14.581 MIT PhD International Trade —Lecture 8: The Ricardo-Viner and Heckscher-Ohlin Models (Empirics Part II)—

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Plan of Today's Lecture

1. Tests of the Heckscher-Ohlin model, continued:
   1.1 Factor Content of Trade Tests
      1.1.1 Leontief (1953) and Leamer (1980)
      1.1.2 Bowen, Leamer and Sveikauskas (1987)
      1.1.3 Trefler (1993)
      1.1.4 Trefler (1995)
      1.1.5 Davis, Weinstein, Bradford and Shimpo (1997)
      1.1.6 Davis and Weinstein (2001)
   1.2 Brief Discussion of Other Tests

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The (Net) Factor Content of Trade

Recall: the Heckscher-Ohlin-Vanek Theorem

- Now we consider the case of $G \geq F$. As we discussed in the theory lecture, in this case factor market clearing conditions lead to:

$$A^c(w^c)T^c = V^c - A^c(w^c)\alpha^c(p^c)Y^c$$

- Where $\alpha^c(p^c)$ is the expenditure share on each good.

- If we also have free trade ($p^c = p$), identical technologies ($A^c(.) = A(.)$), identical tastes ($\alpha^c(.) = \alpha(.)$), and factor endowments inside the FPE set so FPE holds ($w^c = w$), then this simplifies dramatically to the HOV equations:

$$A(w)T^c = V^c - s^c V^w.$$

Constructing the NFCT: An Aside

- In reality, production uses intermediates:
  - So the (say) 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 (ie amount of rubber in a shoe). And let $B(w)$ be the matrix of direct factor inputs (ie the amount of labor in rubber and amount in a shoe).
  - 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 is to use $\bar{B}(w) \equiv B(w)(I - A(w))^{-1}$ in place of $A(w)$ above.
    - Trefler and Zhu (2010) show that the 'only final goods are traded' assumption is not innocuous.

Testing the 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 many things one can do with these predictions, so many different tests have been performed.

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Leontief's Paradox

- The first work based on the NFCT was in Leontief (1953)
- Leontief had just computed (for the first time), the input-output table (ie $A^{US}(w^{US})$ 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: $F^{US}_{K/L,X} \equiv \bar{B}^{US}(w^{US})X^{US} = \$13,700$ per worker.
  - He didn't have $\bar{B}^{US}(w^{US})$ for all (or any!) countries that export to the US (to compute the factor content of US imports), so he applied the assumption of HO that all countries have the same technology and face the same prices and that FPE and FPI hold: $\bar{B}^{US}(w^{US}) = \bar{B}^{c}(w^{c})$.
  - He then used $\bar{B}^{US}(w^{US})$ to compute the K/L ratio of US exports: $F^{US}_{K/L,M} \equiv \bar{B}^{US}(w^{US})M^{US} = \$18,200$ per worker.
- The fact that $F^{US}_{K/L,M} > F^{US}_{K/L,X}$ was a big 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 $F_k^{US} \equiv \bar{B}(w)_k T^{US}$ is the factor content of US net exports in factor k.
  - This says that the factor content of production has to be greater than the factor content of consumption.
  - But not necessarily that the factor content of exports should exceed the factor content of imports, as Leontief (1953) had tested (which would be true for 2 goods and balanced trade).

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Bowen, Leamer and Sveikauskas (1987)

- BLS (AER, 1987) continued the serious application of HOV theory to the data that Leamer (1980) started.
  - BLS (1987), along with Maskus (1985), was the first real test of the HOV equations.

- Some details:
  - BLS only observed $\bar{B}(w)$ in the US in 1967, but they applied the HO assumption that $\bar{B}(w)$ is the same for all other countries in 1967 as it is in the US in 1967.
  - BLS noted that there is one HOV equation per country and factor: $C \times F$ equations, so $C \times F$ tests.
  - BLS had data on 12 factors and 27 countries

BLS (1987): Tests

- But how to test $\bar{B}(w)T^c = V^c - s^c V^w$?
  - They should hold with equality and most certainly do not.
  - Not even for the US! This should really worry us, since $\bar{B}(w)$ was calculated for the US, so it should (and does, more or less) predict *output* at least as an identity.

- BLS propose two tests:
  1. Sign tests: How often is it true that $\text{sign}\{F_k^c\} = \text{sign}\{V_k^c - s^c V_k^w\}$? Only 61 % of the time (not much better than a coin toss).
  2. Rank tests: How often is it true that if $F_k^c > F_{k'}$ then $(V_k^c - s^c V_k^w) > (V_{k'}^c - s^c V_{k'}^w)$? Only 49 % of the time!

- This was considered to be a real disappointment. Maskus (1985) made a similar point, and put it well: The Leontief Paradox is not a paradox, but rather a "commonplace"!

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Trefler (JPE, 1993)

- Trefler (1993) and Trefler (AER, 1995) extended this work in an important direction, by dropping the assumption that technologies are the same across countries.
  - Trefler (1993) in particular allowed countries to have different technologies in a *very* flexible manner.
- This is not only realistic, but also allows the HO model to be reconciled with the clear failure of FPE in the data.
- The key challenge was to incorporate productivity differences in a coherent, theory-driven way in which all of the attractions of the HO model would still hold, even though technologies differ across countries.

An Aside on Non-FPE

Leamer (JEL, 2007) has a nice way of viewing this...

