An Account of Global Factor Trade

Variants of HOV Model and the Tests

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Motivation

Why account for factor content of trade?

- Trace the effects of international influences on relative and absolute factor prices within a country.
- It provides a concrete prediction against which to measure how well our models work.

Why HOV?

- Sharp predictions for the link btw trade, technology, and endowments.

Theorem (From HOV)

The net export of factor services will be the difference between a country's endowment and the endowment typical in the world for a country of that size.

The prediction is elegant, intuitive, and spectacularly at odds with the data.

Standard HOV

Assumptions

- Identical, CRS production functions for all countries;
- Factor and goods mkts are perfectly competitive;
- No trade barriers and trade is costless;
- Number of goods $\geq$ number of primary factors
- Distribution of factors are consistent with the integrated EQ;
- Factor prices is equalized $\Rightarrow$ same techniques of production.
- Identical and homothetic preferences across countries.

Production and Specification 1

$$\mathbf{B}^{c'}\mathbf{Y}^{c} = \mathbf{V}^{c} \tag{P1}$$

$$\mathbf{B}^{c'}\mathbf{T}^{c} = \mathbf{B}^{c'}(\mathbf{Y}^{c} - \mathbf{D}^{c}) = \mathbf{V}^{c} - s^{c}\mathbf{V}^{W} \quad \forall\ c \tag{T1}$$

A Common Tech Matrix measured with Error

Both the true and measured technology matrices are identical across countries (typically U.S. tech). Now, we consider the measurement error, assume that for country c the measured technology matrix is given as

$$\ln \mathbf{B}^c = \ln \mathbf{B}^\mu + \varepsilon^c \tag{1}$$

$\ln \mathbf{B}^\mu$ is the natural log of true technology matrix and ε is a matrix of normal error terms. Then it gives rise to our second set of tests:

Production and Trade Specification 2:

$$\mathbf{B}^\mu \mathbf{Y}^c = \mathbf{V}^c \tag{P2}$$

$$\mathbf{B}^\mu \mathbf{T}^c = \mathbf{V}^c - s^c \mathbf{V}^W \quad \forall\ c \tag{T2}$$

Hicks-Neutral Technical Differences

We consider cross-country diffrences in productivity, BLS(1987) and Trefler(1995) use Hicks-neutral technical diffrences as a parimonious way to capture these effects. This can be characterized via country-specific technology shifts λ^c:

$$\mathbf{B}^c = \lambda^c \mathbf{B}^\lambda \quad \forall\ c \tag{2}$$

We can express a country's endowments in effeciency terms:

$$\mathbf{V}^{cE} = \frac{1}{\lambda^c}\mathbf{V}^c \quad \forall\ c \tag{3}$$

HOV with effiency units (endowments) becomes:

Production and Trade Specification 3

$$\mathbf{B}^\lambda \mathbf{Y}^c = \mathbf{V}^{cE} \tag{P3}$$

$$\mathbf{B}^\lambda \mathbf{T}^c = \mathbf{V}^{cE} - s^c \mathbf{V}^{WE} \quad \forall\ c \tag{T3}$$

DFS model

David Dollar et al.(1988) found that capital to labor usage (industry factor usage) is corelated with country capital abundance (factor abundance). Two reasons:

- Breakdown in Factor price equalization (NEXT MODEL)
- Due to aggregating goods of heterogenous factor content within industry categories.

In a two-country DFS model (with continuum of goods), we expect input usage in correlated with capital abundance for tradables but not for nontradables.

Specification must recognizes that

- Tradable industries production varies systematically with country capital abundance.
- Absorption should measured with producer country's input coeffients.

