International Macroeconomics
Economics of exchange rates

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Recap

This session: Economics of exchange rates

- How can we explain observed movements in real and nominal exchange rates, in the short and long-run?

What this session doesn't look at...

- Market micro-structure models
- Micro-founded models with nominal rigidities
- The role of markups and producer vs. local currency pricing with imperfect competition

Learning points

- Real exchange rate innovations are very long-lived.
- Nominal and real exchange rates are very volatile, with increased volatility for flexible ER regimes.
- The relative importance of relative non-traded goods prices in RER fluctuations is higher than we once thought.
- Better data based on individual relative prices yields different results for LoOP and PPP.
- Long-run real exchange rates behave not unlike the standard Balassa-Samuelson model.
- The simple overshooting model correctly predicts high volatility, but ultimately we don't have a good model for nominal exchange rates.

Roadmap for this section

1. RER and the TOT in the models we have seen so far
2. Short-run exchange rate movements and monetary models
3. PPP, the importance of traded goods, and the long-run behaviour of real exchange rates

RER and the TOT so far: Summary

1. RER and ToT movements crucial for transmission of shocks
2. RER dynamics crucial in arbitrage across assets
3. Law of one price holds in all models. PPP does not hold if preferences differ across countries.
4. Real shocks drive fluctuation in RER and ToT.

Roadmap for this section

1. RER and the TOT in the models we have seen so far
2. Short-run exchange rate movements and monetary models
    - LoOP deviations and the border effect
    - Nominal exchange rate changes and the LoOP
    - Ad hoc monetary models of nominal exchange rates
    - Empirical tests of UIP

I The short run: Volatility, regime dependence and disconnect

Volatility of LoOP deviations

Volatility of LoOP deviations: Engel and Rogers (1996)

- Analyse relative volatility in intra- vs. international relative prices, using city-specific **indices** for CPI components in US and Canada. Find:
  - Volatility of relative prices increases with distance within countries
  - The US-Can border is between 2500 to 23000 miles wide.
  - Relative prices are significantly correlated with nominal exchange rates

Factors preventing goods arbitrage

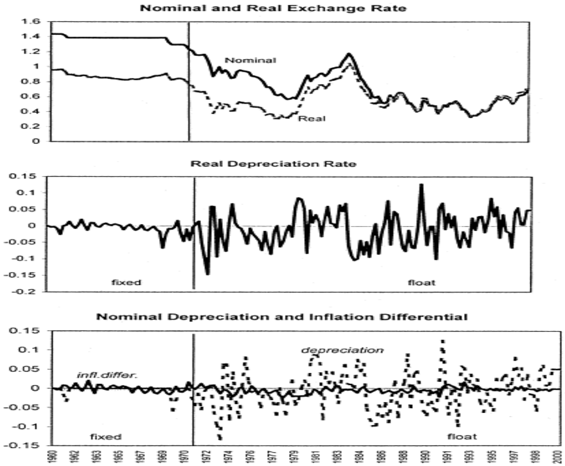
1. Transport costs imply non-linear reaction of trade arbitrage to relative price differences
2. Price differences due to non-tradable inputs cannot be arbitraged by definition
3. Tariffs
4. Non-tariff barriers
5. Pricing to market by monopolistic producers

LoOP strikes back: Broda and Weinstein (2008)

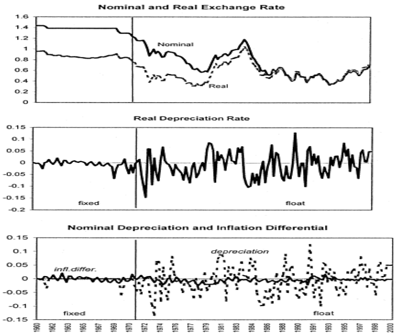
- Use Barcode data from supermarket transactions in US and Canada
  - The effect is much smaller: Border is between 3 and some hundred miles wide.
  - Reason for difference: Indices average out difference in relative prices.
  - Differences due to exchange rates are common for all goods, so do not average out.

