Testino Heckscher-Ohlin-Vanek Model and Extensions
(Davis and Weinstein, 2001)

Prerequisites:
These are 2 good sites for learning elementary matrix operations:
(Just Topic 2, up to page 16)
http://www.mathphysics.com/spingarn/lane/
(Just the first two topics)

I. Introduction
A method of testing the Heckscher-Ohlin model is to compute actual factor content of trade and see how close that is to what the Heckscher-Ohlin-Vanek model predicts.

We will learn how to do such tests in this data analysis exercise.

FACT: The basic Heckscher-Ohlin model does not predict world trade very well. [We know about the Leontief paradox, which actually shows the HO model is invalid. We also know how Trefler (1993) shows that HOV are theoretically right and that an adjustment to factors would strongly validate the HO model.]

Trefler (1995) shows that factor content of trade is far smaller than what the HOV model predicts.
What are the problems?
   1. Factor Price Equalization
   2. Technology differences
   3. Nontraded goods
   4. Geography

D&W extend the basic HOV model to see how well the model does predict when the model is extended to take account of these problems.
II: The Basic Heckscher-Ohlin-Vanek Model

Assumptions:
1. Many factors, many goods, many countries: $G (=34)$ goods, $F (=2)$ factors, $J (=10+1)$ countries.

2. $\#$ traded goods $= \#$ factors.

3. Factor price equalization [see Leamer’s graphs] (we relax this FPE assumption later).

   NOTE: When factor prices are equalized, all producers of a good will use the same techniques of production, regardless of where they are located in the world. The idea behind this assumption is to assume away differences in technology: Comparative advantage in HO model is due mainly to differences in factor endowments.

4. We will assume equilibrium or market clearing in goods and factor markets (general equilibrium). So there is full employment of factors.
Notation: Bold font=Matrix or Vector, regular font=Scalar.

SUPPLY SIDE:

1. **Technology Matrix:** $B^c = M \times G$ matrix of factor inputs for country $c$. The $fi^{th}$ element of this matrix is the amount of inputs of factor $f$ used per unit of output of good $i$ produced.

   **NOTE:** When intermediate goods are used then we say that the $fi^{th}$ element of this matrix is the total (direct plus indirect) use of input $f$ per unit of net output of good $i$.

2. **Net Output Vector:** $Y^c = G \times 1$ vector of output in country $c$. The $i^{th}$ element of $Y^c$ is the output of good $i$ in country $c$ (with intermediate goods it is net output). Let $Y^W = G \times 1$ vector of world net output of goods.

3. **Factor Endowment Vector:** $V^c = M \times 1$ vector of factor endowments of country $c$. The $f^{th}$ element of $V^c$ is the amount of factor $f$ that country $c$ possesses. For us, $M=2$ (K and L).

**FACT 1:** Since we have FPE, technology matrix is the same in all countries. Let $B^c = B$ for all countries.

**FACT 2:** By definition, $BY^c = V^c$.

**Note:** Fact 2 implies that factor prices are such that we have full employment of factors (market clearing).

Also, since FACT 2 holds for every country, $BY^W = V^W$. 
DEMAND SIDE:

4. **Demand Vector**: \( D^c = G \times 1 \) vector of demand for goods in country \( c \). The \( i^{th} \) element of \( D^c \) is the demand for good \( i \) in country \( c \).
   
   Let \( D^W = G \times 1 \) vector of demand for goods in the world.

**FACT 3**: By Assumption 4 (market clearing), world demand equals world supply (output): \( D^W = Y^W \)

**Assumption 5**. Simple demand structure so that each country consumes in proportion to its GDP (total output). Let country \( c \)'s GDP as a proportion of world GDP be \( s^c \).

**FACT 4**: \( D^c = s^c Y^W \)

**General Equilibrium Result**:

**RESULT 1**: \( BD^c = s^c BY^W = s^c V^W \)

First equality is from FACT 4 (pre-multiply both sides by \( B \)). Second equality is from FACT 2.
TWO TESTS OF THE BASIC HOV MODEL:

**P1:** (With Production data)
By FACT 2, \( B Y^c = V^c \) for all countries.

**T1:** (With Trade data)
Let the \( G \times 1 \) trade vector for country \( c \) be denoted by \( T^c \). We note that trade is simply the difference between domestic output and domestic demand: \( T^c = Y^c - D^c \). Then, for every country (indexed by \( c \)),
\[
BT^c = B(Y^c - D^c) = BY^c - BD^c = V^c - s^c V^W,
\]
where the final equality uses P1 and RESULT 1.

