Behavior of nominal exchange rates

Tomasz Michalski[1]

[1]GREGHEC: HEC Paris

[International Macroeconomics]

Why do we care?

- The nominal (and real) exchange rates are often the most important price in a (small, open) economy
- Surely we would like to understand what drives their behavior,
- be able to write down economic models pinning the most important forces
- and test them on readily available data!

Outline

"Classic" models

Classic models

- The Purchasing Power Parity (PPP)
- Uncovered Interest Rate Parity
- The Monetary Model
- The Monetary Model with rational expectations and news.

The Purchasing Power Parity

- Assumption : there is arbitrage in the market for goods. The same goods should cost everywhere the same after converted to the same currency. No transaction costs, full information, quick adjustment.
- Absolute version :

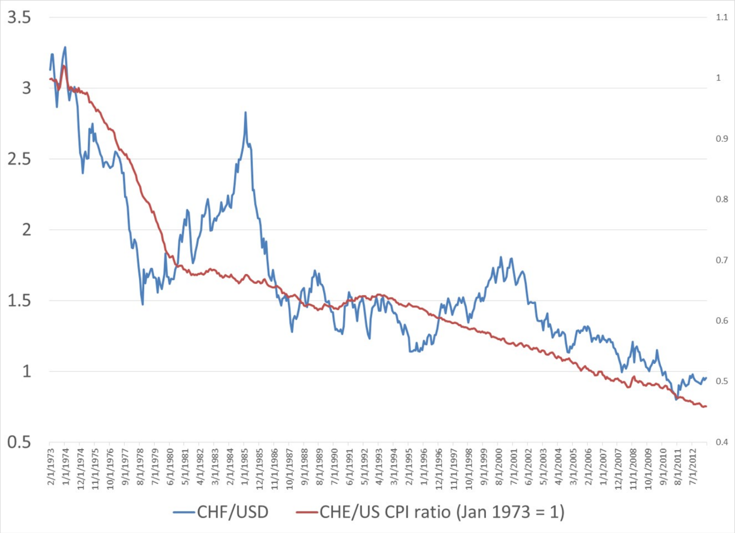
$$s_t = p_t - p_t^\star \tag{1}$$

- Relative version :

$$\triangle s_{t,t+1} = s_{t+1} - s_t = \pi_{t,t+1} - \pi^\star_{t,t+1} \tag{2}$$

- A building block for many models : often assumed to hold in the long run even if not in the short run.

PPP and the nominal exchange rate



Uncovered Interest Rate Parity I

- Assumption : there is costless arbitrage in the market for assets.
- In expectations, risk-neutral investors should earn the same return in assets in different currencies.

$$E_t(s_{t+1}) - s_t = i_{t \to t+1} - i^{\star}_{t \to t+1} \tag{3}$$

- "Uncovered" because the investors face future currency risk.
- Fisher equation. Suppose that $i_{t \to t+1} = \pi_{t,t+1} + r_{real}$ and $r_{real} = r^{\star}_{real}$. Then

$$i_{t \to t+1} - i^{\star}_{t \to t+1} = \pi_{t,t+1} - \pi^{\star}_{t,t+1} \tag{4}$$

Uncovered Interest Rate Parity II

- A building block for many models. Even if doesn't work well empirically.
- Testing : unbiasedness.
- With risk-aversion, a risk premium : $E_t(s_{t+1}) - s_t = i_{t\to t+1} - (i^\star_{t\to t+1} + \rho_t)$
- The risk premium can be endogenously derived from a standard portfolio-choice model.
- For example, for investors with CARA preferences with the risk aversion coefficient γ, the conditional variance of the exchange rate σ_t^2 and stochastic net supply of foreign currency n_t the UIRP may take the form of (Jeanne and Rose, 2002) :

$$\overline{E_t}(s_{t+1}) - s_t = i_{t\to t+1} - i^\star_{t\to t+1} + \gamma n_t \sigma_t^2 \tag{5}$$

where $\overline{E_t}$ are "average" market expectations at time t.

