Macroeconomic Fundamentals and the Exchange Rate

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Introduction

- Widespread perception in economics profession that exchange rates are disconnected from macroeconomic fundamentals. Exhibited in three ways: levels, volatility and PPP puzzles.
- Levels: apparently poor forecasting performance of macro based exchange rate models. Only after 3 years that predictability kicks in.
- Volatility: both inter- and intra-regime: perception that macro fundamentals can't explain.

Introduction

- The PPP puzzle of Rogoff (1995) – combination of high real exchange rate volatility and slow mean reversion of real rates. Usefulness for equilibrium calculations?
- Purpose of talk to say macro fundamentals can be used to explain the levels and volatility puzzles.
- Alternatives to PPP which mean we can recover sensible long run measures of the real exchange rate which can be used for assessment purposes.

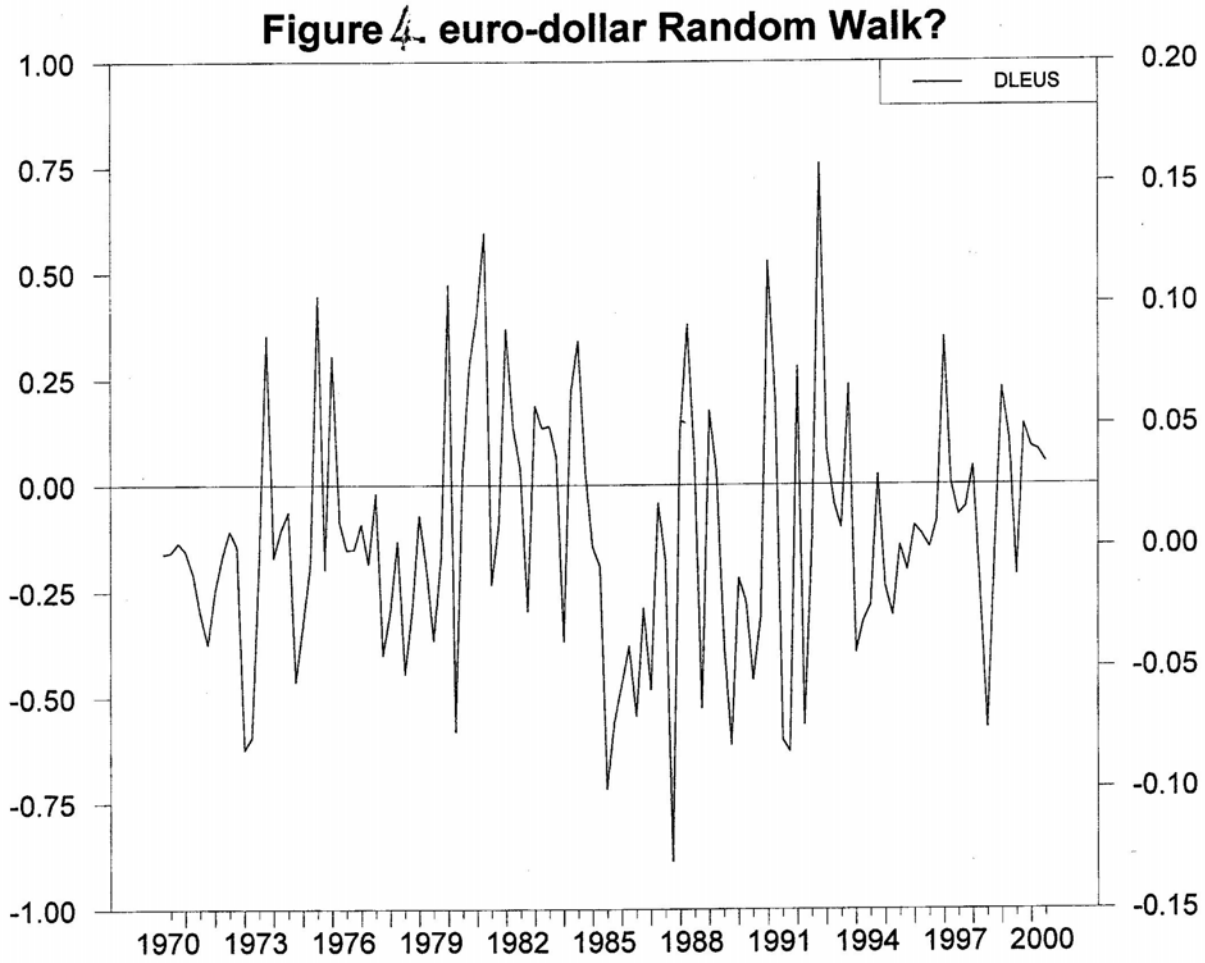
The Levels Puzzle and Exchange Rate Forecasting