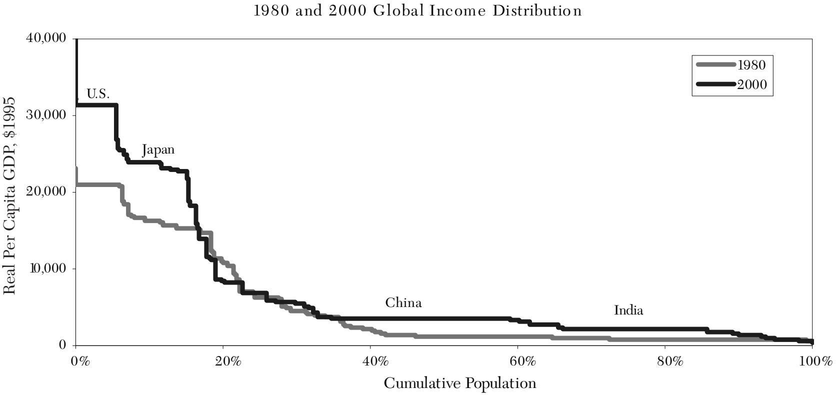

Figure 7. Global Labor Pools in 1980 and 2000

Trefler (1993): Set-up I

- Trefler (1993) adds factor- and country-specific productivity shifters (π_{ck}) to an otherwise standard HO model.
  - This is closely related to Leontief's preferred explanation for his 'paradox': The US is not labor-abundant when you just count workers. But if you count 'equivalent productivity workers' across countries, than the US *is* labor-abundant.
  - This amounts to defining factors in 'productivity-equivalent' units: $V_{ck}^* \equiv \pi_{ck} V_{ck}$.
  - So now factor prices also have to be in 'productivity-equivalent' units: $w_{ck}^* \equiv \frac{w_{ck}}{\pi_{ck}}$
- Trefler assumes that the only production-side differences across countries are these π_{ck} terms:
  - That implies that $\bar{B}_c^*(w_c^*) = \bar{B}_{c'}^*(w_{c'}^*)$.

Trefler (1993): Set-up II

- Then Trefler shows that all of the traditional HO logic goes through in terms of V^*_{ck} and w^*_{ck} rather than V_{ck} and w_{ck}:
  - HOV: $F^*_{ck} \equiv \bar{B}^*(w^*)T^c = \pi_{ck}V_{ck} - s^c(V^*_k)^w$
  - FPE ('conditional FPE'): $w^*_{ck} = w^*_{c'k}$

Trefler (1993): Methodology I

- What can you then do with these HO predictions? The central problem is that unlike the $\bar{B}(w)$ matrix, the $\bar{B}^*(w^*)$ matrix is not observable in any country.
  - Fundamentally, the π_{ck}s are unknown.
  - In principle, we could estimate these using cross-country productivity/output data. But Trefler (1993) doesn't pursue this, for fear that such data isn't reliable enough. (Is this still binding nearly 20 yeas later?)
- Instead, Trefler *estimates* the π_{ck}s from the HOV equations.
  - It turns out that this estimation is trivial since there is a (unique) set of π_{ck} terms that make the HOV equations hold with equality (up to the normalization that one country's $\pi_{ck} = 1$ for all k; for Trefler, this country is the US).
  - So unrestricted country- and factor-specific productivity differences can make the HOV equations fit always and everywhere!

Trefler (1993): Methodology II

- Once we've estimated the $\widehat{\pi}_{ck}$ terms (which fit the HOV equations perfectly), how do we then assess the HO model?
  1. Trefler shows that there exist values of (hypothetical) data (ie T, $\bar{B}_{US}(w)$, s and V) such that some of the $\widehat{\pi}_{ck}$ terms will be *negative*. But if the estimated $\widehat{\pi}_{ck}$s are negative, this casts serious doubt on the notion that they are well-estimated productivity parameters. Reassuringly, only 10 out of 384 are negative.
  2. Further, we haven't used the FPE part of HO. So Trefler checks how well the estimated $\widehat{\pi}_{ck}$ terms (estimated off of trade data) bring about 'conditional FPE' (ie adjust observed factor prices, which don't satisfy FPE, so that the constructed w^*_{ck}s come closer to satisfying FPE). See Figure 1 below.
  3. Other sensible restrictions: eg, we tend to think that the US is more productive than most countries, so the $\widehat{\pi}_{ck}$ terms should be less than one most of the time. Reassuringly, this is true.

Trefler (1993): Results

The estimated π_{ck}s (for k as labor) correlate very well with relative wages

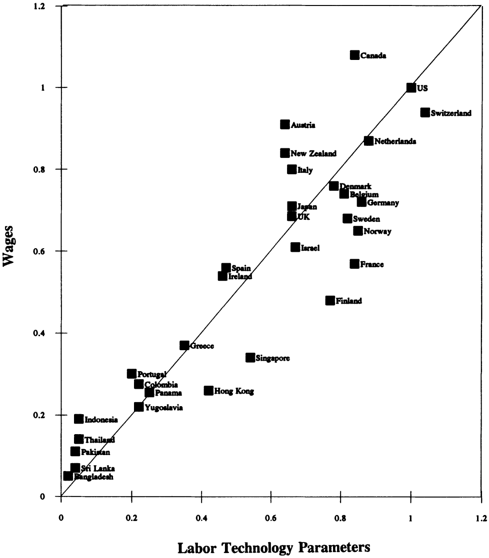

FIG. 1.—Wages and labor technology parameters

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Trefler (AER, 1995)

- Trefler (1995) provides two advances in understanding about NFCT:

    1. He 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.')

    2. He explores how a number of parsimonious (as opposed to the approach in Trefler (1993) which was successful, but 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 $\varepsilon_{ck} \equiv F_{ck} - (V_{ck} - s^c V_k^w)$) against predicted NFCT (ie $V_{ck} - s^c V_k^w$): Figure 1.
    - The vertical line is where $V_{ck} - s^c V_k^w = 0$.
    - The diagonal line is the 'zero [factor content of] trade' line: $F_{ck} = 0$, or $\varepsilon_{ck} = -(V_{ck} - s^c V_k^w)$.

- 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. But they don't.
    - If the HOV equations were correct, $\varepsilon_{ck} = 0$, so all observations would lie on a horizontal line. But 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”

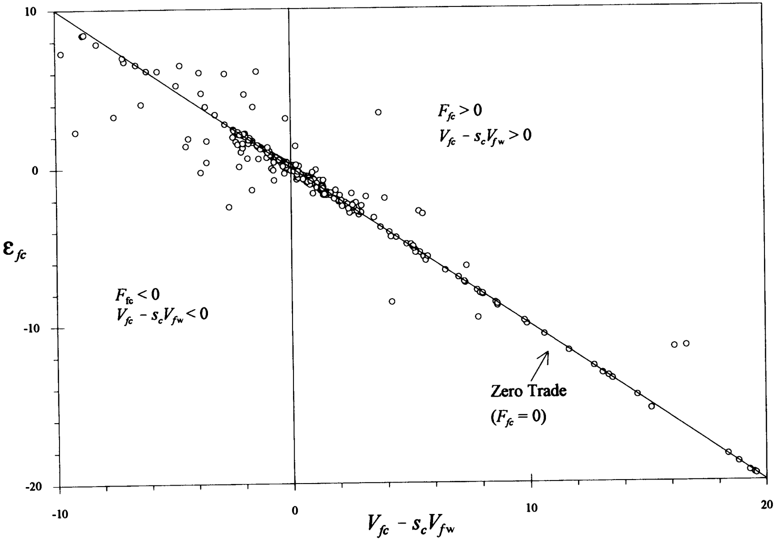

FIGURE 1. PLOT OF $\varepsilon_{fc} = F_{fc} - (V_{fc} - s_c V_{fw})$ AGAINST $V_{fc} - s_c V_{fw}$