The monetary model

Flexible prices, PPP and UIRP hold : Frenkel (1976), Mussa (1976), and Bilson (1978).

$$s = p_t - p_t^\star \tag{6}$$

$$m_t - p_t = l(i_t, y_t) \tag{7}$$

$$m_t^\star - p_t^\star = l(i_t^\star, y_t^\star) \tag{8}$$

then

$$s_t = (m_t - m_t^\star) - (l(i_t, y_t) - l(i_t^\star, y_t^\star)) \tag{9}$$

and linearizing

$$s_t = (m_t - m_t^\star) - c(y_t - y_t^\star) + b(i_t - i_t^\star) \tag{10}$$

Problem here : is the interest rate really an exogenous variable ?
Portfolio balance models : adding assets to the equation.

Rational expectations : a building block.

- Efficient markets hypothesis : prices fully reflect all available information. Any good forecasting model should have no systematic errors in predictions.
- Agents have rational expectations about a variable if their subjective expectations are the same as the expected value conditional of all publicly available information.
- RE : a consistency requirement in economic models. Agents must form expectations consistent with the model.

The monetary model with RE and news (I)

$$s_t = (m_t - m_t^\star) - c(y_t - y_t^\star) + b(i_t - i_t^\star) \tag{11}$$

Substitute from the UIRP for the interest rates and assume $\gamma z_t = (m_t - m_t^\star) - c(y_t - y_t^\star)$.

$$s_t = \gamma z_t + b(E_t(s_{t+1}) - s_t) \tag{12}$$

or, where $\beta = \frac{b}{1+b} \in (0, 1)$

$$s_t = \frac{\gamma}{1+b} z_t + \beta E_t(s_{t+1}) \tag{13}$$

But, agents with RE have an expectation (given the model) what $E_t(s_{t+1})$ is.

$$E_t(s_{t+1}) = \frac{\gamma}{1+b} E_t z_{t+1} + \beta E_t(s_{t+2}) \tag{14}$$

The monetary model with RE and news (II)

Repeating for all future t we obtain

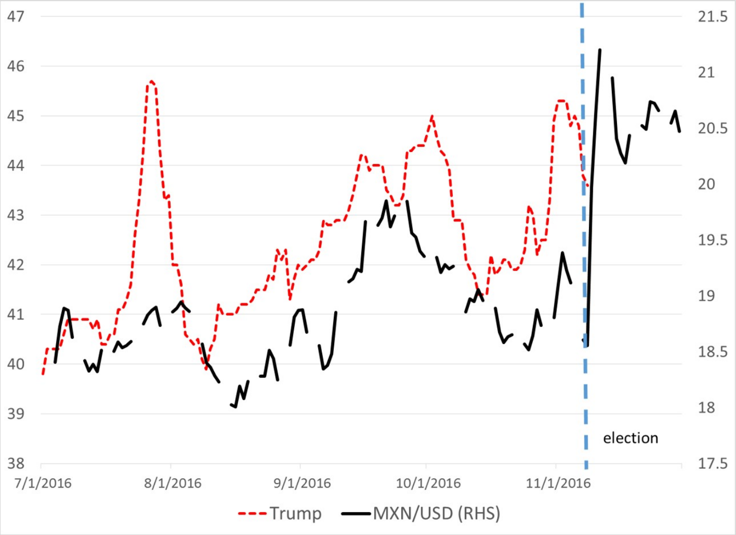
$$s_t = \frac{\gamma}{1+b} \sum_{k=0}^{\infty} \beta^k E_t(z_{t+k}) \tag{15}$$

Then

$$s_t - E_{t-1}s_t = \frac{\gamma}{1+b} \sum_{k=0}^{\infty} \beta^k (E_t(z_{t+k}) - E_{t-1}(z_{t+k})) \tag{16}$$

- "Surprises" or "news" drive the changes in the exchange rate.
- Fundamentals included can be more general than the ones we assumed here.

Exchange rates and news : an example



The monetary model with RE (III)

We have

$$s_t = \frac{\gamma}{1+b} \sum_{k=0}^{\infty} \beta^k E_t(z_{t+k}) \tag{17}$$

and

$$E_t s_{t+1} = \frac{\gamma}{1+b} \sum_{j=0}^{\infty} \beta^j E_t z_{t+1+j} \tag{18}$$

then

$$E_t s_{t+1} - s_t = \frac{\gamma}{1+b} \sum_{j=0}^{\infty} \beta^j \left(E_t z_{t+1+j} - E_t z_{t+j}\right) \tag{19}$$

- In a model with rational expectations, the exchange rate could be perfectly predictable.
- Expectations about the changes in the future fundamentals should drive the expected changes in the exchange rates !
- Problem for forecasting : how to know these objects ?