In sum, this test is: \( BT^c = V^c - s^c V^W \).

**Discussion:** Both these tests are stated in terms of matrices that can be measured using real world data. You will test these two hypotheses. P1 uses data on technology (\( B \) from input output matrices of a representative country, say U.S. [show example]), data on output (\( Y^c \) from country \( c \)’s national accounts), and data on factor endowments (from country \( c \)’s manufacturing surveys and various other sources of world data).

T1 uses, in addition to data for P1, data on trade (\( T^c \) from same source as used in Data Analysis I). \( s^c \) is simple to get, and \( V^W \) is the sum of individual countries’ endowment vectors.
III: Extensions of The Heckscher-Ohlin-Vanek Model

III.1 Technical Differences

Simple way to deal with technological differences (unlike Eaton-Kortum, where this is the focus) is through “Hicks-neutral” shifts:

$$B^c = \lambda^c B,$$

where $\lambda^c$ is the shift parameter for country $c$ (each country has a different shift parameter by which a common technology matrix $B$ is “shifted”). For example, if $\lambda^{US} = 1$ (base case=1) and $\lambda^{ITALY} = 2$, then (all) U.S. factors are twice as productive as the corresponding Italian factors.

Redefine factors in *efficiency terms* as:

$$V^{cE} = \left(\frac{1}{\lambda^c}\right) V^c$$

The lhs now adjusts the raw factors $V^c$ (i.e. hours of labor, dollars of capital, acres of land) for “quality”. So if 1 acre of land in the US can grow twice as much wheat than Mexico (e.g. $\lambda^{US} = 1$, $\lambda^{MEXICO} = 2$), then, effectively, Mexico has half as much land of the same quality as the US. So $V^{cE}$ is quality-adjusted factors, so all of the factors are measured in same efficiency units.
TESTS OF THE EFFICIENCY ADJUSTED HOV MODEL:

**P3:** (With Production data)
\[ \mathbf{BY}^c = \mathbf{V}^{cE} \] for all countries.

**T3:** (With Trade data)
\[ \mathbf{BT}^c = \mathbf{V}^{cE} - s^c \mathbf{V}^{WE} \]

Note that the \( \mathbf{B} \) matrix is the same.
III.2 No FPE: Traded vs. Non-Traded goods

Without factor price equalization, two effects:

1. The failure of FPE leads countries to specialize in different tradable goods.

2. Further, even though all countries produce the same nontradable goods, the failure of FPE leads them to use different techniques of production (same isoquants, but production at different points on the isoquants).

Due to 1. and 2., $B$ differs across countries. So we use the notation $B^c$.

[See Feenstra (2002) for more detailed explanation.]
In order to deal with failure of FPE:

Step 1.
Separate out $B^e$ into the part used to produce nontradable goods and the part used to produce tradables:

$$B^e = [B^{cN} \ B^{cT}]$$

Step 2.
Similarly separate output

$$Y^e = \begin{bmatrix} Y^{cN} \\ Y^{cT} \end{bmatrix}$$

With factor market clearing,

$$B^e Y^e = V^e.$$  
This is the basis of the test with Production data.

Step 3.
In order to develop the test with Trade data, break this up into T- and N-components:

$$B^{cN} Y^{cN} + B^{cT} Y^{cT} = V^e$$

or

$$B^{cT} Y^{cT} = V^e - B^{cN} Y^{cN}$$

The expression on the rhs is basically the amount of factors embodies in the production of tradable goods. Let it be denoted $V^{cT}$. Then

$$(*) \quad B^{cT} Y^{cT} = V^{cT}.$$
Step 4.
We will make simple assumption about preferences:

i. every country spends a fixed proportion on tradables and nontradables (e.g. 50% on tradables, and 50% on nontradables)

ii. every country spends on tradables according to its share in world’s total income. Denote this share for country $c$ as $s^c$ (e.g. is country $c$’s GDP is $100$ and world’s GDP is $1000$, then it’s share in world income is $0.10$. Here, $s^c = 0.10$.)