- Levels behaviour of exchange rates. Stylised fact: *S* follows an **approximate** random walk:

$$S_t = S_{t-1} + \varepsilon_t$$

- Standard proposition in the Finance literature for asset prices.
- Usually '**approximate'** is ignored - perception that asset prices follow a pure random walk. Which is true and does it matter?
- See Figure:

The Levels Puzzle and Exchange Rate Forecasting



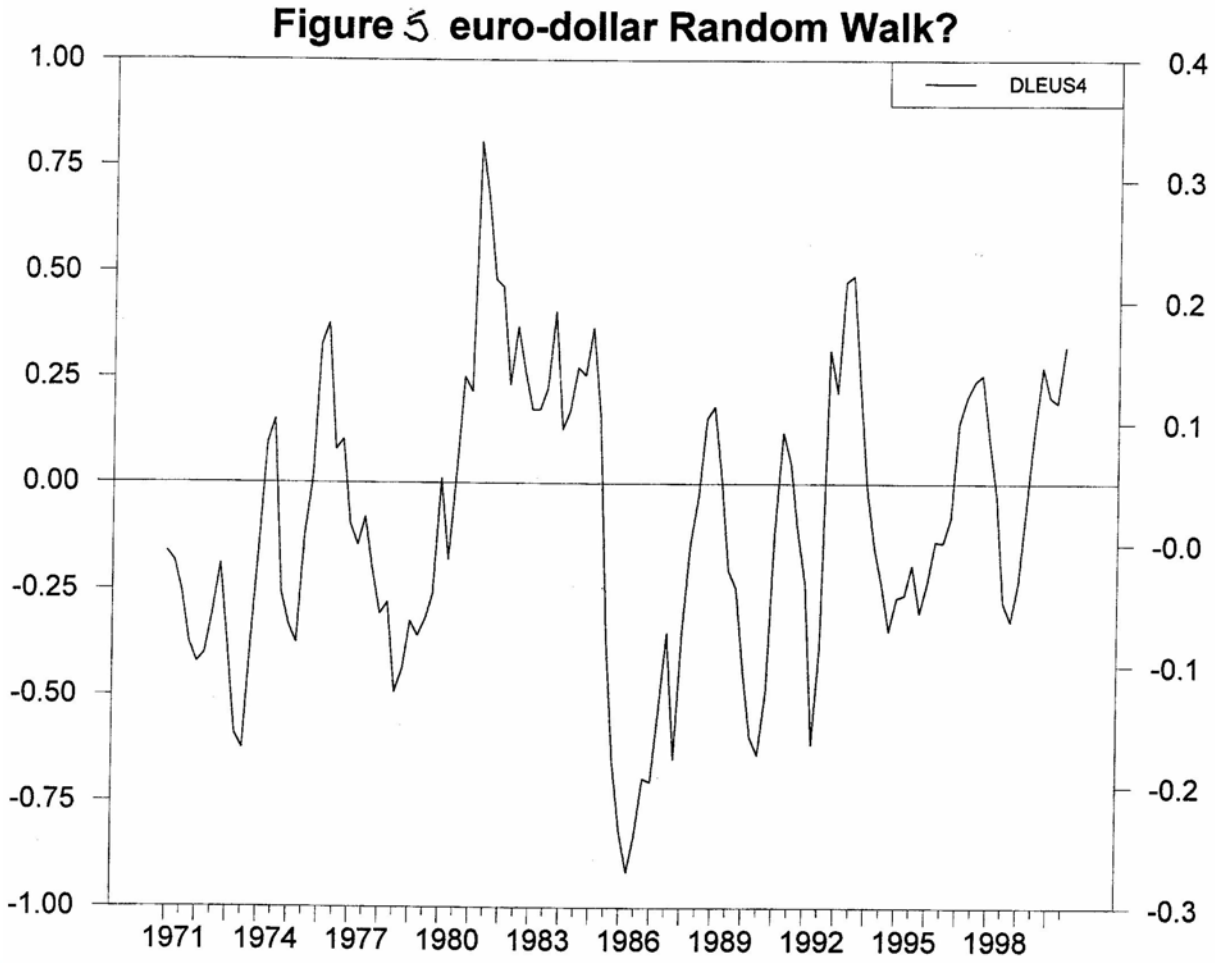
The Levels Puzzle and Exchange Rate Forecasting

- At first blush, Figure would seem to indicate pure random walk (although if look hard trends perhaps appear?)
- Consistent with the Meese and Rogoff (1983) paradigm. They demonstrate Macro fundamentals cannot beat a random walk in out-of- sample forecasting contest. Seems to have become stylised fact for horizons < 3 years. Mark (1995) and Rogoff (1995) and Frankel and Rose (1995).