Forecastability and Predictability

Forecastability and Predictability of exchange rates

- The Meese and Rogoff (1983) puzzle ?
- Coping with the aftermath.
- How forecasting is done.

The Meese and Rogoff (1983) puzzle ?

- Received wisdom : exchange rate models based on fundamentals cannot beat the random walk in forecasting out-of-sample at short term horizons (1-month).
- This pertains to models based on prices (PPP), interest rates (UIRP) or monetary fundamentals, etc. (*all* in fact !)
- Across different samples, currencies and periods (see Rossi [2013] for a review)
- This is a big challenge to international macroeconomics !

Reactions to the Meese and Rogoff (1983) puzzle

- Erroneous views : efficient market hypothesis works ! Exchange rates should NOT be predictable.
- Different statistical methods
- New models
- Different objectives :
  - Directional predictions.
  - A portfolio criterion.
  - Predictability.
- Refined data : real-time data, eliciting expectations etc.

Efficient market hypothesis and exchange rate forecastability

- "Efficient financial markets hypothesis" (EFMH) does not imply that the exchange rates should be unpredictable or unrelated to fundamentals.
- EFMH : the bilateral exchange rate would be the best guess of the market of the fundamental value of a currency at each time based on all available information.
- This best guess would be related to the best guesses about future fundamentals - that may be difficult to predict.

Different statistical models

- Cointegration : Mark (1995), ...
- Long samples and panel data : Mark and Sul (2001), Rapach and Wohar (2002), Cerra and Saxena (2010),...
- Markov switching models : Engel (1994), ...
- Time-varying parameter models : Wolff (1987), Schinasi and Swamy (1989), ...
- Nonlinear methods, machine learning methods : Schinasi and Swamy (1989), Amat, Michalski and Stoltz (2015)...
- Bayesian Model Averaging (of linear models) : Wright (2008),...
- Principal components : Greenaway-Mcgrevy (2012),...

Forecastability vs. predictability

- Forecastability : does the model provide better forecasts than the random walk ?
- Predictability : Do the fundamentals provide valuable information when included in the forecasting equation ?
  - Most recent literature about predictability.
- forecastability $\neq$ predictability
- Both are different from testing whether variables considered in the model are estimated with the right coefficients.

The typical forecasting equations

- Generic forecasting equation :

$$\ln \widehat{S}_{t+1} - \ln S_t = \alpha_t + \sum_{j=1}^{N} \beta_{j,t}(f_{j,t}^A - f_{j,t}^B) \qquad (20)$$

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- The (relative) PPP (fundamentals = inflation rates)

$$\ln \widehat{S}_{t+1} - \ln S_t = \alpha + \beta \left(\pi_t - \pi_t^{\star} \right) \tag{21}$$

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- Flexible price monetary model (fundamentals = money stock and output)

$$\ln \widehat{S}_{t+1} - \ln S_t = \alpha + \beta_1\left(\widehat{m}_t - \widehat{m}_t^\star\right) + \beta_2\left(\widehat{y}_t - \widehat{y}_t^\star\right) \tag{23}$$

Varieties of forecasting equations : the example of PPP

- The (absolute) PPP (fundamentals = prices)

$$\ln \widehat{S}_{t+1} - \ln S_t = \alpha + \beta \left(p_t - p_t^{\star} \right) \tag{24}$$

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- An error-correction PPP

$$\ln \widehat{S}_{t+1} - \ln S_t = \alpha + \beta \left(s_t - \left(p_t - p_t^{\star}\right)\right) \tag{26}$$