Fact 2: “The Endowments Paradox”

- Trefler (1995) then looks at HOV deviations by country in Figure 2.
  - Here he plots the number of times (out of 9, the number of factors k) that $\varepsilon_{ck} < 0$.
  - Because F_{ck} is so small, this is mirrored almost one-for-one in $V_{ck} - s^c V_k^w > 0$ (ie country c is abundant in factor k).

- 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 is that some factors are not being measured in ‘effective (ie productivity-equivalent) units’.

Fact 2: "The Endowments Paradox"

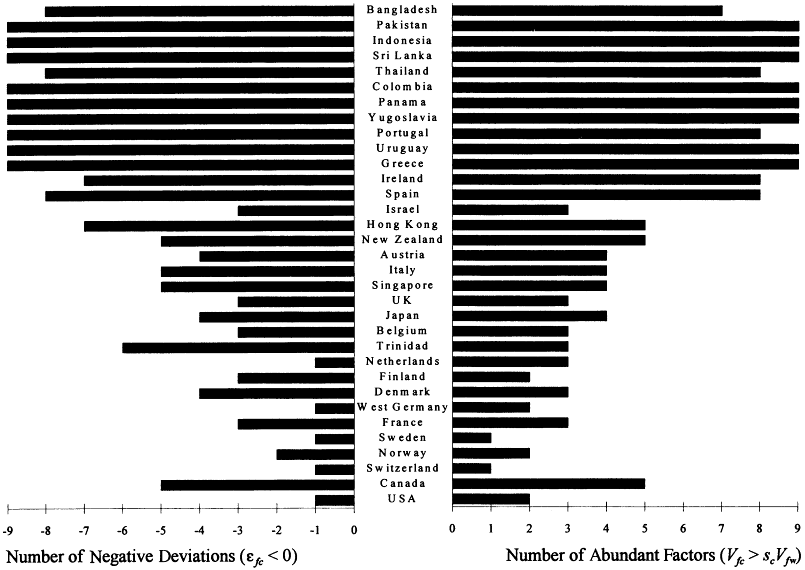

FIGURE 2. DEVIATIONS FROM HOV AND FACTOR ABUNDANCE

Trefler (1995): Altering the Simple HO Model I

- Trefler 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:

  1. T1: restrict π_{ck} in Trefler (1993) to $\pi_{ck} = \delta_c$. ('Neutral technology differences').
  2. T2: restrict π_{ck} in Trefler (1993) to $\pi_{ck} = \delta_c \phi_k$ for less developed countries ($y^c < \kappa$, where κ is to be estimated too) and $\pi_{ck} = \delta_c$ for developed countries.
  3. 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).
  4. 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.
  5. TC2: $\delta_c = y_c / y_{US}$ and C2.

Trefler (1995): Results

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

Hypothesis	Description: Parameters (k_i)	Description: Equation	Likelihood: $\ln(L_i)$	Likelihood: Schwarz criterion	Mysteries: Endowment paradox	Mysteries: Missing trade	Goodness-of-fit: Weighted sign	Goodness-of-fit: $\rho(F, \hat{F})$
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.

Gabaix (1997)

- Trefler (1995)'s 'missing trade' has had a strong impact on the way that NFCT empirics has proceeded since.
- Ironically however, as Gabaix (1997) (unpublished and hard to find, but discussed in Davis and Weinstein (2003, *Handbook* survey of FCT)) pointed out, 'missing trade' makes the impressive fit of the $\widehat{\pi}_{ck}$s in Figure 1 of Trefler (1993) not that impressive after all.
    - That is, Gabaix (1997) showed that if trade is *completely* missing (ie $F_{ck} = 0$) then Trefler (1993) is finding the $\widehat{\pi}_{ck}$s such that $\widehat{\pi}_{ck} V_{ck} = s^c \sum_c \widehat{\pi}_{ck} V_{ck}$.
    - If countries are small relative to the world this approximates to: $\frac{\widehat{\pi}_{ck}}{\widehat{\pi}_{c'k}} = \frac{Y^c / V_{ck}}{Y^{c'} / V_{c'k}}$.
    - That is, the relative productivity parameters are just GDP per factor; hence Figure 1 in Trefler (1993) isn't that surprising (GDP per worker should correlate with wages!)

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Davis, Weinstein, Bradford and Shimpo (AER, 1997)

- DWBS (1997) were the first to explore a different (from Trefler (1995)) sort of 'diagnostic' exercise on the HOV equations.

- In particular, they note that statements about the NFCT are really two statements about:

    1. The FC of Production: $\bar{B}^c(w^c)y^c = V^c$
    2. The FC of Consumption (really: 'Absorption', to allow for intermediates): $\bar{B}^c(w^c)D^c = s^c V^w$.

- DWBS (1997) use data on regions within Japan to test 1 and 2 separately, to thereby shed light on whether it's the failure of 1 or 2 (if not both) that is generating 'missing trade.'

DWBS (1997): Factor Content of Production

- DWBS (1997) have data on $A^J(w^J)$, the input-output table, and $B^J(w^J)$, the primary factor use matrix, for Japan as a whole.
- Factor market clearing implies that $B^J(w^J)X^J = V^J$:
  - NB: Here, X^c is *gross output*, not value-added.
  - Note that this is not some sort of test of factor market clearing. Instead, this is an identity that must hold for the case of Japan since $B^J(w^J)$ is computed such that this is true.
  - At least, they *should* be computed this way! In the BLS (1987) data, where $B^{US}(w^{US})$ is used, it is not true that $B^{US}(w^{US})X^{US} = V^{US}$, which is worrying. The reason for this is that the $B(w)$ matrices come from statistical agencies who have their own definition of a factor (eg, how do you define and measure 'capital'?), which isn't necessarily the same definition that researchers are using to define V^c.