Production and Trade Specification 4

$$\mathbf{B}^{cDFS}\mathbf{Y}^{c} = \mathbf{V}^{c} \tag{P4}$$

$$\mathbf{B}^{cDFS}\mathbf{Y}^{c} - \left[\mathbf{B}^{cDFS}\mathbf{D}^{cc} + \sum_{c' \neq c} \mathbf{B}^{c'DFS} M^{cc'}\right] = \mathbf{V}^{c} - s^{c}\mathbf{V}^{W} \tag{T4}$$

Helpman no-FPE Model

Consider a economy where the extent of differences in endowments is sufficient that some countries do not share factor price equalization. Model setup:

$$\mathbf{B}^{cH} = [\mathbf{B}^{cHN} \quad \mathbf{B}^{cHT}] \quad \mathbf{Y}^{c} = [\mathbf{Y}^{cN} \quad \mathbf{Y}^{cT}]' \tag{4}$$

Denote $\mathbf{V}^{cN}$ ($\mathbf{V}^{cT}$) the resource devoted in country c to production of nontradable (tradable) goods. Namely:

$$\mathbf{V}^{cJ} = \mathbf{B}^{cHJ}\mathbf{Y}^{cJ} \quad J \in \{N, T\} \tag{5}$$

Production and Trade Specification 5

$$\mathbf{B}^{cH}\mathbf{Y}^{c} = \mathbf{V}^{c} \tag{P5}$$

$$\mathbf{B}^{cHT}\mathbf{Y}^{cT} - \left[\mathbf{B}^{cHT}\mathbf{D}^{ccT} + \sum_{c' \neq c}\mathbf{B}^{c'HT}\mathbf{M}^{cc'}\right] = \mathbf{V}^{cT} - s^{c}\mathbf{V}^{WT}$$

$$= \left[\mathbf{V}^{c} - s^{c}\mathbf{V}^{W}\right] - \left[\mathbf{V}^{cN} - s^{c}\mathbf{V}^{WN}\right] \tag{T5}$$

Demand, HOV, and Gravity

Consequence of Frictionless Assumptions:

- Overstates the expected volume of trade
- Overstates the opportunities for arbitrage of factor price differences.

Gravity equation (use distance as a proxy for costs of trade)

$$\ln(M_i^{cc'}) = \alpha_{0i} + \alpha_{1i} \ln(s_i^{Tc} X_i^{c'}) + \delta_i \ln(d_{cc'}) + \zeta_i^{cc'} \quad (6)$$

where $X_i^{c'}$ is gross output in sector i in country c', the α's and δ are parameters to be estimated. $\hat{\mathbf{M}}^{cc'}$ are the predicted imports.

Trade Specification 7:

$$\mathbf{B}^{cH}\mathbf{Y}^c - \left[\mathbf{B}^{cH}\mathbf{D}^{cc} + \sum_{c' \neq c} \mathbf{B}^{c'H}\mathbf{M}^{cc'}\right] = \mathbf{V}^c - \left[\mathbf{B}^{cH}\hat{\mathbf{D}}^{cc} + \sum_{c' \neq c} \mathbf{B}^{c'H}\hat{\mathbf{M}}^{cc'}\right] \quad \text{(T7)}$$

Set demand for domestically produced goods($\hat{\mathbf{D}}^{cc}$) = total demand - total imports from gravity equation($\sum_{c' \neq c} \hat{\mathbf{M}}^{cc'}$).

Summary of Specifications

Summary of Specifications (Grouping)

	Yes	No
I. All countries share a common technology matrix (Absolute FPE)	(T1)–(T2)	(T3)–(T7)
II. FPE (Absolute, Adjusted, or Approximate)	(T1)–(T4)	(T5)–(T7)
III. Industry capital to labor ratios identical across countries	(T1)–(T3)	(T4)–(T7)
IV. Identical, homothetic preferences with zero trade costs	(T1)–(T6)	(T7).