Volatility and regime dependence of nominal and real exchange rates

Volatility and regime dependence: Nominal and real exchange rates (US$-DM)



Volatility and regime dependence: Nominal and real exchange rates (US$-DM)



Source: Monacelli 2003

- RER and NER comove strongly, much more volatile than price levels

Monetary shocks and short-run ER movements

1. Comovement of RER - NER, and high volatility makes nominal shocks more likely as source of SR fluctuations
2. Traditional monetary models of exchange rates
   2.1 The standard flex-price model
   2.2 The Dornbusch overshooting model

The standard flex-price model of exchange rates

Recap: The standard flex-price model of exchange rates

1. MD in logs: $m_t - p_t = -\nu i_{t+1} + \phi y_t$
2. y_t and MS are exogenous
3. *UIP*: $i_{t+1} = i^\star_{t+1} + E[e_{t+1}] - e_t$
4. *PPP*: $e_t = p^\star_t - p_t$
5. Eliminating p_t and i_{t+1} from (1) using *PPP* and *UIP* yields

$$m_t - \phi y_t - \nu i^\star_{t+1} - p^\star_t - e_t = -\nu(E[e_{t+1}] - e_t) \qquad (1)$$

6. Solve forward and impose convergence to PPP ($lim\ e_t = 0$) to get

$$e_t = \frac{1}{1-\nu}\sum_{s=t}^{\infty}(\frac{\nu}{1-\nu})^{s-t}E_t(m_s - \phi y_s - \nu i^\star_{s+1} - p^\star_s) \qquad (2)$$

7. So MS level (growth) shocks affect NER level 1 to 1 (more than 1-to-1).

The standard flex-price model of exchange rates

1. HW: Show that with a change in the growth rate from 0 to g the ER change is

$$\Delta e_t = (1 + \nu)g \tag{3}$$

The Dornbusch overshooting model of exchange rates

- What are the implications of monetary shocks for nominal and real exchange rates when prices are not fully flexible

The Dornbusch overshooting model of exchange rates (OR 9.2)

1. MD in logs: $m_t - p_t = -\nu i_{t+1} + \phi y_t$
2. y_t demand-determined, via *AD*: $y_t = \overline{y} + \delta(e_t + p_t^\star - p_t - \overline{q})$
3. *UIP*: $i_{t+1} = i^\star + E[e_{t+1}] - e_t$
4. *RER*: $q_t = e_t + p_t^\star - p_t$
5. *PhC*: $p_{t+1} - p_t = \psi(y_t - \overline{y}) + (\widetilde{p_{t+1}} - \widetilde{p}_t)$, for $\widetilde{p}_t = e_t + p_t^\star - \overline{q}$, or $\widetilde{p_{t+1}} - \widetilde{p}_t = e_{t+1} - e_t + p_{t+1}^\star - p_t^\star$
6. Assuming $p^\star = i^\star = \overline{y} = 0$, *PhC* yields

$$p_{t+1} - p_t = \psi(y_t - \overline{y}) + e_{t+1} - e_t \;\Rightarrow q_{t+1} - q_t = -\psi\delta(q_t - \overline{q}) \quad (4)$$

7. From *RER* $-p_t = q_t - e_t$, from *UIP* $i_{t+1} = E[e_{t+1}] - e_t$, plus *AD* in *MD* yields

$$m_t - e_t + q_t = -\nu(E[e_{t+1}] - e_t) + \phi\delta(q_t - \overline{q}) \quad (5)$$

The Dornbusch overshooting model of exchange rates

$$q_{t+1} - q_t = -\psi\delta(q_t - \overline{q}) \tag{6}$$

$$m_t - e_t + q_t = -\nu(E[e_{t+1}] - e_t) + \phi\delta(q_t - \overline{q}) \tag{7}$$

$$\Delta e_{t+1} = \frac{e_t}{\nu} - \frac{(1-\delta\phi)q_t}{\nu} - \frac{\phi\delta\overline{q} + m_t}{\nu} \tag{8}$$

1. Shock Δm to MS leads to fall in interest rate, so $E[e_{t+1}] - e_t < 0$ from *UIP*
2. So both RER and NER overshoot steady state.
3. Model implies REAL UIP $i_{t+1} - (p_{t+1} - p_t) = q_{t+1} - q_t = -\psi\delta(q_t - \overline{q})$

Evaluation of traditional monetary exchange rate models

- Usual criticism of ad hoc models applies.
- Empirically, Dornbusch model seems to account for effects of monetary reforms.
- Also, explains volatility of RER by SR nominal rigidity and asset-price character of NER
- But: Model hinges on LR PPP and both real and nominal UIP
- Meese and Rogoff (1983): Both flex and sticky price models do worse than random walk in predicting exchange rate movements

UIP and the forward premium puzzle

- UIP: $1 + i_{t+1} = (1 + i^{\star}_{t+1})E[\frac{e_{t+1}}{e_t}]$
- CIP:

$$1 + i_{t+1} = (1 + i^{\star}_{t+1})\frac{F_t}{e_t} \tag{9}$$

for F_t 1-period forward exchange rate. NB: no E[..]!