Note that the world production vector $Y_W$ is:

$$Y_W = \sum_{c=1}^{J} Y^c$$

(sum for all $J$ countries)

Let $D^c$ denote $c$’s demand (absorption) of world’s production. Then:

$$D^c = s^c Y_W = s^c \sum_{c=1}^{J} Y^c$$

Specifically, $c$’s absorption from country $c'$, denoted is $D^{cc'}$ is:

$$D^{cc'} = s^c Y^{c'}.$$

Now break up absorption by tradables ($D^{cc'T}$) and nontradables ($D^{cc'N}$):
Finally, for tradables, note that if $c \neq c'$, then $D^{ce'T} = M^{ce'}$ (imports of $c$ from $c'$). If $c = c'$, then $D^{ce'T} = D^{ceT}$, which is simply spending on domestically produced tradable goods.

Now let’s work our way to the main result. First, due to our assumption about preferences, the demand by $c$ for tradables produced in $c'$, $D^{ce'T}$, is

$$D^{ce'T} = s^c Y^{c'T}.$$  

The factor content of this demand is $B^{c'T} D^{ce'T}$ (premultiply by $B^{c'T}$ since production is in $c'$), which is

$$B^{c'T} D^{ce'T} = s^c B^{c'T} Y^{c'T} = s^c V^{c'T}.$$  

The second equality uses notation in Step 3: $V^{c'T}$ is the vector of factors used to produce tradables in country $c'$.

Second, summing over all countries:

$$\sum_{c' = 1}^{J} B^{c'T} D^{ce'T} = \sum_{c' = 1}^{J} s^c V^{c'T}.$$
Rewrite this as

\[(***) \quad B^c T D^{ccT} + \sum_{c' \neq c} B^{c'T} M^{cc'} = s^e \ V^{WT},\]

where lhs breaks up domestic production and imports,

while on rhs we use the notation \( V^{WT} = \sum_{c' = 1}^{J} V^{c'T} \).

Now, subtracting each side of (*) from corrp. side of (**):

\[(***) \quad B^c T Y^{cT} - \gamma B^c T D^{ccT} + \sum_{c' \neq c} B^{c'T} M^{cc'} = V^{cT} - s^e V^{WT}.\]

So we get the simple HOV equation but (i) restricted to world endowments in tradable production, and (ii) weight absorption according to actual technique of production used in each country.

But recall that failure of FPE affects tradables and nontradables.
The rhs of (****) can be expanded as:

\[
V^c T - s^c V^{WT} = (V^c - B^{c N} Y^{c N}) - s^c \sum_{c' = 1}^{J} [V^{c'} - B^{c' N} Y^{c' N}]?
\]

\[
= (V^c - s^c V^W) - B^{c N} Y^{c N} - s^c \sum_{c' = 1}^{J} B^{c' N} Y^{c' N}?
\]

\[
(***) = (V^c - s^c V^W) - (V^{c N} - s^c V^{WN})?
\]

The second inequality rearranges the expression, and the third equality uses the notation $V^{c N}$ for resources devoted in country $c$ to nontradables production.
TESTS OF THE HOV MODEL WITHOUT FPE

**P5** (Production data) From Step 2:
\[ B^c Y^c = V^c \] for all countries.
(Note this includes tradables and nontradables)

**T5:** (With Trade data) From (***) and (****):
\[
B^cT Y^cT - \bar{B}^cT D^{cT} + \sum_{c' \neq c} B^{c'T} M^{c'c'} = (V^c - s^c V^W) - (V^{cN} - s^c V^{WN})
\]

Note that the \( B \) matrix differs for each country, and in T5 uses only its tradables part.
VARIATIONS/EXTENSIONS OF T5

T6: Same as T5 but uses ROW technology as well.

T7: (With Trade data) From (***) and (****):

\[
B^cY^c - \sum_{c' \neq c} B^{c'} M^{c'e'} + \sum_{c' \neq c} B^{c'} M^{c'e'}
\]

\[
= V^c - \sum_{c' \neq c} D^{c'e} + \sum_{c' \neq c} B^{c'} M^{c'e'}
\]

where \(D^{c'e}\) and \(M^{c'e'}\) are the fitted values using a gravity model (we will skip T6 and T7).

IV: Calculating the Technology Matrices B

In P1, P3, P5, different B matrices are to be used. Same with T1, T3, T5 (T5, T6, T7 uses same B)

• In P1 and T1, \(B = B^{US}\)
• In P3 and T3, \(B^c = B^{c\lambda}\)
  where \(B^{c\lambda}\) accounts for Hicks-neutral technical differences.
• In P5 and T5-T7, \(B^c = B^{cH}\)
  where \(B^{cH}\) is the technology matrix when FPE fails.