The Levels Puzzle and Exchange Rate Forecasting

- Frankel and Rose (1995): "...the Meese and Rogoff analysis of short horizons [less than 36 months] has never been convincingly overturned or explained. It continues to exert a pessimistic effect on the field of empirical exchange rate modelling, in particular, and international finance in general" (page 23, emphasis added). FR suggest move to market microstructure.
- But next Figure indicates **approximate** nature of random walk behaviour of exchange rates. Evidence of trend behaviour?

The Levels Puzzle and Exchange Rate Forecasting



The Levels Puzzle and Exchange Rate Forecasting

- So:

$$\Delta s_t = \Delta s_{t-1} + \varepsilon_t$$

- Are such trends exploitable for forecasting? I argue YES, if appropriate econometric methods are used. Also other variables may be able to reduce the standard error of the regression and give explanatory power.

The Levels Puzzle and Exchange Rate Forecasting

- Basic fundamentals-based work horse in exchange rate literature is monetary model

$$s_t = \alpha_0(m_t - m_t^*) - \alpha_1(y_t - y_t^*) + \alpha_2(i_t - i_t^*) + u_t$$

- In sample performance poor with 'traditional' techniques but greatly improved with time series methods which capture the time series properties of the data.
- For example MacDonald and Taylor (1994) have long-run equation of:

The Levels Puzzle and Exchange Rate Forecasting

- $$s_t = (m_t - m_t^*) - (y_t - y_t^*) + 0.049 i_t - 0.050 i_t^*$$

- Then used to produce a dynamic error correction relationship of the following form:

$$\Delta s_t = \underset{(0.073)}{0.244}\,\Delta s_{t-2} - \underset{(0.235)}{0.417}\,\Delta_2 \Delta m_t - \underset{(0.343)}{0.796}\,\Delta y_t - \underset{(0.003)}{0.008}\,\Delta^2 i_t^* - \underset{(0.013)}{0.025}\, z_{t-1} + \underset{(0.003}{0.00}$$

- The above equations performance judged impressive: passes wide range of in-sample diagnostic tests and forecasts well out-of-sample, using the static CHOW and PF statistics as the metric. However, the latter statistics are static in nature and do not use the exchange rate forecasts generated by the model.

The Levels Puzzle and Exchange Rate Forecasting

- Out of sample performance? Key criterion RMSE:

$$RMSE = \sqrt{\frac{(F - A)^2}{n}}$$

- And

$$RMSE^r = \frac{RMSE^m}{RMSE^{rw}}$$

Is this less than one?

The Levels Puzzle and Exchange Rate Forecasting

Horizon	$RMSE^M$	$RMSE^{RW}$	$RMSE^R$
(Months)			
12	0.131	0.148	0.885
9	0.103	0.112	0.919
6	0.081	0.088	0.920
3	0.043	0.053	0.811
2	0.032	0.040	0.800
1	0.028	0.030	0.933

The Levels Puzzle and Exchange Rate Forecasting

- To illustrate that the random walk model can be convincingly beaten MacDonald and Marsh (1997, 2004). They use UIP / PPP Can be justified either in terms of BofP type relationship:

$$s_t = p_t - p_t^* - (\beta/\alpha)z_t - (i_t^*/\alpha)a_t - \frac{\mu}{\alpha}(i_t - i_t^* - \Delta s_{t+k}^e$$

- or statistically (Johansen and Juselius (1990) and Juselius and MacDonald (2000)): The I(1) trend in q is killed by I(1) trend in interest diff. Focus on:

- $x' = [s, p, p^*, i^l, i^{l*}]$

- Modelling approach involves the Structural Econometric Modelling of Hendry and Mizon (1993) and Johansen and Juselius (1994). Essentially this involves moving from the VECM, to CVAR, to PVAR to SEM.
- Key advantage of this strategy gives full system of equations, rather than a single reduced form, and involves parsimonious dynamics and Error correction term. Facilitates a stringent test of forecast ability since predicted values of all terms (exchange rates, prices and interest rates) are used rather than actual data values.