Data

Data Sources

- OECD countries (10 con*34 ind): technology, net output, endowments, absorption and trade data.
  - The Organization for Economic Cooperation and Development's Input-Output Database [OECD (1995)]
  - OECD's International Sectoral Database $\Rightarrow$ endowment data
  - The OECD's STAN Database $\Rightarrow$ input requirements
- ROW (Rest of World):
  - Capital: Robert Summers and Alan W. Heston (1997) Database
  - Labor: International Labor Organization
  - Gross output: United Nation's Industrial Statistics Yearbook
- Bilateral trade flows: Draw from Robert C. Feenstra et al.(1997)
- Bilateral distance: Shang-Jin Wei(1996)

For more info. about data and data manipulation, please ref the Data Appendix.

Estimating Technology I

1. For indentical technology (P1):
   $\mathbf{B}^c = \mathbf{B}^{c'}$, We reject this restriction by inspection.
2. For measurement error model (P2):

$$\ln B^c_{fi} = \beta_{fi} + \varepsilon^c_{fi} \tag{$\hat{\text{P}}2$}$$

   β_{fi} are parameters to be estimated corresponding to the log of common factor input requirement for factor f in sector i.
3. For Hicks-neutral technical differences (P3):

$$\ln B^c_{fi} = \theta^c + \beta^c_{fi} + \psi^c_{fi} \tag{$\hat{\text{P}}3$}$$

where $e^{\theta^c} = \lambda^c$. Normalization for θ^c, set $\theta^{US} = 0(\lambda^{US} = 1)$.

Estimating Technology II

4. For DFS model (P4):

$$\ln B_{fi}^{c} = \theta^{c} + \beta_{fi} + \gamma_{f}^{T} \ln\left(\frac{K^{c}}{L^{c}}\right) TRAD_{i} + \phi_{fi}^{c} \qquad (\hat{\mathrm{P}}4)$$

$TRAD_i$ is dummy variable that takes value of one if the sector is tradable.

5. For FPE breaks down model (P5):

$$\ln B_{fi}^{c} = \theta^{c} + \beta_{fi} + \gamma_{f}^{T} \ln\left(\frac{K^{c}}{L^{c}}\right) TRAD_{i} + \gamma_{f}^{NT} \ln\left(\frac{K^{c}}{L^{c}}\right) NT_{i} + \phi_{fi}^{c} \qquad (\hat{\mathrm{P}}5)$$

6. More Genenral Specification:

$$\ln B_{fi}^{c} = \theta^{c} + \beta_{fi} + \gamma_{fi} \ln\left(\frac{K^{c}}{L^{c}}\right) + \phi_{fi}^{c} \qquad (\hat{\mathrm{P}}5')$$

method: In each specification, we have 68 equations, SUR will used up the degress of freedom. We estimated these equations as a system of SUR with cross-equation restrictions but imposed a diagonal variance-covariance matrix on the residuals.

Model	Measurement error	Hicks-neutral technical differences (HNTD)	Continuum model with HNTD and FPE	Helpman no-FPE model with HNTD	Unrestricted Helpman no-FPE model with HNTD	Implied λ^c
	($\hat{P}2$)	($\hat{P}3$)	($\hat{P}4$)	($\hat{P}5$)	($\hat{P}5'$)	
θ^{Aus}	—	0.531	0.531	0.530	0.528	1.7
		(0.035)	(0.035)	(0.035)	(0.035)	
θ^{Can}	—	0.381	0.381	0.380	0.381	1.5
		(0.035)	(0.035)	(0.035)	(0.034)	
θ^{Den}	—	0.508	0.504	0.508	0.508	1.7
		(0.036)	(0.036)	(0.036)	(0.034)	
θ^{Fra}	—	0.494	0.493	0.494	0.492	1.6
		(0.034)	(0.034)	(0.034)	(0.035)	
θ^{Ger}	—	0.112	0.111	0.112	0.111	1.1
		(0.034)	(0.034)	(0.034)	(0.035)	
θ^{Italy}	—	0.709	0.707	0.709	0.704	2.0
		(0.034)	(0.034)	(0.034)	(0.036)	
θ^{Japan}	—	0.431	0.430	0.431	0.430	1.5
		(0.033)	(0.033)	(0.033)	(0.034)	
θ^{Neth}	—	0.057	0.057	0.056	0.058	1.1
		(0.035)	(0.035)	(0.035)	(0.035)	
θ^{UK}	—	0.520	0.516	0.520	0.542	1.7
		(0.034)	(0.034)	(0.034)	(0.040)	
θ^{US}	—	0	0	0	0	1.0
γ^{KT}	—	—	0.408	0.364	—	
			(0.046)	(0.061)		
γ^{KN}	—	—	—	0.493	—	
				(0.071)		
γ^{LT}	—	—	−0.408	−0.449	—	
			(0.046)	(0.060)		
Number of parameters	68	77	78	80	144	
−Log L	−1741.5	−934.4	−855.7	−802.8	−740.7	
Schwarz criterion	−1963.3	−1185.5	−1110.1	−1063.7	−1210.3	