Let’s figure out how to get \(B^{c\lambda}\) and then \(B^{cH}\).
Figuring out how to get $B^{e\lambda}$ (for P3, T3 tests)

Recall, $B^e = \lambda^e B$. Let the element of $B$ corresponding to factor $f$ ($f=K,L$) and good $i$ ($i=1,...,34$), be denoted $B_{fi}$. [So there are 68 elements in each country’s $B$ matrix].

Note that, taking logs, $\ln B^e = \ln \lambda^e + \ln B$. Let $\theta^e=\ln \lambda^e$. Then $\ln B^e = \theta^e + \ln B$.

D&W use this to estimate each element of $B$ (so that we get different $B$ matrices for each country), using a regression model:

$$\ln B^{e}_{fi} = \theta^e + \beta_{fi} + \text{error}.$$ 

Idea is we have data on lhs variables (IO matrices of all 10 OECD countries), so we have $68\times10=680$ observations. We want to estimate a 68 element matrix that is “common” to all countries from the 68 parameters $\beta_{fi}, f=1,2$ and $i=1,...,34$. These parameters are estimated as the coefficients on the 68 dummy variables for the 2 factors and 34 goods. Now the 10 parameters $\theta^e$, one for each country, are estimated as the coefficients on the 10 country dummies.

Then the $fi$-element of the technology matrix of country $c$ is given as: $\exp(\hat{\theta}^c + \hat{\beta}_{fi})$, where “hats” indicate estimated parameters.
Figuring out how to get $B^{cH}$ (for P5, T5 tests)

D&W estimate a regression model for the no FPE case based on the fact that in countries with a higher K/L ratio, more K-intensive techniques of production are used (here in tradables):

$$\ln B_{fi}^c = \theta^c + \beta_{fi} + \gamma^T \ln (K^c/L^c) + \text{error},$$

Actually this model has three new variables to estimate the three $\gamma^T$ parameters: $\gamma_{K,Tradables}, \gamma_{K,Nontradables}, \gamma_{L,Tradable}$. These variables are constructed as $\ln (K^c/L^c)$ multiplied by the 3 dummies, one each for $(K,Tradables), (K,Nontradables), (L,Tradables)$. That is, dummy $D^{KT}$ takes on the value 1 if the observation pertains to the factor $K$ and the good is a tradable good (similar defs apply to dummies $D^{KN}$ and $D^{LT}$).

Then the $fi$-element of the technology matrix of country $c$ is given as: $\exp(\hat{\theta}^c + \hat{\beta}_{fi} + \hat{\gamma}^{iT})$. Note that estimates of the $\gamma^T$ parameters are applied when $i=T$ (tradable) or $i=N$ (nontradable).

**Discuss Table 1.**
<table>
<thead>
<tr>
<th>Model</th>
<th>Measurement error</th>
<th>H Hicks-neutral technical differences (HNTD)</th>
<th>Continuum model with HNTD and FPE</th>
<th>Helpman no-FPE model with HNTD</th>
<th>Unrestricted Helpman no-FPE model with HNTD</th>
<th>Implied $A^C$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta_{ASS}$</td>
<td>(P2)</td>
<td>(P3)</td>
<td>(P4)</td>
<td>(P5)</td>
<td>(P5')</td>
<td>1.7</td>
</tr>
<tr>
<td>$\theta_{Con}$</td>
<td>0.531</td>
<td>0.531</td>
<td>0.530</td>
<td>0.528</td>
<td>1.5</td>
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<td>$\theta_{Den}$</td>
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<td>0.381</td>
<td>0.380</td>
<td>0.381</td>
<td>1.7</td>
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<td>$\theta_{Fra}$</td>
<td>0.035</td>
<td>0.035</td>
<td>0.035</td>
<td>0.034</td>
<td>1.6</td>
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<td>$\theta_{Ger}$</td>
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<td>0.493</td>
<td>0.494</td>
<td>0.492</td>
<td>1.1</td>
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<tr>
<td>$\theta_{Ita}$</td>
<td>0.112</td>
<td>0.111</td>
<td>0.112</td>
<td>0.111</td>
<td>1.1</td>
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<td>$\theta_{Jpn}$</td>
<td>0.709</td>
<td>0.707</td>
<td>0.709</td>
<td>0.704</td>
<td>2.0</td>
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<tr>
<td>$\theta_{Neth}$</td>
<td>0.431</td>
<td>0.430</td>
<td>0.431</td>
<td>0.430</td>
<td>1.5</td>
<td></td>
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<tr>
<td>$\theta_{UK}$</td>
<td>0.057</td>
<td>0.057</td>
<td>0.056</td>
<td>0.058</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>$\theta_{US}$</td>
<td>0.520</td>
<td>0.516</td>
<td>0.520</td>
<td>0.542</td>
<td>1.7</td>
<td></td>
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<tr>
<td>$\gamma^{KT}$</td>
<td>0.034</td>
<td>0.034</td>
<td>0.034</td>
<td>0.040</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>$\gamma^{KN}$</td>
<td>(0.046)</td>
<td>(0.061)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>$\gamma^{LT}$</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td></td>
</tr>
</tbody>
</table>

