widetilde{F}_f^c = \pi_f^c v_f^c - s^c \sum_{j=1}^{C} \pi_f^j v_f^j, \quad f = 1, ..F; c = 1, ..., C \tag{1}$$

$$\frac{w_f^c}{\pi_f^c} = \frac{w_f^{c'}}{\pi_f^{c'}}, \quad f = 1, ..F; c, c' = 1, ..., C \tag{2}$$

Trefler (1993)

Data for year 1983, for 33 countries, 10 factors

Uses equation (1) to compute the π_f^c, i.e. technology / productivity parameters

In doing so, cannot assess the fit of the model with the trade / endowment data but:

- If the π_f^c are negative, bad fit
- Can test for FPE

Trefler (1993)

- Conditional Factor Prices equalization approximately hold

  - For labor $\ln w_l^c = -0{,}18 + 0{,}678 \ln \pi_l^c \qquad R^2 = 0{,}9$

  ($R^2 = 0{,}6$ for capital)

  - Smaller correlation for capital: measurement problems

- Is it consistent with Leontief idea?

Trefler (1993)

FACTOR PRICES AND THE π_{fc} FOR CAPITAL AND AGGREGATE LABOR

Aggregate Labor			Capital			
Country	$\pi_{Lc}/\pi_{L,\mathrm{US}}$ (1)	$w_{Lc}/w_{L,\mathrm{US}}$ (2)	Country	$\pi_{Kc}/\pi_{K,\mathrm{US}}$ (3)	$w_{Kc}/w_{K,\mathrm{US}}$ (4)	$\alpha\pi_{Kc}/\pi_{K,\mathrm{US}}$ (5)
Bangladesh	.02	.05	Sri Lanka	.13	.22	.22
Sri Lanka	.04	.07	Indonesia	.26	.39	.43
Pakistan	.04	.11	Portugal	.31	.86	.52
Indonesia	.05	.19	Yugoslavia	.31	.88	.52
Thailand	.05	.14	Panama	.34	.75	.56
Portugal	.20	.29	Singapore	.34	.97	.57
Colombia	.22	.29	Thailand	.41	.67	.68
Yugoslavia	.22	.22	Uruguay	.42	.51	.70
Uruguay	.22		Trinidad	.43	.86	.73
Panama	.25	.26	Greece	.45	.97	.77
Greece	.35	.37	Ireland	.49	1.00	.83
Hong Kong	.42	.26	Colombia	.50	.62	.84
Ireland	.46	.56	Pakistan	.50	.69	.84
Spain	.47	.56	Israel	.52	.90	.88
Trinidad	.51		Italy	.53	.95	.89

Trefler (1993)

Singapore	.54	.34	Spain	.53	.91	.90
New Zealand	.64	.84	Hong Kong	.53	1.18	.90
Austria	.64	.91	Austria	.56	1.06	.94
United Kingdom	.66	.70	Switzerland	.62	1.19	1.05
Japan	.66	.71	France	.63	1.07	1.06
Italy	.66	.80	Norway	.64	1.28	1.07
Israel	.67	.61	New Zealand	.64	1.17	1.07
Finland	.77	.48	Finland	.66	1.10	1.12
Denmark	.78	.76	Belgium	.66	1.11	1.12
Belgium	.81	.74	Japan	.67	1.27	1.12
Sweden	.82	.68	West Germany	.68	1.10	1.15
France	.84	.57	Denmark	.72	1.13	1.22
Canada	.84	1.08	Canada	.75	.98	1.27
Norway	.85	.65	Netherlands	.77	1.15	1.29
West Germany	.86	.72	United Kingdom	.84	1.22	1.41
Netherlands	.88	.86	Bangladesh	.94	.78	1.58
United States	1.00	1.00	Sweden	.97	1.63	1.64
Switzerland	1.04	.94	United States	1.00	1.00	1.68
Mean	.53	.54	Mean	.57	.96	.96
Correlation	.90		Correlation	.68		
Rank correlation	.86		Rank correlation	.71		

NOTE.—Col. 5 is col. 3 multiplied by α = .96/.57. This ensures that col. 5 has the same mean as col. 4.

Trefler (1993)

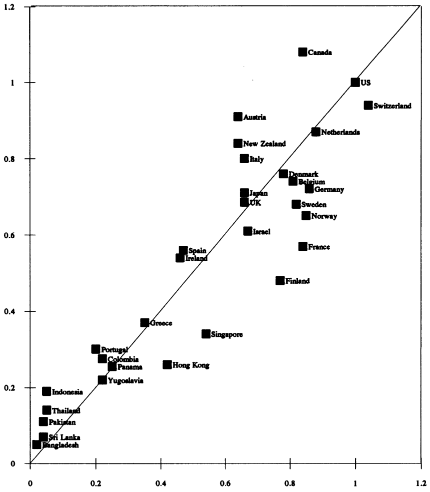

FIG. 1.—Wages and labor technology parameters

Trefler (1993)