Notes: Standard errors are reported in parentheses. $\gamma^{LN} = -\gamma^{LT} - \gamma^{KT} - \gamma^{KN}$. There is very little variation in the θ's as we move across specifications because of the constraint that capital to labor ratios cannot affect productivity.

Estimating Demand

We use a gravity model as the basis for our demand predictions in specification (T7),

$$\ln(M_i^{cc'}) = \alpha_{0i} + \alpha_{1i} \ln(s_i^{Tc} X_i^{c'}) + \delta_i \ln(d_{cc'}) + \zeta_i^{cc'} \tag{7}$$

- zero-trade-cost case: $\alpha_{0i} = \delta_i = 0$
- result: α_{1i} close to 1, δ_i is significant and negative in all sectors, $\Rightarrow$ statistical rejection the hypothesis of costless trade.

Problem: In some sectors we found large systematic errors in predicting trade with the ROW. This may be the result of mis-measurement of distance or the fact that the true ROW is some multiple of our sample of countries.
Solution: Add dummy variables corresponding the country importing country being the ROW.

Key Specifications

	Key assumption	Production specifications		Trade specifications
(P1)	Conventional HOV with U.S. technology	$\mathbf{B}^{US}\mathbf{Y}^c = \mathbf{V}^c$	(T1)	$\mathbf{B}^{US}\mathbf{T}^c = \mathbf{B}^{US}(\mathbf{Y}^c - \mathbf{D}^c) = \mathbf{V}^c - s^c\mathbf{V}^W$
(P2)	Average technology matrix	$\hat{\mathbf{B}}^{\mu}\mathbf{Y}^c = \mathbf{V}^c$	(T2)	$\hat{\mathbf{B}}^{\mu}\mathbf{T}^c = \mathbf{V}^c - s^c\mathbf{V}^W$
(P3)	Hicks-neutral efficiency adjustment	$\hat{\mathbf{B}}^{\lambda}\mathbf{Y}^c = \mathbf{V}^{cE}$	(T3)	$\hat{\mathbf{B}}^{\lambda}\mathbf{T}^c = \mathbf{V}^{cE} - s^c\mathbf{V}^{WE}$
(P4)	Continuum model: Different input ratios in traded goods and H-N efficiency	$\hat{\mathbf{B}}^{cDFS}\mathbf{Y}^c = \mathbf{V}^c$	(T4)	$\hat{\mathbf{B}}^{cDFS}\mathbf{Y}^c - [\hat{\mathbf{B}}^{cDFS}\mathbf{D}^{cc} + \sum_{c' \neq c} \hat{\mathbf{B}}^{c'DFS}\mathbf{M}^{cc'}] = \mathbf{V}^c - s^c\mathbf{V}^W$
(P5)	Helpman no-FPE model, different input ratios in all, H-NE	$\hat{\mathbf{B}}^{cH}\mathbf{Y}^c = \mathbf{V}^c$	(T5)	$\hat{\mathbf{B}}^{cH}\mathbf{Y}^{cT} - [\hat{\mathbf{B}}^{cH}\mathbf{D}^{ccT} + \sum_{c' \neq c} \hat{\mathbf{B}}^{c'H}\mathbf{M}^{cc'}] = [\mathbf{V}^c - s^c\mathbf{V}^W] - [\mathbf{V}^{cN} - s^c\mathbf{V}^{WN}]$
	Forces ROW production model to work		(T6)	As above
	Adds gravity-based demand determination		(T7)	$\hat{\mathbf{B}}^{cH}\mathbf{Y}^c - [\hat{\mathbf{B}}^{cH}\mathbf{D}^{cc} + \sum_{c' \neq c} \hat{\mathbf{B}}^{c'H}\mathbf{M}^{cc'}] = \mathbf{V}^c - [\hat{\mathbf{B}}^{cH}\hat{\mathbf{D}}^{cc} + \sum_{c' \neq c} \hat{\mathbf{B}}^{c'H}\hat{\mathbf{M}}^{cc'}]$