Number of parameters: 68

$-\log L$: 1741.5

Schwarz criterion: 1963.3

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

V.1 Production Tests

Recall $P1$: $BY^c = V^c$ for all countries.

1. Slope test:
   Regression of measured factor content of production (MFCP) on predicted factor content of production (PFCP). So the regression model is:
   
   $MFCP = \alpha PFCP + \text{error}$
   
   Example: for $P1$, MFCP is $BY^c$ and PFCP is $V^c$.
   The HOV model’s prediction is $\alpha=1$.

2. Median Error test:
   absolute value of prediction error as a proportion of PFCP or $|\text{error}|/PFCP$.
   Example: for $P1$, this is $|BY^c - V^c|/ V^c$. 
V.2 Trade Tests

Recall \( T1: BT^c = V^c - s^c V^W \).

1. Slope test:
   Regression of measured factor content of trade (MFCT) on predicted factor content of trade (PFCT).
   So the regression model is:

   \[
   MFCT = \alpha \text{ PFCT} + \text{error}
   \]

   Eg.: for \( T1 \), MFCT is \( BT^c \) and PFCT is \( V^c - s^c V^W \).
   The HOV model’s prediction is \( \alpha=1 \).

2. Sign test:
   Asks if signs are as predicted:
   \( \text{sign(MFCT)} = \text{sign(PFCT)}? \)
   Express as \% of sample correctly predicted.
   Varies from 0 to 1

3. Variance Ratio test:
   Variance(MFCT)/Variance(PFCT).
   Varies from 0 (poor fit) to 1 (perfect fit)
Discuss Table 3 and 4, Discuss Figures 1, 2, 4, 7, 8.

Done!

Recap:

Note that if use actual IO matrices of each country then the production test is exactly satisfied, by construction. As on p. 1430, eq. (1) states that $BY \equiv V$ for each country and eq. (2) states $Y-D \equiv T$ for each country. That is, the endowment data $V$ and matrices of direct factor requirements $B$ are constructed so that these are satisfied. That is, $V$ is what the data say they are. Question is whether the endowments thus constructed are also what the theory says they should be.

Essentially, the D&W papers says (i) if FPE holds, then technology should be the same. Then do P1/T1 (&P2/T2). (ii) FPE is also consistent w/ Hicks-neutral shifts, so do P3/T3. (iii) If no FPE then use Helpman to understand what $B$-matrices are reasonable for tradables and nontradables. Assume tradables and nontradables matrices correlated with K/L ratios in order to reconstruct what the theory says the technologies should be.
Table 3—Production and Trade Tests
All Factors

<table>
<thead>
<tr>
<th>Production tests: Dependent variable MFCP</th>
<th>(P1)</th>
<th>(P2)</th>
<th>(P3)</th>
<th>(P4)</th>
<th>(P5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted</td>
<td>0.24</td>
<td>0.33</td>
<td>0.89</td>
<td>0.89</td>
<td>0.97</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.09</td>
<td>0.11</td>
<td>0.06</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.27</td>
<td>0.29</td>
<td>0.92</td>
<td>0.94</td>
<td>1.00</td>
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<tr>
<td>Median error</td>
<td>0.34</td>
<td>0.21</td>
<td>0.07</td>
<td>0.05</td>
<td>0.03</td>
</tr>
<tr>
<td>Observations</td>
<td>20</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
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</table>

