The Harrod-Balassa-Samuelson Effect: Reconciling the Evidence

ECB - BoC Workshop: “Exchange Rates and Macroeconomic Adjustment”
15 - 16 June 2011
Introduction & Motivation: HBS Hypothesis

- Developed by Harrod (1933), Balassa (1964) and Samuelson (1964)

- To explain sustained real exchange rate (RER) appreciations in rapidly growing economies, via productivity increases
  - Strongest evidence in Japan and Eastern Europe

- Posits that relatively strong productivity growth in the tradables sector raises the relative price of nontradables and the RER

- Provides an argument against long-run purchasing power parity
Japan: RER and Real Per Capita Income

(1970 = 100)
Poland, Czech & Slovakia: RER & Real Per Capita Income

(1994 = 100)

Poland - REER index
Czech Republic - REER index
Slovakia - REER index
Poland - Real GDP per capita index
Czech Republic - Real GDP per capita index
Slovakia - Real GDP per capita index
Brazil, Chile and Mexico: RER & Per Capita Income

(1994 = 100)
RER adjustment in Latin America versus East Asia

Chart 2: EME Real Effective Exchange Rate

Source: JP Morgan
Purpose: Reconciling the evidence

- The main purpose of the paper is to attempt to reconcile the mixed evidence surrounding the HBS hypothesis
- Both theoretically and empirically
- Derive a theoretically based empirical model
  - Using per-capita income is not a true test of HBS hypothesis
- Estimate the model using a consistent OECD panel database on labour productivity by sector
Methodology / Outline

1. Derive the *conventional* empirical model for the HBS hypothesis

2. Derive an *extended* version of the empirical model of the HBS hypothesis using a monopolistically competitive model

3. Estimate the empirical model using time series/panel data techniques

4. Interpret and reconcile the results
Theoretical Framework

- Derive the empirical relations to represent the HBS hypothesis

- Two countries (home and foreign), one factor (labour), and two composite goods (tradable and nontradable goods)

- Focus on long-run effects: Assume flexible prices, financial autarky, mobile labour and balanced trade

- To facilitate comparison across two models, assume CES aggregators and a continuum of goods in tradable and nontradable bundles
The Conventional Model

Consumption: Aggregate, Nontradable and Tradable

\[ C = \left[ \gamma^{1/\varepsilon} C_N^{(\varepsilon-1)/\varepsilon} + (1 - \gamma)^{1/\varepsilon} C_T^{(\varepsilon-1)/\varepsilon} \right]^{\varepsilon/(\varepsilon-1)} \]

\[ C_N = \left[ \int_{i \in \Omega_N} C_N(i)^{(\sigma-1)/\sigma} \, di \right]^{\sigma/(\sigma-1)} \]

\[ C_T = \left[ \int_{j \in \Omega_T} C_T(j)^{(\sigma-1)/\sigma} \, dj \right]^{\sigma/(\sigma-1)} \]

Production: Nontradable and Tradable

\[ Y_N(i) = A_N L_N(i) \]

\[ Y_T(j) = A_T L_T(j) \]
The Conventional Model

Real Exchange Rate Relation:

- Each country’s tradable/nontradable productivity ratio affects the RER via the relative price of nontradables

- Assume that the share of nontradables is same across countries, the RER is related to home/foreign productivity ratio in each sector

- Letting a hat over a variable denote the log deviation from its initial value, obtain a typical form of the HBS relation:

\[ \hat{Q} = \gamma (\hat{A}_T - \hat{A}_T^*) - \gamma (\hat{A}_N - \hat{A}_N^*) \]
Monopolistic Competition Model

- Monopolistic competition in each sector with symmetrical firms and free entry

- Nontradable good is still an aggregate of (nontradable) varieties

- Tradable good now is of a continuum of home & foreign varieties:

\[
C_T = \left[ \theta^{1/\eta} C_H^{(\eta-1)/\eta} + (1 - \theta)^{1/\eta} C_F^{(\eta-1)/\eta} \right]^{\eta/(\eta-1)}
\]

\[
C_H = \left[ \int_{j \in \Omega_H} C_H(j)^{(\sigma-1)/\sigma} dj \right]^{\sigma/(\sigma-1)}
\]

\[
C_F = \left[ \int_{j^* \in \Omega_F} C_F(j^*)^{(\sigma-1)/\sigma} dj^* \right]^{\sigma/(\sigma-1)}
\]
Monopolistic Competition Model

- $1/A_N$ and $1/A_H$ units of labor to produce a unit of a domestic non-tradable and a tradable variety

- $\phi/A_N$ and $\phi/A_H$ fixed amounts for non-production activities

- In the monopolistic competition model, home-foreign productivity differentials affect the RER through two additional channels:
  1. the terms of trade
  2. the number of home and foreign varieties
Monopolistic Competition Model

Real Exchange Rate Relation:

- Solve the model to derive:

\[ \hat{Q} = (\gamma + T_1 + N_1)(\hat{A}_F - \hat{A}_H^*) + (-\gamma + T_2 + N_2)(\hat{A}_N - \hat{A}_N^*) \]

- \( \gamma \) represents the conventional effect via the nontraded/traded price ratios

- \( T_1, T_2 \) are the terms of trade channel effects

- \( N_1, N_2 \) are the number of varieties channel effects
The terms of trade channel effects depend on:

1. $\epsilon$ - elasticity of substitution between tradables and nontradables
2. $\eta$ - elasticity of substitution between home and foreign tradables
3. $\theta - \theta^*$ - home bias in the consumption of tradable goods

The effects via the number of varieties channel also depend on the same parameters.
Data

- Annual data from 1977 to 2006 – 30 observations per country
- 16 OECD countries: Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Korea, the Netherlands, Norway, Portugal, Sweden, U.K. and U.S.
- RER and productivity differential data are calculated relative to the average of the rest of the sample
- RER is obtained using NER and CPI from the IMF’s IFS database
- Labour productivity is output per employee in four tradable goods industries and five nontradable goods industries from the OECD’s STAN database
Regression model and estimation

- Dynamic OLS specification (to incorporate co-integration)

\[ \ln Q_i = \delta_i + \beta_i^T (\ln A_{iT} - \ln A_{wT}) + \beta_i^N (\ln A_{iN} - \ln A_{wN}) + \text{one lead and one lag of the first differences} \]

- HBS Hypothesis: \( \beta_i^T > 0 \) and \( \beta_i^N < 0 \)

- Three different panel DOLS techniques:
  1. Fixed -Effect Panel: Homogeneous LR & SR coefficients
  2. Pooled Mean-Group Panel: Homogeneous LR coefficients
  3. Group Mean Panel: Panel average of heterogeneous LR coefficients
## Estimation results: World Base

<table>
<thead>
<tr>
<th>DOLS Estimation Technique</th>
<th>Tradable Productivity Differential</th>
<th>Nontradable Productivity Differential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed-Effect Panel</td>
<td>-0.31** (0.13)</td>
<td>0.43 (0.32)</td>
</tr>
<tr>
<td>Pooled-Mean Group Panel</td>
<td>-0.19*** (0.04)</td>
<td>0.04 (0.12)</td>
</tr>
<tr>
<td>Group-Mean Panel</td>
<td>-0.48*** (0.10)</td>
<td>0.29*** (0.13)</td>
</tr>
<tr>
<td>Dependent Variable: $\ln RER$</td>
<td>Sample: 1977-2006</td>
<td></td>
</tr>
</tbody>
</table>
Estimation Results: Other Notable Findings

- Using the U.S. or Germany as the basis for comparison does not change the qualitative nature of the results
  - Values/significance of the coefficients change somewhat

- The results using aggregate productivity as the explanatory variable, as a proxy for per capita income, are more mixed

- Estimates by country are very heterogeneous with no obvious pattern
Interpreting and Reconciling the Results

- The mixed results are consistent with other findings
  - E.g., Peltonen and Sager (ECB, 2009)

- Theoretical reconciliation
  - Numerically simulating the theoretical monopolistic competition model with different estimates for key substitution elasticities

- Empirical reconciliation
  - Investigate robustness of the results
Home-Foreign Goods Substitution Elasticity

- The effect of the tradable productivity differential depends on $\eta$
  - Below a critical value, the effects (via the terms of trade and number of varieties channels) can cause a real depreciation
  - The increase in home productivity causes an increase in supply and a decline in the terms of trade

- Thus, the conventional HBS effect can be offset and even reversed for a small enough value of $\eta$
Tradable-Nontradable Substitution Elasticity

- If $\varepsilon > 1$, the nontradable productivity differential causes a RER appreciation via the terms of trade
  - E.g., a productivity increase in home nontradables would raise the share of nontradables and reduce the supply of tradables, thereby increasing the terms of trade

- The nontradable productivity differential could also cause a real appreciation via the number of varieties

- Thus, the sign of the coefficient of non-tradable productivity differential in the conventional model could also be reversed
Reconciling the Results: Numerical Simulation

- We use data for OECD countries (averaged over periods & countries) to set the nontradable share equal to 0.73 and the home bias equal to 0.3.

- We let the elasticity of substitution between varieties ($\sigma$) equal to 6 based on the evidence on mark-ups $\sim$ 20%.

- Estimates of the elasticity of substitution between home and foreign tradable goods ($\eta$) range from $<1$ to $>>1$.