DWBS (1997): Factor Content of Production

- So DWBS (1997) are deliberately not interested in testing the FC of Japan's production as a whole (ie $B^J(w^J)X^J = V^J$).
- Instead they test:
  - FPE and identical technologies for the entire world: $B^J(w^J)X^c = V^c$ (using 21 other countries c).
  - FPE and identical technologies within Japan: $B^J(w^J)X^r = V^r$ (using 10 regions of Japan, r).

DWBS (1997): Factor Content of Production

This scatter plot is a row of the vector equation $B^J(w^J)X^c = V^c$, plotted for all $c \neq J$

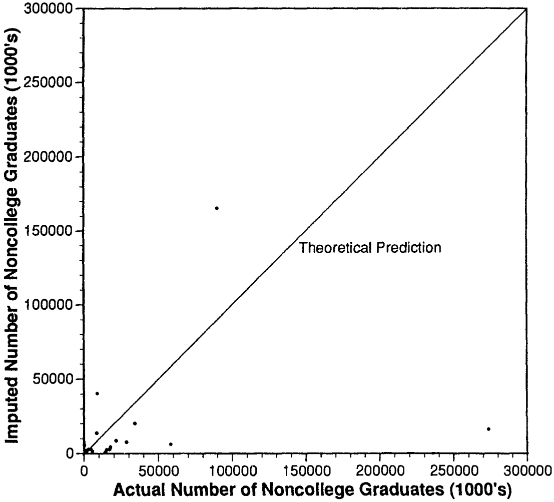

FIGURE 1. INTERNATIONAL PRODUCTION TEST: ACTUAL VERSUS IMPUTED NONCOLLEGE ENDOWMENT

DWBS (1997): Factor Content of Production

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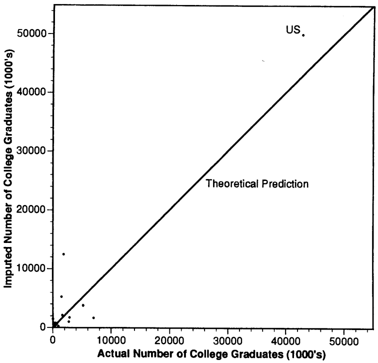

FIGURE 2A. INTERNATIONAL PRODUCTION TEST: ACTUAL VERSUS IMPUTED COLLEGE ENDOWMENT

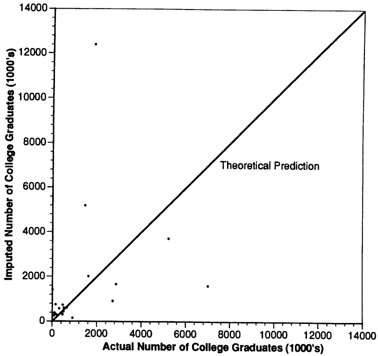

FIGURE 2B. INTERNATIONAL PRODUCTION TEST: ACTUAL VERSUS IMPUTED COLLEGE ENDOWMENT (WITHOUT U.S.)

DWBS (1997): Factor Content of Production

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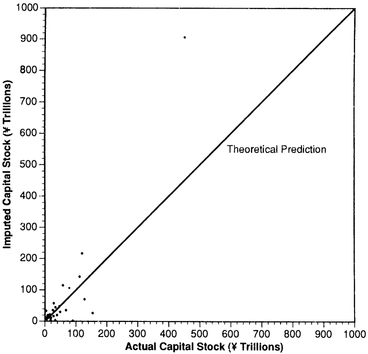

FIGURE 3A. INTERNATIONAL PRODUCTION TEST: ACTUAL VERSUS IMPUTED CAPITAL STOCK

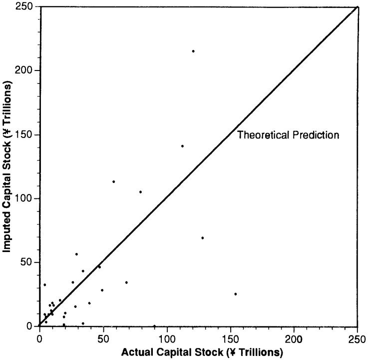

FIGURE 3B. INTERNATIONAL PRODUCTION TEST: ACTUAL VERSUS IMPUTED CAPITAL STOCK (WITHOUT U.S.)

FC of Production: Interpretation I

- The FC of production appears to perform very badly in the cross-country data.
  - This means that $B^c(w^c) \neq B^J(w^J)$.
  - This could arise due to non-FPE (ie $w^c \neq w^J$) or non-identical technologies ($B^c(w^J) \neq B^J(w^J)$).
  - DWBS (1997) don't seek to test which of these is at work.
  - They do note that the richer the country, the better the fit. But that could either be because of similar technologies or similar endowments (and hence production in the same cone of diversification), or both.

FC of Production: Interpretation II

- DWBS (1997) go on to look at the FC of production across Japanese regions.
  - These fit better, which is very nice.
  - However, we have to bear in mind that $B^J(w^J)$ was calculated to hold as an identity for all of Japan. So it is representative of some average Japanese region by construction. And hence we should expect the fit to improve somewhat compared to the cross-country results.
  - We should also bear in mind that just because FPE seems to hold well within Japan, this doesn't necessarily show that HO-style mechanisms made it so. Factors (and technology) could also be mobile. (But recall, in a strictly HO world, factors wouldn't actually *want* to move, due to FPE!)