<table>
<thead>
<tr>
<th>Trade tests: Dependent variable MFCT</th>
<th>(T1)</th>
<th>(T2)</th>
<th>(T3)</th>
<th>(T4)</th>
<th>(T5)</th>
<th>(T6)</th>
<th>(T7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted</td>
<td>-0.002</td>
<td>-0.006</td>
<td>-0.05</td>
<td>0.17</td>
<td>0.43</td>
<td>0.59</td>
<td>0.82</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.005</td>
<td>0.003</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.04</td>
<td>0.03</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.01</td>
<td>0.14</td>
<td>0.31</td>
<td>0.77</td>
<td>0.96</td>
<td>0.92</td>
<td>0.98</td>
</tr>
<tr>
<td>Sign test</td>
<td>0.32</td>
<td>0.45</td>
<td>0.50</td>
<td>0.86</td>
<td>0.86</td>
<td>0.82</td>
<td>0.91</td>
</tr>
<tr>
<td>Variance ratio</td>
<td>0.0005</td>
<td>0.0003</td>
<td>0.008</td>
<td>0.07</td>
<td>0.19</td>
<td>0.38</td>
<td>0.69</td>
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<tr>
<td>Observations</td>
<td>22</td>
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<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
</tr>
</tbody>
</table>

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.
<table>
<thead>
<tr>
<th></th>
<th>Production tests: Dependent variable MFCP</th>
<th>Trade tests: Dependent variable MFCT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(P1)</td>
<td>(P2)</td>
</tr>
<tr>
<td>Predicted</td>
<td>0.77</td>
<td>0.99</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.11</td>
<td>0.15</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.84</td>
<td>0.84</td>
</tr>
<tr>
<td>Median error</td>
<td>0.34</td>
<td>0.20</td>
</tr>
<tr>
<td>Sign test</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Production and Trade Tests**

**Labor**

<table>
<thead>
<tr>
<th></th>
<th>Production tests: Dependent variable MFCP</th>
<th>Trade tests: Dependent variable MFCT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(P1)</td>
<td>(P2)</td>
</tr>
<tr>
<td>Predicted</td>
<td>0.07</td>
<td>0.12</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.06</td>
<td>0.09</td>
</tr>
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<td>$R^2$</td>
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<td>0.16</td>
</tr>
<tr>
<td>Median error</td>
<td>0.42</td>
<td>0.22</td>
</tr>
<tr>
<td>Sign test</td>
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</tbody>
</table>

**Notes:** The theoretical coefficient on "predicted" is unity. The theoretical value of the sign test is unity (100-percent correct matches).
Table 5—Trade Tests
Excluding ROW and the United States
All Factors

<table>
<thead>
<tr>
<th>Trade tests: Dependent variable MFCT</th>
<th>(T1)</th>
<th>(T2)</th>
<th>(T3)</th>
<th>(T4)</th>
<th>(T5)</th>
<th>(T6)</th>
<th>(T7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prediction</td>
<td>-0.05</td>
<td>-0.04</td>
<td>0.05</td>
<td>0.30</td>
<td>0.35</td>
<td>0.42</td>
<td>0.64</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.01</td>
<td>0.01</td>
<td>0.07</td>
<td>0.07</td>
<td>0.11</td>
<td>0.14</td>
<td>0.09</td>
</tr>
<tr>
<td>Sign test</td>
<td>0.28</td>
<td>0.39</td>
<td>0.56</td>
<td>0.61</td>
<td>0.83</td>
<td>0.78</td>
<td>0.89</td>
</tr>
<tr>
<td>Variance ratio</td>
<td>0.00</td>
<td>0.01</td>
<td>0.09</td>
<td>0.09</td>
<td>0.30</td>
<td>0.49</td>
<td>0.54</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.47</td>
<td>0.33</td>
<td>0.03</td>
<td>0.51</td>
<td>0.41</td>
<td>0.36</td>
<td>0.76</td>
</tr>
</tbody>
</table>

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 $\text{Var(MFCT)}/\text{Var(PFCT)}$ and has a theoretical value of unity.
Figure 1. Production with Common Technology (US) (P1)
Figure 2. Trade with Common Technology (US) (T1)
Figure 4. Production with Hicks-Neutral Technical Differences (P3)
Figure 7. Production without FPE
(P5)
Figure 8. Trade with No-FPE, Nontraded Goods (T5)