- Estimates of elasticity of substitution between tradable and non-tradable goods ($\varepsilon$) has received less attention, but worth exploring.
  - Typically assumed to be close to one.
Numerical simulation: Effects on $lnQ$ (RER)

<table>
<thead>
<tr>
<th>$\varepsilon$</th>
<th>$\eta$</th>
<th>$ln A_T - ln A_T^*$</th>
<th>$ln A_N - ln A_N^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>3.0</td>
<td>0.594</td>
<td>-0.801</td>
</tr>
<tr>
<td>1.0</td>
<td>1.0</td>
<td>-0.091</td>
<td>-0.802</td>
</tr>
<tr>
<td>1.0</td>
<td>0.5</td>
<td>-1.659</td>
<td>-0.803</td>
</tr>
<tr>
<td>2.0</td>
<td>3.0</td>
<td>0.532</td>
<td>-0.756</td>
</tr>
<tr>
<td>2.0</td>
<td>1.0</td>
<td>-0.227</td>
<td>-0.0375</td>
</tr>
<tr>
<td>2.0</td>
<td>0.5</td>
<td>-0.0925</td>
<td>0.009</td>
</tr>
<tr>
<td>3.0</td>
<td>3.0</td>
<td>0.476</td>
<td>-0.705</td>
</tr>
<tr>
<td>3.0</td>
<td>1.0</td>
<td>-0.300</td>
<td>-0.130</td>
</tr>
<tr>
<td>3.0</td>
<td>0.5</td>
<td>-0.733</td>
<td>0.219</td>
</tr>
</tbody>
</table>
Empirical robustness

- Consider different samples periods

- Signs of estimated LR coefficients on the productivity differentials are sensitive to the sample period

- Lee and Tang (2007) also find that the results are sensitive to the definition of productivity (TFP versus labour)
Recursive Regression Results: U.S. Base

Coefficients for US-based series
- Tradable Sector
- Non-tradable Sector

Last year of sample
Recursive Regression Results: World Base

Coefficients for world-based series

- Tradable Sector
- Non-tradable Sector

Last year of sample:
- 1995
- 1996
- 1997
- 1998
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006

Values range from -0.8 to 0.6.
Concluding remarks

- Made progress in understanding mixed empirical results for HBS hypothesis by extending theoretical model

- Empirical results are unstable over time and across countries
  - Sample may be too short to obtain low-frequency estimates
  - Time series/panel techniques unable to remove cyclical effects and other macro factors

- Future work:
  - Investigate the empirical results further (e.g., RER & China)
  - Build a dynamic version of model to replicate mixed empirical results
Extra slides
The Terms of Trade Channel

- The effects through the terms of trade adjustment are

\[
T_1 = \frac{\sigma[\gamma(1 - \beta) + \beta](1 - \gamma + \gamma \tilde{\varepsilon})}{(\sigma - 1)\Delta}
\]

\[
T_2 = \frac{-\sigma\gamma[\gamma(1 - \beta) + \beta](\tilde{\varepsilon} - 1)}{(\sigma - 1)\Delta}
\]

\[\Delta \equiv 1 - (1 - \gamma + \gamma \tilde{\varepsilon})(1 - \beta) - \eta(1 + \beta)\]

\[\tilde{\varepsilon} \equiv \varepsilon(\sigma - 1) / (\sigma - \varepsilon), \beta = \theta - \theta^*\]

- The effects depend on:
  - \(\varepsilon\) the elasticity of substitution between tradables & nontradables
  - \(\eta\) the elasticity of substitution between home & foreign tradables
  - \(\beta\) the home bias in the consumption of tradable goods
The Number of Varieties Channel

- The effects through the adjustment of number of varieties are

\[
N_1 = \frac{\tilde{\varepsilon} \gamma}{\sigma - 1} \left[ 1 + \frac{(1 - \gamma + \gamma\tilde{\varepsilon})}{\tilde{\Delta}} \right]
\]

\[
N_2 = \frac{-\tilde{\varepsilon} \gamma}{\sigma - 1} \left[ 1 + \frac{\gamma(\tilde{\varepsilon} - 1)}{\tilde{\Delta}} \right]
\]

- These effects also depend on the two elasticities and home bias
Implications for the Productivity Effects

- Adjustment in terms of trade can weaken or even reverse the effect of the tradable productivity differential on RER via supply effects
  - (Benigno and Thoenissen, 2003)

- The effect through the number of varieties channel has not been fully explored

- The role of the two channels for the effect of the nontradable productivity differential also needs to be examined
Home-Foreign Substitution Elasticity: Estimates

- Controversy about the value of the elasticity of substitution between home and foreign tradable goods

- Estimates based on macro models indicate that the value of this elasticity is low and below 1.0 (Bergin, 2006; Lubik and Schorfheide, 2005)

- Studies based on the disaggregated trade data suggest the average value of the elasticity to be much larger (Imbs and Mejean, 2009)
Tradable-Nontradable Substitution Elasticity: Estimates

- Elasticity of substitution between tradable and non-tradable goods has received less attention
  - Typically assumed to be close to one

- But this assumption is not based on empirical estimation, and this elasticity could be greater than one

- Given the uncertainty about the values of the two elasticities, we consider a wide range of values for these elasticities