The Levels Puzzle and Exchange Rate Forecasting

- Success of forecasts gauged in 3 ways:

  (i) **relative to random walk** using the RMSE criterion:

  (ii) in terms of **directional ability**:

$$D = \frac{(1 \text{ if forecast direction=actual,else } 0)}{n}$$

- Pure Chance: D = 0.5

- (iii) **relative to a panel** of 150 professional forecasts, located in G7 financial centres, as collected by Consensus Economics of London (in terms of $RMSE^r$).

The Levels Puzzle and Exchange Rate Forecasting

Horiz	DM		£		JY	
	RW	DIR	RW	DIR	RW	DIR
1	1.08	0.50	1.01	0.55	1.06	0.50
2	1.06	0.54	0.99	0.65	1.03	0.54
3	1.00	0.58	0.03	0.69	0.97	0.53
4	0.93	0.66	0.87	0.83	0.95	0.51
5	0.89	0.74	0.85	0.88	0.96	0.62
6	0.88	0.82	0.85	0.78	0.95	0.66
7	0.88	0.78	0.85	0.75	0.91	0.75
8	0.88	0.71	0.84	0.77	0.84	0.74
9	0.90	0.70	0.81	0.77	0.82	0.83
10	0.91	0.66	0.81	0.79	0.77	0.89
11	0.90	0.57	0.80	0.78	0.68	0.93
12	0.88	0.56	0.81	0.74	0.62	0.96

The Levels Puzzle and Exchange Rate Forecasting

- Key findings of MacDonald and Marsh: 1. Easily beat the RMSE ratio and in majority of cases significantly so.
- 2 Very good directional properties – hedge funds looking for figure of around 0.6
- 3. Across all forecast horizons and currencies beat all of the professional forecasters (in terms of RMSE ratio)

- The essential point of this modeling: an S model which has sensible long-run equilibrium and dynamic properties, rich enough to capture the DGP, and with a parsimonious structure will do better than a static model or one with very simple dynamics.

The Levels Puzzle and Exchange Rate Forecasting

- Other forecasting studies:

- MacDonald and Marsh (2006), Tripolar Modelling produces more stringent tests and similar forecasting performance.
- Mark and Sul (2001) use panel estimates to construct 1 and 16 quarter ahead out-of-sample forecasts - compare to random walk using $RMSE^r$. SF, Yen and USD as numeraire
- Majority of RMSEr for 1 quarter forecasts using Swiss franc sig < 1, No of ratios <1 for yen slightly < 1/2 of total No of countries. Mark and Sul conclude: 'There is a preponderence of statistically superior predictive performance by the monetary model exchange rate regression'.
- Cheung, Chinn and Pascal (2005) is Meese and Rogoff redux but non parsimonious.

$s_t) \leq Var(s_t)$

Volatility Puzzle

Two types of volatility relevant : **intra and inter regime.**

- Intra-regime volatility. When exchange rates are flexible they are extremely volatile. Volatility in a flexible rate regime appears excessive - in excess of fundamentals. i.e.
- A standard asset pricing framework would imply:

$$Var(s_t) \leq Var(\hat{s}_t)$$

- But widespread perception that inequality reversed

Volatility Puzzle

- Closely related volatility issue is **inter-regime volatility.** Baxter and King (1989) and Flood and Rose (1999): in move from fixed to floating rates volatility of composite fundamentals unchanged but volatility of *s* increases dramatically – see Figs 1 and 2.