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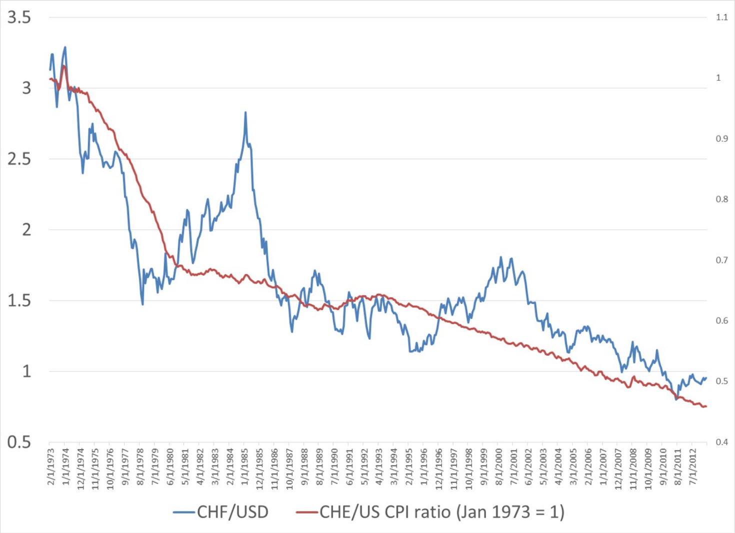
- An error-correction PPP with relative PPP

$$\ln \widehat{S}_{t+1} - \ln S_t = \alpha + \beta_1 \left(s_t - \left(p_t - p_t^{\star} \right) \right) + \beta_2 \left(\pi_t - \pi_t^{\star} \right) \tag{27}$$

PPP and the nominal exchange rate (repeat)



Forecasts and evaluating their quality

- Generic forecasting equation :

$$\ln \widehat{S}_{t+1} - \ln S_t = \alpha_t + \sum_{j=1}^{N} \left(\beta^A_{j,t} f^A_{j,t} - \beta^B_{j,t} f^B_{j,t} \right) = \sum_j \beta_{j,t} f_{j,t}$$

- Evaluation method : Root mean square error (RMSE)
- Training (estimation) period of $t_0 = 120$ months

$$RMSE = \sqrt{\frac{1}{T - t_0} \sum_{t=t_0+1}^{T} \left(\ln \widehat{S}_t - \ln S_t \right)^2}$$

$$= \sqrt{\frac{1}{T - t_0} \sum_{t=t_0+1}^{T} \left(\left(\ln \widehat{S}_t - \ln S_{t-1} \right) - \left(\ln S_t - \ln S_{t-1} \right) \right)^2}$$

New models

New models

- The "Taylor-rule" model of exchange rates
- The Gourinchas – Rey model
- The Scapegoat model

The "Taylor-rule" model of exchange rates [I]

Central banks started using the Taylor rule in their monetary policy.

$$\overline{i_t} = \pi_t + \phi(\pi_t - \overline{\pi}) + \gamma \widetilde{y}_t + r + \delta q_t \tag{28}$$

where

- $\overline{i_t}$ is the target interest rate
- $\overline{\pi}$ is the target inflation rate
- $\widetilde{y}_t$ is the output gap and r is the equilibrium level of the interest rate
- q_t is the real exchange rate (for small open economies)

The "Taylor-rule" model of exchange rates [II]

Molodtsova and Papell [2009] consider a model where the interest rate partially adjusts to the target

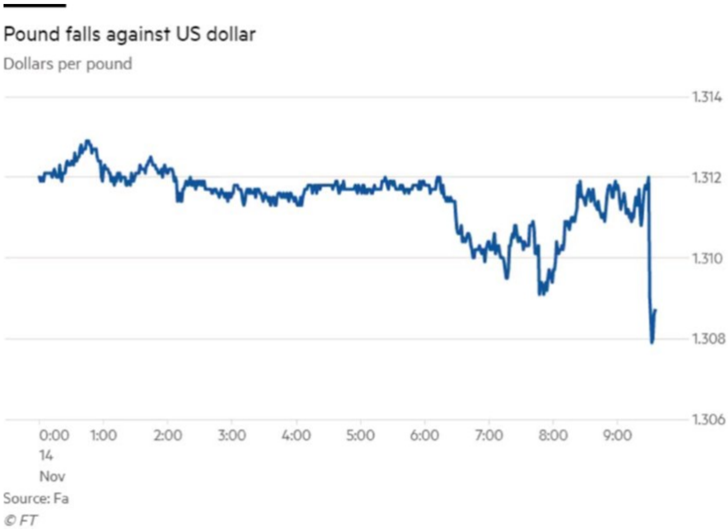
$$i_t = (1 - \varpi)\overline{i_t} + \varpi i_{t-1} + \nu_t \tag{29}$$

Then

$$\begin{aligned} \triangle s_{t,t+1} = & \omega - \omega_\pi \pi_{t,t+1} + \omega_\pi^\star \pi_{t,t+1}^\star - \omega_{\widetilde{y}} \widetilde{y}_t + \omega_{\widetilde{y}}^\star \widetilde{y}_t{}^\star \\ & + \omega_{q_t}^\star q_t^\star - \omega_i i_{t-1} + \omega_i^\star i_{t-1}^\star \end{aligned}$$

- Note that the effect of higher inflation is opposite than in the monetary model (instantaneous appreciation).
- The future change depends on whether UIRP holds or not.