- Null hyp. that UIP holds on average (or that F_t is unbiased predictor of E_t) implies $a_1 = 1$ in

$$e_{t+1} - e_t = a_0 + a_1(f_t - e_t) + \epsilon_t \tag{10}$$

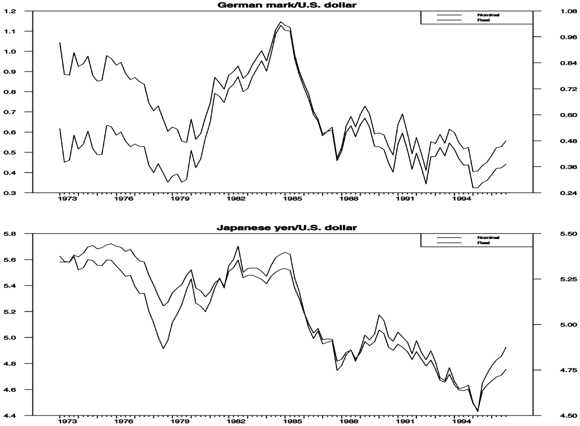
- Estimates $\widehat{a_1}$ are often negative!!
- Time-varying risk-premia bias a_1 downward. But need negative $cov(RP, e_{t+1} - e_t)$ to explain negative $\widehat{a_1}$.

UIP and the forward premium puzzle

- UIP works better in high inflation environments, on coarse horizons, in fixed exchange rate regimes
- Surveys: Engel (1996), Bansal and Dahlquist (2000).

II. The long run: RER persistence and income levels

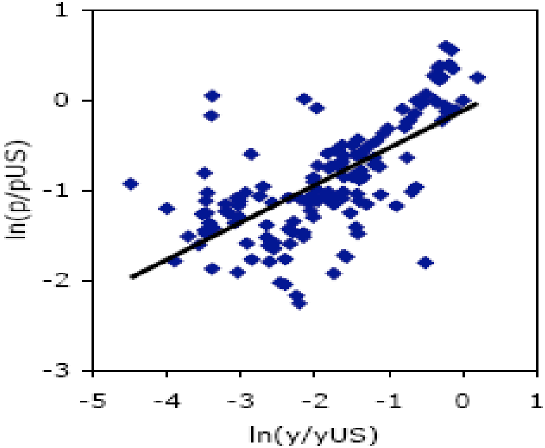
Nominal and RER De / Jap - US



Source: Papell 2002

- Large Long-run movements, and trends, in RER

Income levels and RER



1995 PWT data, Source: Taylor and Taylor 2004

- Higher income - more appreciated RER

II.a PPP: Stationarity and mean reversion of RER

Traditional tests for PPP

- Necessary condition for PPP: stationarity
- Test Null hypothesis $\rho = 1$ against alternative $\rho < 1$ in OLS regression

$$q_t = \rho q_{t-1} + \epsilon_t \tag{11}$$

where q_t is the RER based on CPI prices or some other price index

- Early studies cannot reject Null
- Later studies, using e.g. panel autoregressions, reject Null, but find estimates of ρ around 0.85, implying $half - life$ of 3-5 years.

Imbs et al: PPP strikes back!