Volatility Puzzle

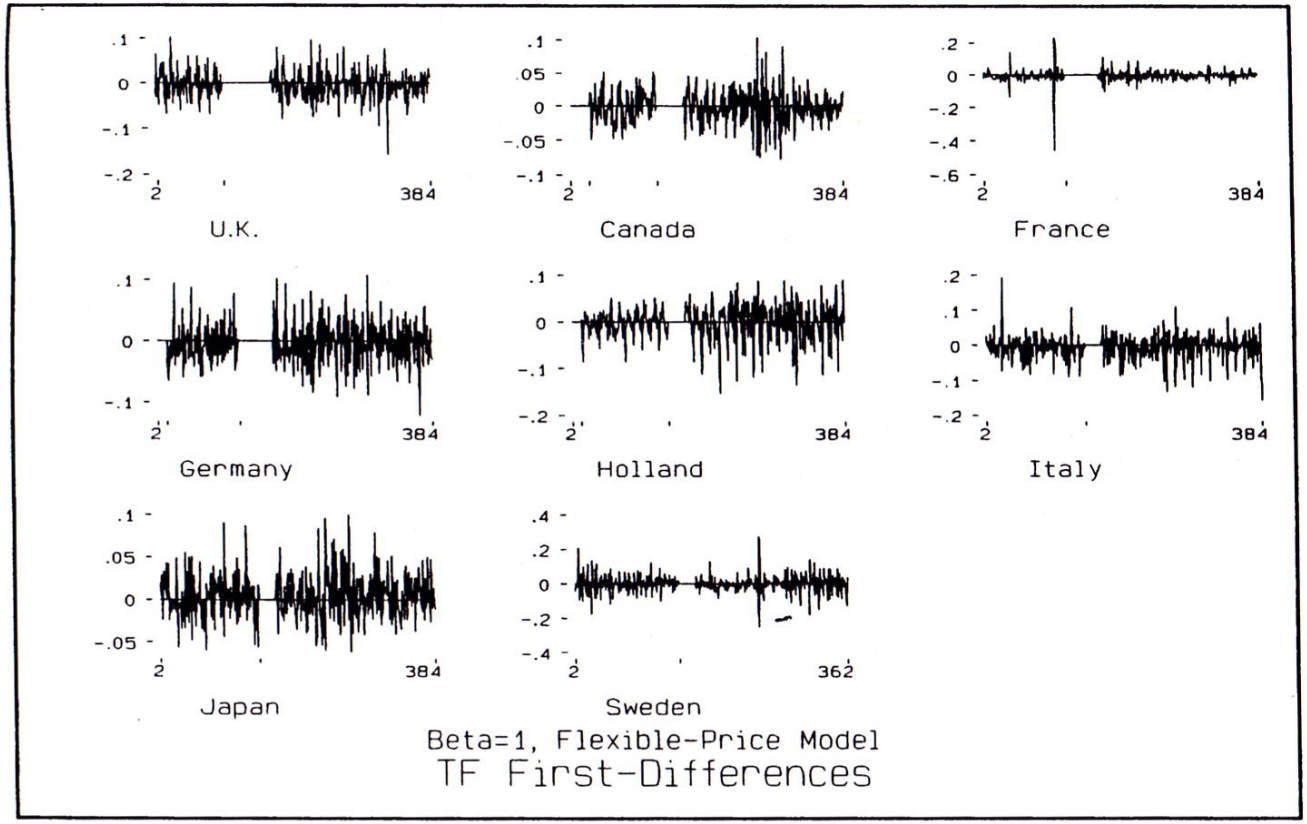


Figure 14B: **Time Series of Traditional Fundamentals, Benchmark Flexible-Price Model**

Volatility Puzzle

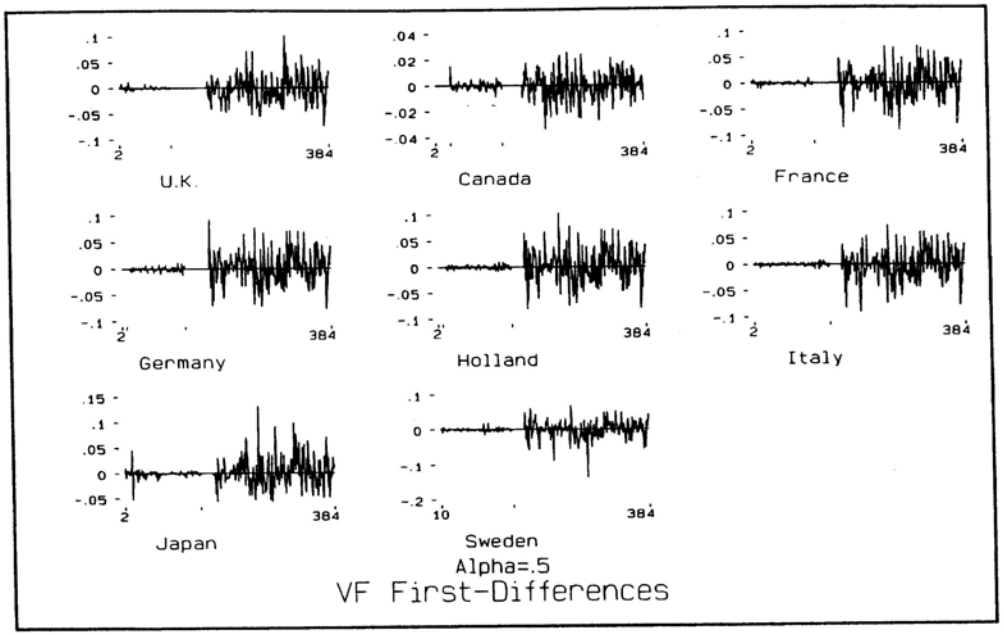


Figure 2 : **Time Series of Benchmark Virtual Fundamentals**

Volatility Puzzle

- Conclusion of Flood and Rose (1995): what changes as move from fixed to flexible is nature of forex market. Therefore market microstructure.
- Reinhart and Rogoff (2002): In BW period nearly every country relied at some point on either capital controls or dual exchange rates. So officially-reported *S* 'profoundly misleading'. Using market instead of official rates shows that *de facto* floating not uncommon during BW period of pegged exchange rates – 45% of pegged countries were on some form of managed float.
- Indeed, Reinhart and Rogoff (2002) suggest difficult to detect any change in S behaviour between BW and post BW regimes. Clearly has important implications for inter regime volatility.