THE LEONTIEF PARADOX AND HIS EXPLANATION

Factor	$\frac{[\mathbf{A^* X}_{US}]_f}{[\mathbf{A^* M}_{US}]_f}$ (1)	$\frac{F_{f,US} - \hat{F}_{f,US}}{\hat{F}_{f,US}}$ (2)	$\frac{V_{f,US}/V_{fw}}{s_c}$ (3)	$\frac{V^*_{f,US}/V^*_{fw}}{s_c}$ (4)
Capital	.84	−.95	.71	.97
Labor	.78	−.98	.54	.96
Land	2.12	−.40	1.28	1.19

NOTE.—Col. 1 reports the factor content of exports relative to the factor content of imports. Col. 2 reports deviations from the HOV theorem: $F_{f,US} = [\mathbf{A^* T}_{US}]_f$ is the factor content of U.S. trade and $\hat{F}_{f,US} = V_{f,US} - s_{US}V_{fw}$ is the endowment-based prediction of $F_{f,US}$. In the HOV theorem, a factor is defined to be abundant if its factor abundance ratio $(V_{f,US}/V_{fw})/s_{US}$ exceeds unity. In the productivity-equivalent version of the HOV theorem (eq. [4]), a factor is defined to be abundant if $(V^*_{f,US}/V^*_{fw})/s_{US}$ exceeds unity.

Trefler (1995)

Trefler (1995)

Two advances in understanding about NFCT:

- Identifies 2 key facts about the NFCT data, which isolate 2 aspects of the data in which the HOV equations appear to fail. (Previous work hadn't said much more than, 'the HOV equations fail badly in the data.')
- Explores how a number of parsimonious (as opposed to the approach in Trefler (1993) which was successful, but deliberately anything but parsimonious!) extensions to basic HO theory can improve the fit of the HOV equations.

Fact 1: "The Case of the Missing Trade"

Consider a plot of HOV deviations (defined as $\epsilon_f^c \equiv F_f^c - (v_f^c - s^c v_f^w)$) against predicted NFCT (ie $v_f^c - s^c v_f^w$): Figure 1.

- The vertical line is where $v_f^c - s^c v_f^w = 0$.
- The diagonal line is the 'zero [factor content of] trade' line: $F_f^c = 0$, or $\epsilon_f^c = -(v_f^c - s^c v_f^w)$

This plot helps us to visualize the failure of the HOV equations:

- If the 'sign test' always passed, all observations would lie in the top-right or bottom-left quadrants. (They don't.)
- If the HOV equations were correct,$\epsilon_f^c = 0$, so all observations would lie on a horizontal line. (They definitely don't.)
- Most fundamentally, the clustering of observations along the 'zero [factor content of] trade' line means that factor services trade is far lower than the HOV equations predict. Trefler (1995) calls this "the case of the missing trade."

Fact 1: "The Case of the Missing Trade"

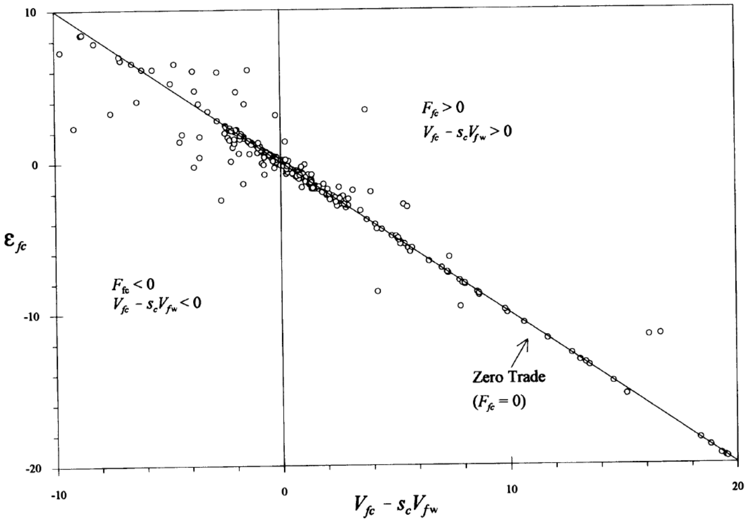

FIGURE 1. PLOT OF $\varepsilon_{fc} = F_{fc} - (V_{fc} - s_c V_{fw})$ AGAINST $V_{fc} - s_c V_{fw}$

Fact 2: "The Endowments Paradox"

Trefler (1995) then looks at HOV deviations by country: Figure 2

- Here he plots the number of times (out of 9, the total number of factors f) that $\epsilon_f^c < 0$
- Because F_f^c is so small (Fact 1), this is mirrored almost one-for-one in $v_f^c - s^c v_f^w > 0$ (i.e. country c is abundant in factor f)

The plot helps us to visualize another failing of the HOV equations:

- Poor countries appear to be abundant in all factors.
- This can't be true with balanced trade, and it is not true (in Trefler's sample) that poor countries run higher trade imbalances.
- So this must mean that there is some omitted factor that tends to be scarce in poor countries.
- A natural explanation (a la Leontieff) is that some factors are not being measured in 'effective (ie productivity-equivalent) units'.