Note: Hats (ˆ) indicate fitted values from estimation of technology and absorption.

Production and Trade Tests

- Production tests:
  - Slope Test: Regress MFCP on PFCP ex. $\mathbf{B}^f\mathbf{Y}^c$ on $\mathbf{V}^{fc}$
  - Median Error Test: ex. $|\mathbf{B}_f^{US}\mathbf{Y}^c - \mathbf{V}_f^c|/\mathbf{V}_f^c$.
- Trade tests:
  - Sign Test: sign$(MFCT)$ = sign$(PFCT)$?
  - Slope Test: Regress MFCT on PFCT.
  - Variance Ratio Test: $Var(MFCT)/Var(PFCT)$

One indicator of “missing trade” is when the variance ratio is close to zero, whereas if the model fit perfectly, the variance ratio would be unity.

Production and Trade Results

Production tests: Dependent variable MFCP

	(P1)	(P2)	(P3)	(P4)	(P5)
Predicted	0.24	0.33	0.89	0.89	0.97
Standard error	0.09	0.11	0.06	0.05	0.01
R^2	0.27	0.29	0.92	0.94	1.00
Median error	0.34	0.21	0.07	0.05	0.03
Observations	20	22	22	22	22

Trade tests: Dependent variable MFCT

	(T1)	(T2)	(T3)	(T4)	(T5)	(T6)	(T7)
Predicted	−0.002	−0.006	−0.05	0.17	0.43	0.59	0.82
Standard error	0.005	0.003	0.02	0.02	0.02	0.04	0.03
R^2	0.01	0.14	0.31	0.77	0.96	0.92	0.98
Sign test	0.32	0.45	0.50	0.86	0.86	0.82	0.91
Variance ratio	0.0005	0.0003	0.008	0.07	0.19	0.38	0.69
Observations	22	22	22	22	22	22	22

Notes: The theoretical coefficient on "predicted" is unity. The theoretical value of the sign test is unity (100-percent correct matches). The variance ratio is Var(MFCT)/Var(PFCT) and has a theoretical value of unity.

Simple HOV Model

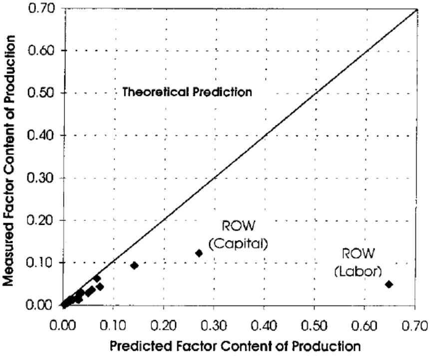

FIGURE 1. PRODUCTION WITH COMMON TECHNOLOGY (US) (P1)