- PPP autoregression is based on indices of individiual prices
- Suppose individual prices have heterogeneous slope coefficients ρ_i

$$q_{it} = \rho_i q_{it-1} + \epsilon_{it} \tag{12}$$

where $Ep\epsilon_{it}] = 0$ and $Var_{\epsilon_i} = \sigma_i^2$, and $\rho_i \in]-1, 1[$ with mean ρ

- Show that heterogeneity in ρ_i can bias estimates for ρ based on aggregate indices

Imbs et al: PPP strikes back!

$$q_{it} = \rho_i q_{it-1} + \epsilon_{it}, \; Var(\epsilon_{it}) = \sigma_i^2 \tag{13}$$

- Proposition 1: Sign of bias is given by

$$\Sigma_i(\rho_i - \rho)\sigma_i^2 \tag{14}$$

- Very intuitive: Estimate of average slope coefficient is biased in direction of most volatile individual components. So if $cov(\rho_i, \sigma_i^2) > 0$ get positive bias
- Using Eurostat data, find strong positive bias in aggregate estimates
- Average half-life 11 months, vs. "consensus" view (Engel 1996) of 3-5 years

II.b What drives RER movements?

What drives RER movements? - Engel (1996)

- Definition of RER: $q_t = s_t + p_t^{\star} - p_t$
- Write price index as geometric average of traded and non-traded prices $p_t = (1-\alpha)p_t^T + \alpha p_t^N$
- So can write

$$\begin{aligned} q_t &= s_t + p_t^{\star T} - p_t^T - \alpha[p_t^{\star N} - p_t^{\star T} \;-\; (p_t^N - p_t^T)] \\ &= q_t^T + q_t^N \end{aligned} \quad (15)$$

- So RER is sum of relative price of tradables and difference between nontradables-prices relative to tradable prices
- "Engel decomposition" can be used to understand relative importance of non-tradable goods prices in RER fluctuations

What drives RER movements? - Engel (1996) cont

$$q_t = s_t + p_t^{\star T} - p_t^T - \alpha[p_t^{\star N} - p_t^{\star T} - (p_t^N - p_t^T)] = q_t^T + q_t^N \quad (16)$$

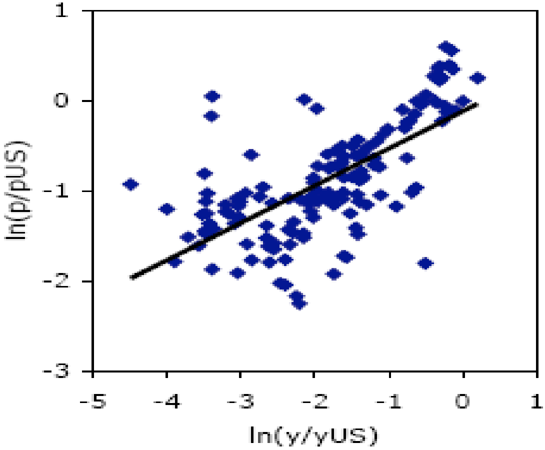
- Engel computes the contribution of changes Δq_t^N to Δq_t at differenct horizons
- Contribution of Δq_t^N is almost negligeable!

q_t^T *Strikes back - Burstein et al (2005, 2006))*

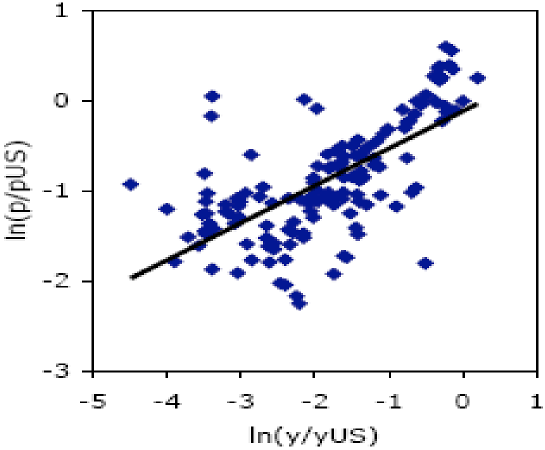
- Engel identifies all goods as tradables
- But:
  1. Does not account for non-tradable inputs into tradables (distribution costs)
  2. Many goods are de facto non-traded ("local goods")
- Burstein et al use import/ export price indexes of "prices at the dock"
- For US quarterly data 1975-2002, find that q_t^N may account for between 56 and 70 percent of variation in tradables.