Fact 2: "The Endowments Paradox"

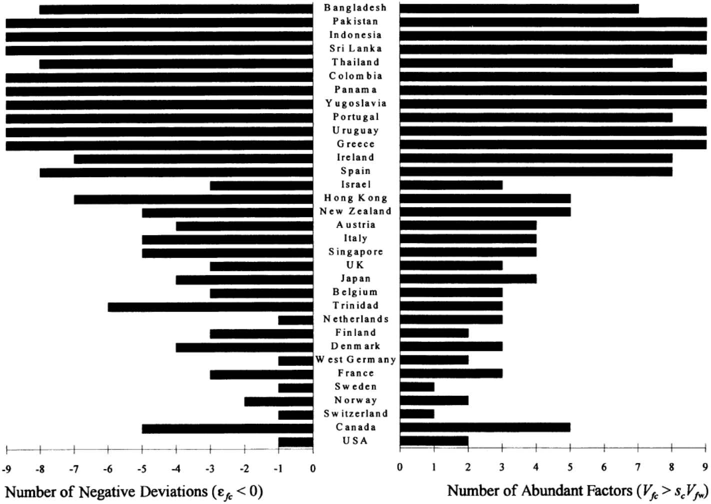

FIGURE 2. DEVIATIONS FROM HOV AND FACTOR ABUNDANCE

Trefler (1995): Altering the Simple HO Model I

Trefler (1995) then (extending an approach initially pursued in BLS,1987) seeks alterations to the simple HO model that:

- Are parsimonious (ie they use up only a few parameters, unlike in Trefler (1993)).
- Have estimated parameters that are economically sensible (analogous to considerations in Trefler (1993)).
- Can account for Facts 1 and 2.
- Fit the data well (in a 'goodness-of-fit sense): eg success on sign/rank tests.
- Fit the data best (in a likelihood or model selection sense) among the class of alterations tried. (But the 'best' need not fit the data 'well').

Trefler (1995): Altering the Simple HO Model II

The alterations that Trefler tries are:

- T1: restrict π_f^c in Trefler (1993) to $\pi_f^c = \delta^c$. ('Neutral technology differences').
- T2: restrict π_f^c in Trefler (1993) to $\pi_f^c = \delta^c \phi_f$ for less developed countries ($y^c < \kappa$, where κ is to be estimated too) and $\pi_f^c = \delta^c$ for developed countries.
- C1: allow the s^c terms to be adjusted to fit the data (this corrects for countries' non-homothetic tastes for investment goods, services and non-traded goods).
- C2: Armington Home Bias: Consumers appear to prefer home goods to foreign goods (tastes? trade costs?). Let α_c^* be the 'home bias' of country c.
- TC2: $\delta_c = y_c / y_{US}$ and C2.

Trefler (1995)

By most tests, TC2 (neutral technological differences with Armington home bias) does best. Sign test is nearly perfectly accurate, mysteries improved considerably.

TABLE 1—HYPOTHESIS TESTING AND MODEL SELECTION

	Description		Likelihood		Mysteries		Goodness-of-fit	
Hypothesis	Parameters (k_i)	Equation	$\ln(L_i)$	Schwarz criterion	Endowment paradox	Missing trade	Weighted sign	$\rho(F, \hat{F})$
Endowment differences								
H_0: unmodified HOV theorem	(0)	(1)	−1,007	−1,007	−0.89	0.032	0.71	0.28
Technology differences								
T_1: neutral	δ_c (32)	(4)	−540	−632	−0.17	0.486	0.78	0.59
T_2: neutral and nonneutral	ϕ_f, δ_c, κ (41)	(6)	−520	−637	−0.22	0.506	0.76	0.63
Consumption differences								
C_1: investment/services/ nontrade.	β_c (32)	(7)	−915	−1,006	−0.63	0.052	0.73	0.35
C_2: Armington	α_c^* (24)	(11)	−439	−507	−0.42	3.057	0.87	0.55
Technology and consumption								
TC_1: $\delta_c = y_c/y_{US}$	(0)	(4)	−593	−593	−0.10	0.330	0.83	0.59
TC_2: $\delta_c = y_c/y_{US}$ and Armington	α_c^* (24)	(12)	−404	−473	0.18	2.226	0.93	0.67

Notes: Here k_i is the number of estimated parameters under hypothesis i. For "likelihood," $\ln(L_i)$ is the maximized value of the log-likelihood function, and the Schwarz-model selection criterion is $\ln(L_i) - k_i \ln(297)/2$. Let $\hat{F}_{fc}$ be the predicted value of F_{fc}. The "endowment paradox" is the correlation between per capita GDP, y_c, and the number of times $\hat{F}_{fc}$ is positive for country c (see Fig. 2). "Missing trade" is the variance of F_{fc} divided by the variance of $\hat{F}_{fc}$ (see Fig. 1). "Weighted sign" is the weighted proportion of observations for which F_{fc} and $\hat{F}_{fc}$ have the same sign. Finally, $\rho(F, \hat{F})$ is the correlation between F_{fc} and $\hat{F}_{fc}$. See Section V for further discussion.

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