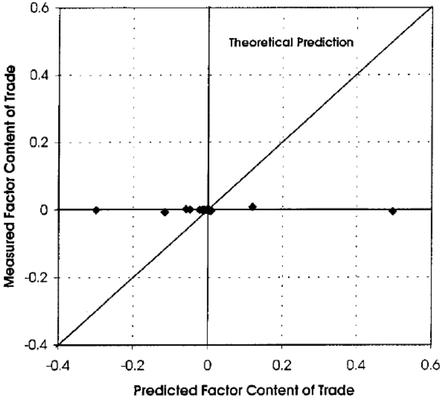

FIGURE 2. TRADE WITH COMMON TECHNOLOGY (US) (T1)

Failure of FPE and Factor Usage in Nontraded Production

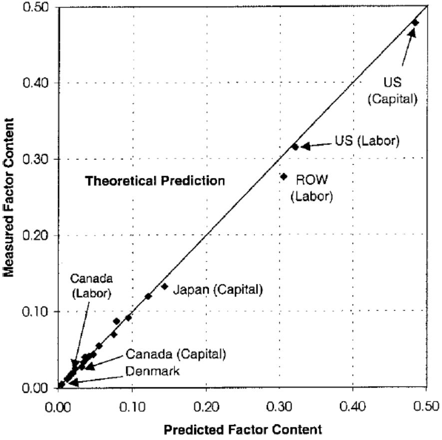

FIGURE 7. PRODUCTION WITHOUT FPE (P5)

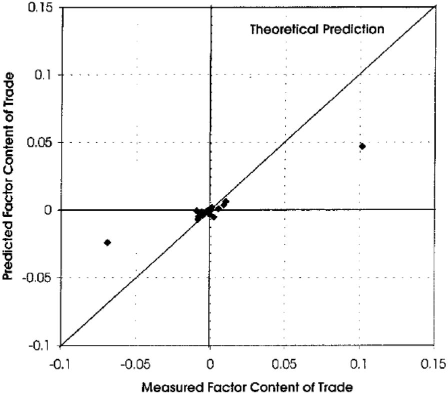

FIGURE 8. TRADE WITH NO-FPE, NONTRADED GOODS (T5)

Corrections on ROW Technology V.S. Gravity Demand HOV

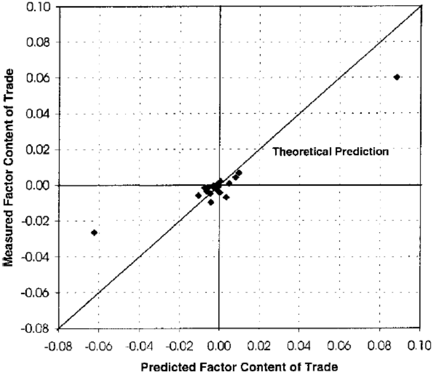

FIGURE 9. TRADE WITH NO-FPE, NONTRADED GOODS, AND ADJUSTED ROW
(T6)

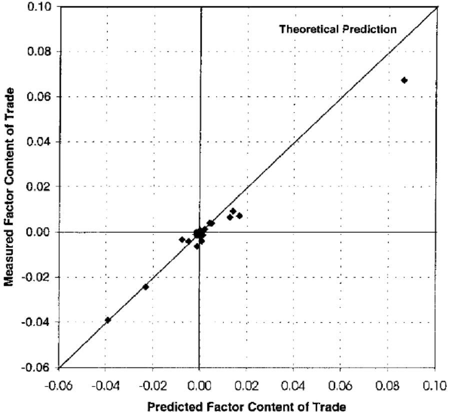

FIGURE 10. TRADE WITH NO-FPE, GRAVITY DEMAND SPECIFICATION, AND ADJUSTED ROW
(T7)

Conclusion

- The study shows that variants of HOV model that permits technical differences, a breakdown in factor price equalization, the existence of nontraded goods, and cost of trade can bring HOV theory and data into congruence.
- Conditional on these amendments, countries export their abundant factors and they do so in approximately the right magnitudes.
- It is a plausible and simple set of departures from the conventional model allows us to so accurately match the international data.