USD/GBP after *weaker* than expected inflation in the UK



The Gourinchas – Rey model

- Current account balance of each country is a result of forward-looking intertemporal saving decisions by economic agents (Obstfeld and Rogoff 1995).
- But : incorporate capital gains and losses on the net foreign asset position (Gourinchas and Rey 2007).
- For a country that has high negative NFA wealth transfers may occur via the depreciation of their home currency.
- Empirical result : Cyclical external balances can forecast the effective (weighted) U.S. dollar exchange rates.

The Scapegoat model : Bacchetta and van Wincoop (2004)

- Observation : Practitioners have different narratives on what "drives" the exchange rates at any given point in time.
- Cheung et al. (2005) : the relationship between fundamentals and the exchange rate is highly variable thru time.
- Idea : The exchange rate may change due to unobserved liquidity trades. The market may seek the fundamental that explains the movements. As a result, some variable is going to be weighted "too much" relatively to others in a period.
- Fratscher et al. (2015) test the model : works in sample, but forecasting power is mixed.

Exchange rates as asset prices

Exchange rates as asset prices

Engel and West (2005) argument

- Exchange rates are asset prices.
- Current and past fundamentals may have low correlations with future exchange rate realizations.
- When agents have discount factors close to one, exchange rates may be well approximated by a random walk (especially in the short run)!
- That is why it is so hard to beat the random walk for models based on fundamentals.

Revisiting the monetary model

Reconsider the equation of the monetary model (11) with the UIRP containing now a term ρ being the risk premium or an expectational error and assuming $\gamma = 1$.

$$E_t(s_{t+1}) - s_t = i_{t \to t+1} - i^{\star}_{t \to t+1} - \rho_t \tag{30}$$

Equation (13) now becomes

$$s_t = (1-\beta)z_t + \beta\rho_t + \beta E_t(s_{t+1}) \tag{31}$$

and the corresponding equation (17) is

$$s_t = (1-\beta)\sum_{k=0}^{\infty}\beta^k E_t(z_{t+k}) + \beta\sum_{k=0}^{\infty}\beta^k E_t(\rho_{t+k}) \tag{32}$$

where β is the discount factor.

Formulation with autoregressive fundamentals and risk premium

Assume that

$$\Delta m_t = \phi \Delta m_{t-1} + \epsilon_{mt} \tag{33}$$

and

$$\Delta \rho_t = \theta \Delta \rho_{t-1} + \epsilon_{\rho t} \tag{34}$$

Then

$$\Delta s_t = \frac{\phi(1-\beta)}{1-\beta\phi}\Delta m_{t-1} + \frac{1}{1-\beta\phi}\epsilon_{mt} + \frac{\beta\theta}{1-\beta\theta}\Delta\rho_{t-1} + \frac{\beta}{(1-\beta)(1-\beta\theta)}\epsilon_{\rho t} \tag{35}$$

Suppose now $\rho_t = 0$. As $\beta \to 1$ then $\Delta s_t \approx \frac{1}{1-\phi}\epsilon_{mt}$ and the variance of Δs_t is finite.
But if $\rho_t \neq 0$ then as $\beta \to 1$ then $\Delta s_t \approx cst\epsilon_{\rho t}$ and the variance of Δs_t grows and is dominated by $\epsilon_{\rho t}$.

Interpretation

If $\beta \approx 1$ then

- A regression of Δs_{t+1} on fundamentals may yield a nonzero coefficient...
- ...but its explanatory power is going to be small
- so that Δs_{t+1} is going to be well approximated by white noise.

Empirically,

- Fundamentals (both observed and unobserved) seem to be either I(1) or highly autoregressive processes.
- The discount factor $\beta \in (0.970.98)$ in the data.
- There is a risk premium that helps to explain some other puzzles (we will return to that).