The RER in the long-run: The Balassa Samuelson model

Price levels and RER



1995 PWT data, Source: Taylor and Taylor 2004



1995 PWT data, Source: Taylor and Taylor 2004

- Higher income - more appreciated RER

Balassa-Samuelson effects across countries

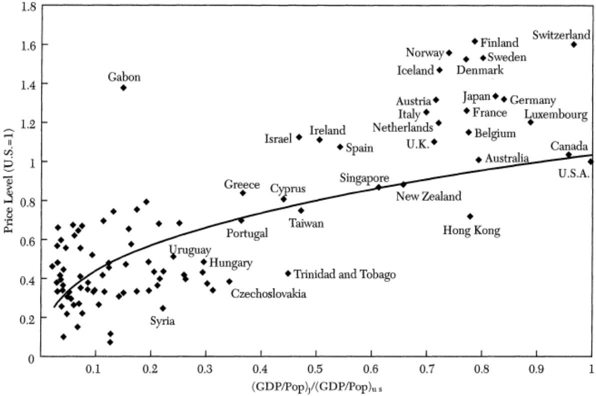


Figure 3. Price Level versus GDP per capita (U.S. = 1) 1990 $\log(P_j/P_{u.s.}) = \underset{(0.090)}{0.035} + \underset{(0.042)}{0.366} \log(Y_j/Y_{u.s.})$

Source: The Penn World Table, Aug. 1994

Source: Rogoff 1996

- Higher income - more appreciated RER

Japan-US CPI and WPI exchange rate

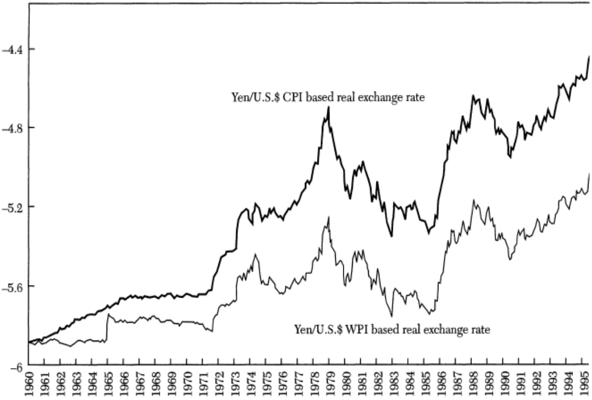


Figure 4. Yen/U.S.$ CPI and WPI based real exchange rates: Jan. 1960–Apr. 1995
Source: International Financial Statistics

Source: Rogoff 1996

- Higher income - more appreciated RER

The RER in the long-run: The Balassa Samuelson model (OR 4.2)

- Consider effect of long-term productivity differentials on RER
- 2 country model
- 2 sectors: traded (T) and non-traded (N) goods, produced using $A_T^{(\star)}F(K_T^{(\star)}, L_T^{(\star)}), A_N^{(\star)}G(K_N^{(\star)}, L_N^{(\star)})$
- Preferences standard VNM over composite of both goods

$$c_t = c_{Nt}^{\gamma} c_{Tt}^{1-\gamma} \qquad (17)$$

- Price index $P_t = p_t^{1-\gamma}, P_t^{\star} = p_t^{\star 1-\gamma}$
- Investment is done in tradables.
- Capital mobility implies equal interest rate in terms of tradables R
- Perfect foresight for simplicity

Equilibrium

- MPK in tradables equalised across countries (for $f = F/L,\ k = K/L$)

$$A_T f_k(k) = pA_N g_k(k) = A_T^\star f_k(k) = p^\star A_N^\star g_k(k) = R_t \quad (18)$$

- 0-profit condition for T,N firms, log-linearised $\mu_T w_T = A_T,\ p + A_N = \mu_N w_N$ for μ the labour share
- Labour-market clearing $w_T = w_N$: $\widehat{p} = \frac{\mu_N}{\mu_T}\widehat{A_T} - A_N$
- So if non-tradables are labour intensive, relative rise in productivity of tradables will increase relative price of non-tradables, and thus price level
- RER differential is

$$\widehat{P} - \widehat{P}^\star = (1-\gamma)[\frac{\mu_N}{\mu_T}(\widehat{A_T} - \widehat{A_T^\star}) - (A_N - A_N^\star)] \quad (19)$$

Summary

- We don't have a good model of NERs. But microstructure models are promising.
- Tests of PPP and LoOP yield very different results when accounting for heterogeneity in price dynamics.
- Importance of relative non-traded goods prices is understated when using CPI data.

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