DWBS (1997): Factor Content of Production

This scatter plot is a row of the vector equation $B^J(w^J)X^r = V^r$, plotted for all $r \in J$

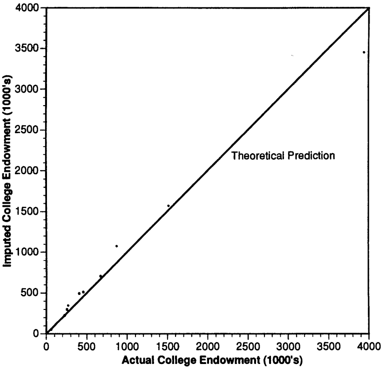

FIGURE 4. REGIONAL PRODUCTION TEST: ACTUAL VERSUS IMPUTED COLLEGE ENDOWMENT

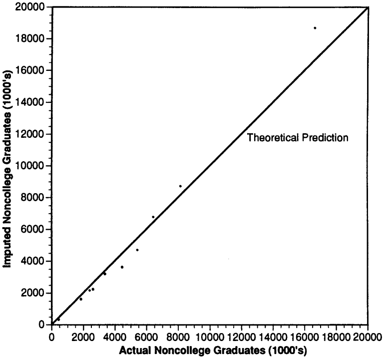

FIGURE 5. REGIONAL PRODUCTION TEST: ACTUAL VERSUS IMPUTED NONCOLLEGE ENDOWMENT

DWBS (1997): Factor Content of Production

This scatter plot is a row of the vector equation $B^J(w^J)X^r = V^r$, plotted for all $r \in J$

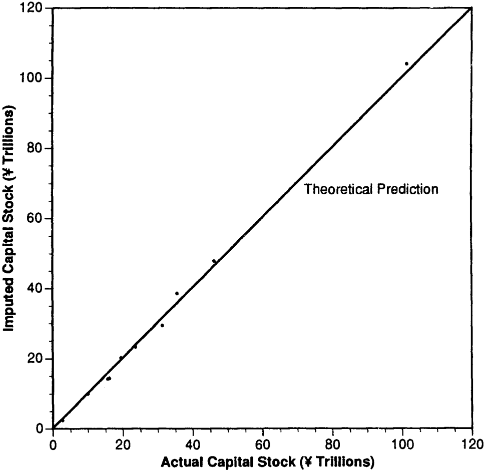

FIGURE 6. REGIONAL PRODUCTION TEST: ACTUAL VERSUS IMPUTED CAPITAL STOCK

DWBS (1997): Goods Content of Absorption

- DWBS (1997) have data on absorption D^r for each region of Japan. But they do not have this data for other countries in the world.
- With this data they test two hypotheses underpinning absorption:
    1. Identical and homothetic preferences (and identical prices) around the world: $D^c = s^c Y^w$ and $D^r = s^r Y^w$, where Y^w is world *net* output (ie GDP). This performs pretty well—see following Figures.
    2. Identical and homothetic preferences (and identical prices) within Japan: $D^r = \frac{s^r}{s^J} D^J$. This performs incredibly well: rank correlations across 45 commodities, or across regions, are almost uniformly above 0.95.

DWBS (1997): Goods Content of Absorption

This scatter plot is D^r vs $s^r Y^w$, for each commodity

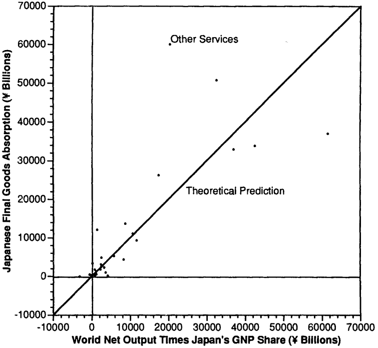

FIGURE 7. JAPANESE ABSORPTION TEST (ALL GOODS)

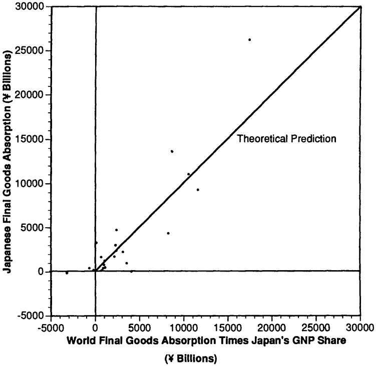

FIGURE 8. JAPANESE ABSORPTION TEST (ONLY TRADABLES)

DWBS (1997): Putting It All Together

- We have seen that (within Japan) the FC of production and the *goods* content of absorption both appear to fit well.
- So we can now put these two together to see how well the FC of trade fits (within Japan).
  - One might think that if both absorption and production fit well, then trade has to fit well by construction.
  - But that is not quite true, since the above test for absorption was done on *goods* not *factor* content.
  - To convert GC of absorption into FC of absorption we need to multiply goods absorption by $B^J(w^J)$, which is implicitly assuming that all countries use the same $B(.)$ matrix as Japan. (That is, we say: $B^J(w^J)D^r = s^r B^J(w^J)Y^w = s^r B^J(w^J)X^w = s^r V^w$.)
  - Figures 9 and 10 show that there is still significant missing trade inside Japan (Figure 9) and that this is primarily due to the absorption side of the factor content of trade being off (Figure 10).

DWBS (1997): Why is There Missing Trade?

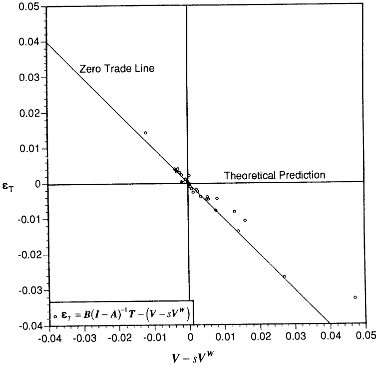

FIGURE 9. TRADE ERRORS VERSUS FACTOR ABUNDANCE (ALL FACTORS CALCULATED RELATIVE TO THE WORLD ENDOWMENT, $\mathbf{V}^W$)

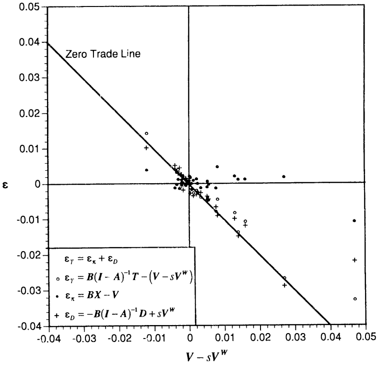

FIGURE 10. ALL ERRORS VERSUS FACTOR ABUNDANCE (ALL FACTORS CALCULATED RELATIVE TO THE WORLD ENDOWMENT, $\mathbf{V}^W$)

DWBS (1997): Final Step

- The above findings suggest that the problem of the missing trade within Japan is primarily due to assuming that there is FPE (or identical technologies) around the world, or that: $B^J(w^J)X^w = s^r V^w$.
- So the last thing that DWBS (1997) do is to see how things look without this assumption.
    - That is, they simply use $B^J(w^J)X^w$ instead of assuming that this is equal to $s^c V^w$.
    - This is like assuming that there is FPE within Japan, but not necessarily across countries.
    - This (as Figure 11 shows) goes some way towards improving the fit.