Volatility Puzzle

- Arnold, MacDonald and de Vries (2006) (AVM) – Important to introduce a distortion term into monetary exchange rate equation in their work: IMF support and capital controls.
- With specific case study for UK thru BW and post-Bretton woods that IMF credit facilities **can** dramatically distort relationship.
- Using off-shore/on-shore interest rate differential as measure of capital controls we show for the UK during BW how marked the volatility of the onshore - offshore differential is for this period - almost the reverse of the stylised s volatility – i.e. highly volatile in Bretton Woods and hardly any volatility in the floating rate period.

Volatility Puzzle

- 1. Intra Regime point Post-Bretton Woods intra regime volatility: construct standard deviations of Δs and Δf Striking result: the order of magnitude of volatility in total fundamentals is not very different from Δs.
- 2. For ERM periods show magnitude of s volatility clearly dependent on whether realignments excluded or not. With realignments included, s rate volatility much greater compared to non-realignment position. Flood - Rose (1995) and others do not include *s* realignments in their work.
- Conclusion from this work: Argue that the intra- and inter-regime volatility disconnection overplayed – there is a clear connection both intra and inter especially if the appropriate fundamentals are utilized issues still open question.

Volatility Puzzle

- A raft of theoretical models able to explain the volatility puzzle:
- Standard Magnification effect – MacDonald (2007)
- Numerous new stories based on New Open Economy variants of magnification effect: Obstfeld and Rogoff (2001) and Duarte and Stockman (2005) risk premium effects; Duarte (2003) incomplete markets; Montacelli (2004) stochastic shocks + Taylor rule; Bacchetta and Wincoop – heterogeneous expectations.

Equilibrium Issues and Fundamentals

- Perhaps best-known equilibrium concept is PPP. But Rogoff's **PPP Puzzle** questions usefulness of PPP: i.e. the high volatility of real and nominal exchange rates + slow mean reversion of *q* – half-life of 3-5 years. Vol. consistent with price stickyness, but slow mean reversion not.
- Although PPP puzzle can be explained, it's not a good measure of equilibrium for assessment/ misalignment discussions - have to move to other measures which explicitly recognise the 'real determinants' of exchange rates.

Equilibrium Issues and Fundamentals

- Are models which focus on real determinants of real exchange rates empirically successful? Yes.
- Balassa Samuelson studies – Chinn and Johnstone (1999) MacDonald and Ricci (2001) show significant and plausible link between productivity differences and real exchange rates for developed countries.
- Real interest parity studies estimate:
- $$q_t = \bar{q}_t + r_t - r_t^*$$
- when appropriate methods are used – I.e. Baxter (1994) significant link between q and $r-r^*$.

Equilibrium Issues and Fundamentals

- Extended RIP – condition q on r-r and other variables driving the systematic movement of the real exchange rate. List of papers - Faruqee (1995), MacDonald (1999) and Clark and MacDonald (1998) all show that sensible long run relationship can be recovered for G7 countries. Give example:

$$q_t = \underset{(0.04)}{0.084}\, ltot + \underset{(0.33)}{2.701}\, ltnt + \underset{(0.10)}{1.237}\, nfa - \underset{(0.01)}{0.004}\, \lambda + \underset{(0.014)}{4.595}$$

Equilibrium Issues and Fundamentals

- Can we use this information to calculate measures of equilibrium and, by implication, misalignment?
- **Internal external balance approach**
- **Internal balance**: level of output consistent with full employment and low inflation - the NAIRU.
- The implied net savings from internal has to be consistent with **external balance**, defined differently in variants and q moves to ensure this.
- In general proponents of this approach do not explicitly estimate a specific reduced form – rather rely on a method of calculation.

Equilibrium Issues and Fundamentals

- Different approaches In IEB approach
- Williamson (1983) equilibrium *q* labeled a fundamental equilibrium exchange rate (FEER): *q* consistent with both internal and external balance in medium run (5 years hence). - not stock-flow equilibrium. Where IB high employment + low inflation and EB: **sustainable** desired net flow of resources between countries when in internal balance.