DWBS (1997): Finding Missing Trade

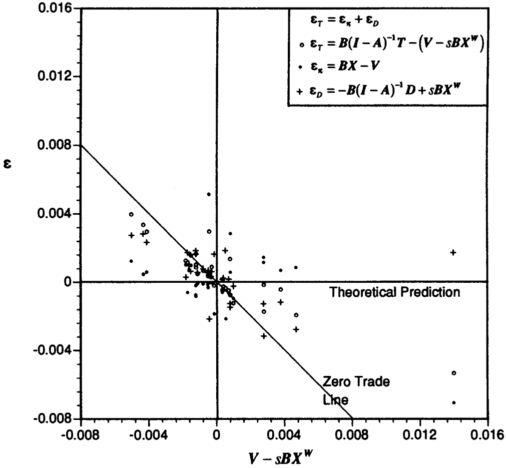

FIGURE 11. ALL ERRORS VERSUS FACTOR ABUNDANCE (ALL FACTORS CALCULATED RELATIVE TO THE IMPUTED WORLD ENDOWMENT, $\mathbf{BX}^W$)

Plan of Today's Lecture

1. **Tests of the Heckscher-Ohlin model, continued:**
   1.1 **Factor Content of Trade Tests**
      1.1.1 Leontief (1953) and Leamer (1980)
      1.1.2 Bowen, Leamer and Sveikauskas (1987)
      1.1.3 Trefler (1993)
      1.1.4 Trefler (1995)
      1.1.5 Davis, Weinstein, Bradford and Shimpo (1997)
      1.1.6 **Davis and Weinstein (2001)**
   1.2 **Brief Discussion of Other Tests**

Davis and Weinstein (AER, 2001)

- The message from DWBS (1997) was that, when restricted to settings where FPE seems plausible (like within a country), HO actually performs pretty well. That is, the failure of FPE seems to be a first-order problem for HO.
- So DW (2001) build on this and seek to understand the departures from FPE within the OECD.

DW (2001): "The Matrix"

- The key to this exercise is getting data on $\bar{B}^c(w^c)$ for all countries c in their sample (not easy!) All prior studies had used one country's $\bar{B}(w)$ matrix to apply to all countries.
  - Just taking a casual glance at these suggests that the $\bar{B}(w)$'s around the OECD are very different. So something needs to be done.
  - One approach would be just to use the data on $\bar{B}^c(w^c)$ for each country—but then the production side of the HOV equations would hold as an identity and that wouldn't be much of a test. (It does shed some light on things though, as Hakura (JIE, 2001) showed.)
  - DW instead seek to parsimoniously *parameterize* the cross-country differences in $\bar{B}^c(w^c)$ by considering 7 nested hypotheses, which drop standard HO assumptions sequentially, about how endowments affect both *technology* (ie $\bar{B}(.)$) and *technique* (ie $\bar{B}(w)$).

DW (2001): The 7 Nested Hypotheses and 7 Results

"P"=Production, "T"=Trade

- "P1&T1": Standard HOV, common (US) technology. (The baseline.)
  - That is, P1: $B^{US}(w^{US})Y^c = V^c$ is tested.
  - That is, T2: $B^{US}(w^{US})T^c = V^c - s^c V^w$ is tested.
- "P2&T2": Common technology with measurement error:
  - Suppose the differences in $\bar{B}(w)$ we see around the world are just classical (log) ME.
  - DW look for this by estimating $\ln \bar{B}^c(w^c) = \ln \bar{B}(w)^\mu + \varepsilon^c$, where $\bar{B}(w)^\mu$ is the common technology around the world, and ε^c is the CME (ie just noise).
  - The actual regression across industries i and factors k is: $\ln \bar{B}^c(w^c)_{ik} = \beta_{ik} + \varepsilon^c_{ik}$, where β_{ik} is a fixed-effect.
  - Then (for P2), $\widehat{\bar{B}(w)}^\mu Y^c = V^c$ is tested, using $\widehat{\beta}_{ik}$ to construct $\widehat{\bar{B}(w)}^\mu$

DW (2001): Hypothesis 1 (Standard HOV)

This is 'P1', the *production* side of H1

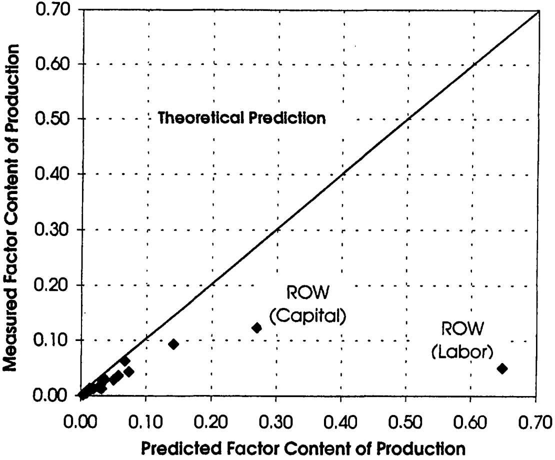

FIGURE 1. PRODUCTION WITH COMMON TECHNOLOGY (US) (P1)

DW (2001): Hypothesis 1 (Standard HOV)

This is ‘T1’, the *trade* side of H1

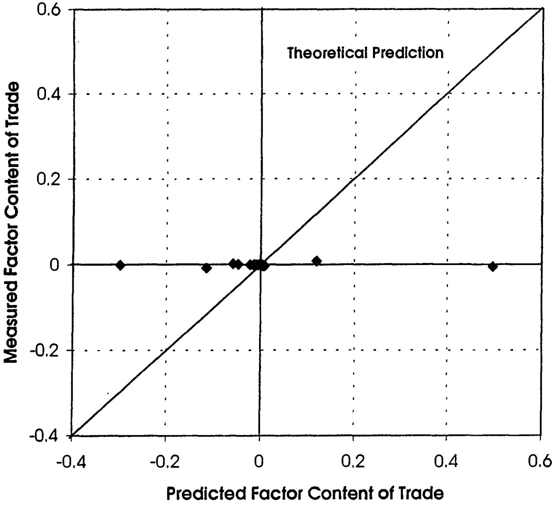

FIGURE 2. TRADE WITH COMMON TECHNOLOGY (US) (T1)

DW (2001): Hypothesis 2 (Measurement error)

This is 'P2', the *production* side of H2. Plot of 'T2' looks like 'T1', apparently.

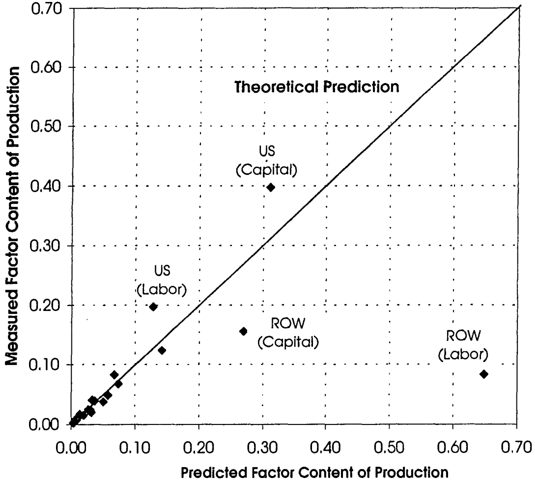

FIGURE 3. PRODUCTION WITH COMMON TECHNOLOGY
(AVERAGE)
(P2)

DW (2001): The 7 Nested Hypotheses and Results (cont)

- "P3&T3": Hicks-neutral technology differences:
  - Here, as in Trefler (1995), they allow each country to have a λ^c such that: $\bar{B}^c(w^c) = \lambda^c \bar{B}(\lambda^c w^c)$.
  - Note that this still has 'conditional FPE', so the *ratio* of techniques used across factors or goods will be the same across countries.
  - This translates into estimating θ^c in the regression: $\ln \bar{B}^c(w^c)_{ik} = \theta^c + \beta_{ik} + \varepsilon^c_{ik}$

DW (2001): Hypothesis 3 (Hicks-neutral tech diffs)

This is 'P3', the *production* side of H3. Plot of 'T3' looks like 'T1', apparently.

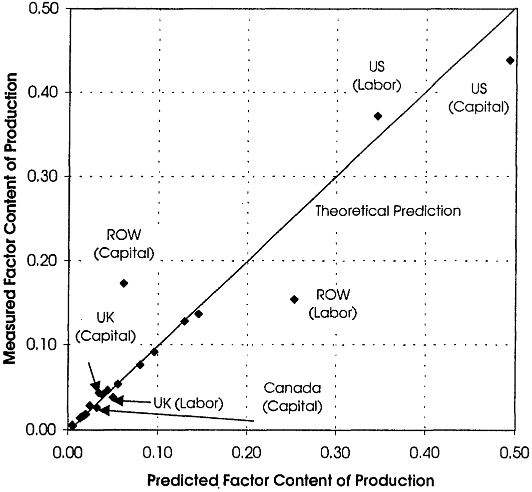

FIGURE 4. PRODUCTION WITH HICKS-NEUTRAL TECHNICAL DIFFERENCES
(P3)

DW (2001): The 7 Nested Hypotheses and Results (cont)

- "P4&T4": DFS (1980) continuum model aggregation:
  - In a DFS-HO model with infinitessimally small trade costs, countries will use different techniques when they produce traded goods. However, this won't spill over onto non-traded goods.
  - If the industrial classifications in our data are really aggregates of more finely-defined goods (as in a continuum) then at the aggregated industry level it will look like countries' endowments affect their choice of technique.
  - To incorporate this, DW estimate $\ln \bar{B}^c(w^c)_{ik} = \theta^c + \beta_{ik} + \gamma_i^T \ln(\frac{K^c}{L^c}) \times TRAD_i + \varepsilon_{ik}^c$, where $TRAD_i$ is a dummy for tradable sectors.
  - Estimates of this are used to construct $\widehat{\bar{B}(w)}^{DFS}$ analogously to before. But this correction alters both the production and absorption equations (since the factor content of what country c imports depends on the endowments of each separate exporter to c).

DW (2001): Hypothesis 4 (DFS model aggregation)

This is ‘P4’, the *production* side of H4.

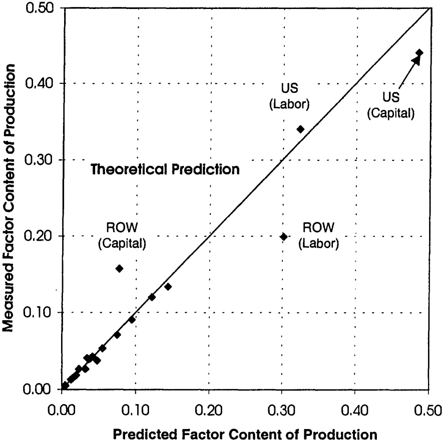

FIGURE 5. PRODUCTION WITH CONTINUUM OF GOODS MODEL AND FPE (P4)

DW (2001): Hypothesis 4 (DFS model aggregation)

This is ‘T4’, the *trade* side of H4.

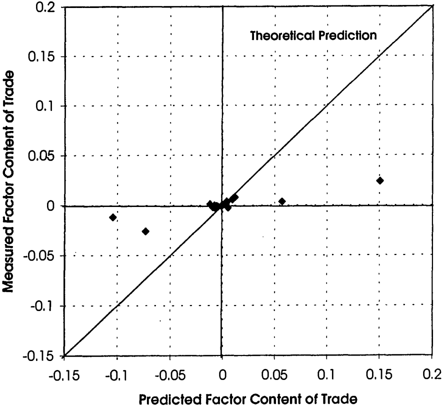

FIGURE 6. TRADE WITH CONTINUUM OF GOODS MODEL AND FPE
(T4)

DW (2001): The 7 Nested Hypotheses and Results (cont)

- "P5&T5": DFS (1980) continuum model with non-FPE:
  - Another reason for $\gamma_i^T \neq 0$ in the regression above (other than aggregation) is the failure of FPE due to countries being in different cones of diversification. (See Helpman (JEP, 1999) for description.)
  - In this case, this effect *will* spill over onto non-traded goods (since factor prices affect technique choice in all industries).
  - To incorporate this, DW estimate $\ln \bar{B}^c(w^c)_{ik} = \theta^c + \beta_{ik} + \gamma_i^T \ln(\frac{K^c}{L^c}) \times TRAD_i + \gamma_i^{NT} \ln(\frac{K^c}{L^c}) \times NT_i \varepsilon_{ik}^c$, where NT_i is a dummy for non-tradable sectors.
  - Here, tests of the HOV analogue equations need to be more careful still, to make sure we use only the bits of the technology matrix that relate to tradable sector production.