Equilibrium Issues and Fundamentals

- FEER estimates typically calculated by
- 1. Take an estimated multi-country macroeconometric model (such as IMFs Multimod), impose internal and external balance, and solve for q: the FEER.

OR

- 2. Partial Equilibrium approach using trade equations.

Equilibrium Issues and Fundamentals

- IMF implementation of I-B approach (see Isard and Faruqee (1998) and Faruqee, Isard and Masson (1999)) consider medium-run flow equilibrium and a longer run equilibrium underlying current account position is compared with stable ratio of NFA to GDP (i.e stock measure of equilibrium).
- Mechanics of calculating medium run equilibrium exchange rate:
- Dynamic savings and investment equations estimated along with dynamic current account equation

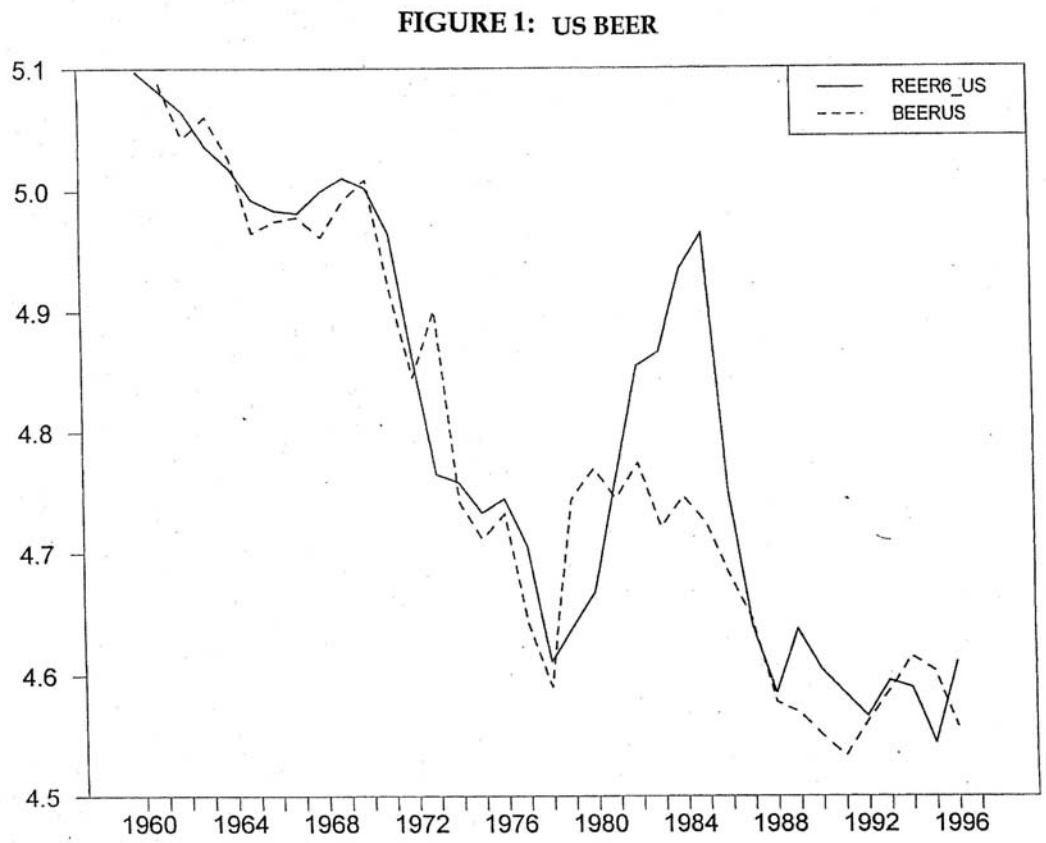
Equilibrium Issues and Fundamentals

- These solved for the long-run (econometric) equilibrium, output gaps set equal to zero and fiscal deficit cyclically adjusted.
- Resulting S-I gap then compared with the estimated CA position and if discrepancy the *q* assumed to move to equilibriate (medium run) the two relationships.