DW (2001): Hypothesis 5 (DFS model with non-FPE)

This is ‘P5’, the *production* side of H5.

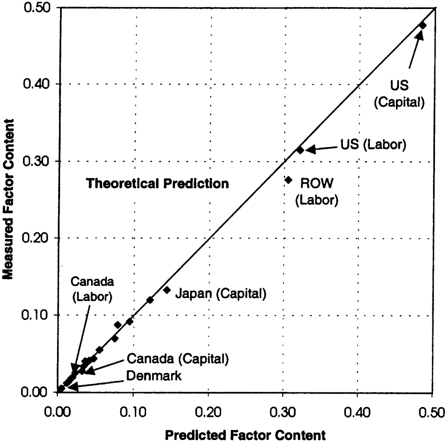

FIGURE 7. PRODUCTION WITHOUT FPE
(P5)

DW (2001): Hypothesis 5 (DFS model with non-FPE)

This is 'T5', the *trade* side of H5.

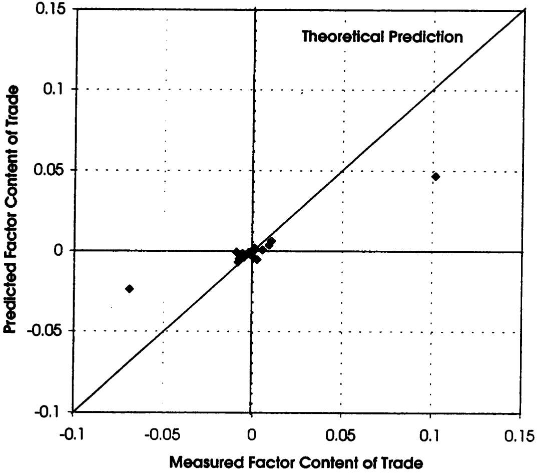

FIGURE 8. TRADE WITH NO-FPE, NONTRADED GOODS (T5)

DW (2001): The 7 Nested Hypotheses and Results (cont)

- "P7&T7": Demand-side differences due to trade costs:
  - Predicted imports in the HO setup are many times larger than actual imports. One explanation is trade costs.
  - To incorporate this, DW estimate gravity equations on imports, allowing them to estimate how trade costs (proxied for by distance) impedes imports.
  - They then use the predicted imports (from this gravity equation) in place of actual data on imports when testing the HOV trade equation (ie T7).
  - Note that this is not really an internally-consistent way of introducing trade costs. Trade costs also tilt relative prices (so countries want different ratios of goods), and relative factor prices (so techniques differ in ways that are not simply dependent on endowments).

DW (2001): Hypothesis 7 (Demand-side differences due to trade costs)

This is ‘T7’, the *trade* side of H7.

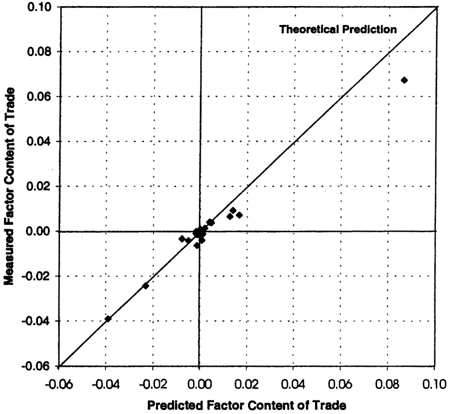

Figure 10. Trade with No-FPE, Gravity Demand Specification, and Adjusted ROW (T7)

DW (2001): Taking Stock

- DW (2001) conduct a formal model test on the production side off the model.
  - For the purposes of fitting production, and as judged by the Schwarz criterion (which trades off fit vs extra parameters used up in a particular way), P5 is 'best'.
- However, because these hypotheses affect the absorption side too, a good fit on the production side doesn't guarantee a good fit on the trade side.
  - By all measures they consider (sign tests, regressions, 'missing trade' statistic) T7 does best on the trade side.
  - And T7 has an R^2 of 0.76, which is pretty impressive when you consider how grand an exercise this is (accounting for production, consumption and trade around the OECD, in a relatively parsimonious model).

Subsequent Work on NFCT Empirics

- Antweiler and Trefler (AER, 2002):
  - Adding external returns to scale (as in parts of Helpman and Krugman (1995 book)) to HOV equations in order to estimate the magnitude of these RTS.
- Schott (QJE, 2003):
  - Even within narrowly-defined (10-digit) industries, the unit value of US imports vary dramatically across exporting countries (and this variation is correlated with exporter endowments).
- Trefler and Zhu (JIE, 2010):
  - The treatment of *traded* intermediates affects how you calculate the HOV equations properly.
  - Also a characterization of the class of demand systems that generates HOV. (That is, is IHP necessary?)
- Davis and Weinstein (2008, book chapter, "Do Factor Endowments Matters for North-North Trade?"):
  - Intra-industry trade and HOV empirics.

Plan of Today's Lecture

1. Tests of the Heckscher-Ohlin model, continued:
   1.1 Factor Content of Trade Tests
      1.1.1 Leontief (1953) and Leamer (1980)
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      1.1.5 Davis, Weinstein, Bradford and Shimpo (1997)
      1.1.6 Davis and Weinstein (2001)
   1.2 **Brief Discussion of Other Tests**

Other Tests of HO Theory

Too much to cover here, but briefly...

- Tests of FPE and 'factor price convergence':
  - Will be discussed in 'trade and wages' lecture.
- Tests of the S-S theorem:
  - Will be discussed in 'trade and wages' lecture.
- Tests of the Rybczinski theorem:
  - Will be discussed in 'trade and wages' lecture (in context of immigration).
- Bilateral tests of NFCT in a non-FPE world:
  - Theory due to Helpman (1984).
  - Empirics in Choi and Krishna (JPE, 2004).
- Autarky price version of the HO theorems:
  - Bernhofen and Brown (2009); case of Japan, 1853.