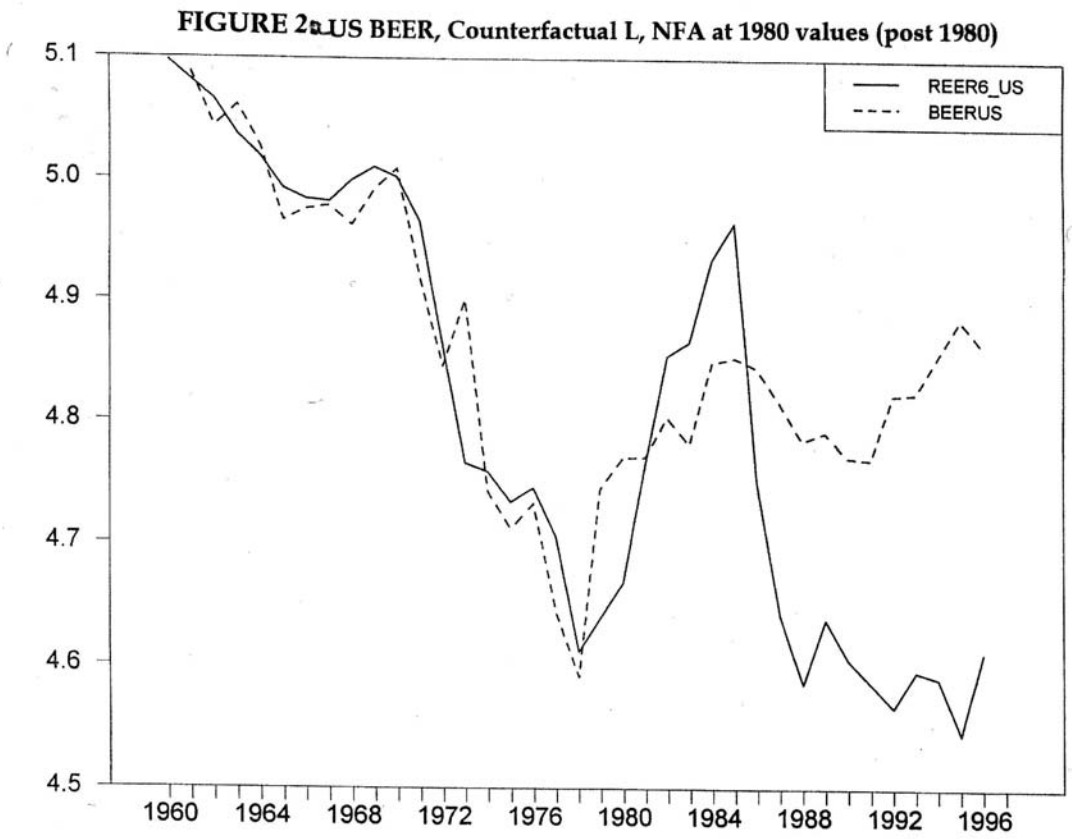
Equilibrium Issues and Fundamentals

- The natural real exchange rate (NATREX) approach of Stein (1994,1995), also in spirit of IEB but uses a reduced form exchange rate relationship to capture equilibrium. Similar in some ways to BEER approach of Clark and MacDonald (1999,2000)
- BEER: Basic idea to take a behavioural exchange rate model and use it for assessment purposes thereby separating the positive from the normative.
- Example:

Equilibrium Issues and Fundamentals



Equilibrium Issues and Fundamentals



Equilibrium Issues and Fundamentals

- **Permanent Equilibrium Exchange Rates: PEERs**
- These rely on a univariate or multivariate time series method to decompose *q* into permanent and transitory components and interpret the former as a measure of equilibrium:

$$q_t = q_t^p + q_t^T$$

- where *qp* is permanent component and *qT* is transitory.

Equilibrium Issues and Fundamentals

- **NOEM Approach to Assessment Issues.**
- Basic idea: optimising behaviour of consumers has implications for CA which, in turn, has implications for *s/q* .
- Need only two pieces of information the consumption elasticity of substitution and the share of consumption of traded goods in the current account. Simple and parsimonious to use.
- In spirit of IEB Approach.

Conclusions

- Widespread perception, indeed consensus, that macro fundamentals are not useful for explaining exchange rate behaviour at short to medium run horizons.
- However to abandon macro fundamentals would be to through the baby out with the bath water!
- I have argued that there are clear reasons why many researchers have not been able to produce good forecasting results: in essence a failure to properly capture the underlying data generation process – dynamics, parsimony and error correction are key.

Conclusions

- The volatility puzzle is not as clear cut as many suggest, and there is empirical evidence and theoretical work which suggests that macro fundamentals can explain the volatility of exchange rates both inter- and intra-regime.
- The PPP puzzle suggests that PPP is not a good way of defining an equilibrium exchange rate. But empirical work suggests that meaningful equilibrium relationships do exist for real exchange rates in terms of macroeconomic fundamentals. Various approaches have exploited this information to produce measures of equilibrium / misalignment.
- The future of exchange rate economics is bright - with macro fundamentals on board!