# Open Economy Macroeconomics
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## News and Volatility of Exchange Rates

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# Introduction

- We will now explicitly acknowledge uncertainty
- We will introduce rational expectations (RE), market efficiency and unbiasedness
- Main focus will be on exchange rate volatility
- The spot rate will reflect:
  - the forward rate (market expectations)
  - unobservable random variation (news about fundamentals)
  - risk premium

# Rational Expectations

- Remember that the expected value (of the distribution) of a random variable is the probability weighted average of the different values taken by the random variable
- Then again, the conditional expected value of a random variable is the expected value conditional on the conditioning information set, say $\mathbb{E}\left[X_t \left| I_{t-j} \right.\right]$ for $j > 0$, where time is explicitly introduced and where $I_{t-j}$ denotes information available at time t-j
- Now, *Rational Expectations* is defined as the equality between market's *subjective expectations of* a random variable and the conditionally expected value of that random variable, conditional on the set of all available information
- Intuition: when forming beliefs/forecasts of the future values of (randomly changing) economic variables, agents act *as if* computing conditionally expected values

# Rational Expectations

- Note that in the definition above we have used *market's* as opposed to an individual's expectations
- Hence, the definition refers to the idea that markets are *on average* correct
- RE allows, in principle, for a set of individuals to be systematically wrong
  - this set of individuals cannot be large relative to the market; otherwise this set would affect market outcomes
- Previously, we used the formalism $X^e$ to denote market's subjective expectations of the future values of the random variable $X$ - like the spot exchange rate: under RE and after introducing time explicitly we have

$$X_t^e = \mathbb{E}_t \left[ X_{t+k} \left| I_t \right. \right] \tag{1}$$

for $k \geq 1$

# Rational Expectations

- Now, check the following reasoning: since the euro price of the dollar $S$ is the reciprocal of the dollar price of the euro $\frac{1}{S}$, market's subjective expectations of $S$ is the reciprocal of its subjective expectations of $\frac{1}{S}$, ie

$$S^e = \frac{1}{(1/S)^e}$$

hence

$$\frac{1}{S^e} = \left(\frac{1}{S}\right)^e$$

- However, when it comes to mathematical expectations (RE!)

$$\frac{1}{\mathbb{E}\left[S_{t+k} \,|\, I_t\right]} \neq \mathbb{E}\left[\frac{1}{S_{t+k}}\right]$$

due to *convexity* (Jensen's inequality)

# Market Efficiency

- Assume that the following holds for the forward and spot exchange market:
  - investors have amble funds available for arbitrage
  - no exchange controls (freely mobile funds)
  - negligible transaction costs
- Assume further that markets operated under RE: we can write the equilibrium for the forward rate $f_t^{t+1}$, say, as

$$f_t^{t+1} = \mathbb{E}_t s_{t+1} + \rho_t$$

  where $\mathbb{E}_t s_{t+1} = \mathbb{E}\left[s_{t+1} \middle| I_t\right]$
- Now, substract the current spot rate from both sides of this equation

$$f_t^{t+1} - s_t = \left[\mathbb{E}_t s_{t+1} - s_t\right] + \rho_t \tag{2}$$

# Market Efficiency

- Recast (2) as

$$f_t^{t+1} - s_{t+1} = u_{t+1} + \rho_t \tag{3}$$

- $u_{t+1}$ is the crucial term: previously we have called it the expected rate of depreciation of the domestic currency, but now we should refocus ourselves and note the it is the difference between conditionally expected (/forecasted) value of tomorrow's spot exchange rate and its realized value tomorrow, ie. a *forecast error*
- Under RE, $u_{t+1}$ has very special properties, as it *should not be forecastable/predictable with currently available information*, ie. the best forecast for it is its conditionally expected value of zero!

# Market Efficiency

- Eq. (3) summarizes the essence of the Efficient Market Hypothesis (EMH) nicely:
  - the gap between the forward rate and current spot rate is equal to the sum of a completely random expectational error and the a premium
    - to sign the risk premium, knowledge of investors'/market's risk preference is needed
- We can rewrite (3) as

$$s_{t+1} = f_t^{t+1} - \rho_t - u_{t+1} \tag{4}$$

or, after lagging by one period

$$s_t = f_{t-1}^{t} - \rho_{t-1} - u_t \tag{5}$$

giving the current spot rate as the sum of the three terms on the r.h.s.

- Note that in order to use an estimated eq. (5) for relating the spot rate to the forward rate, we need to make assumptions about the structure or the risk premium

# Unbiasedness

- Let us make the following, familiar but extreme assumption that investors/markets are risk neutral
- Under RE, the forward rate is equal to the rationally expected spot rate, so that the risk premium is pushed down to zero:

$$s_t = f_{t-1}^t - u_t \tag{6}$$

- This is the essence of *Unbiasedness*: when the forward market is efficient and investors are risk neutral, the forward rate and rationally expected spot rate coincide at the time the forward contract matures
- Rewrite (6) as

$$s_t - s_{t-1} = \left(f_{t-1}^t - s_{t-1}\right) - u_t \tag{7}$$

so that the forward premium, lagged this time, is back on the stage to affect the change in the spot rate; under RE the forward premium reflects expected spot rate change

# Unbiasedness

- Implications?
  - if (7) holds in the data, forward rate is an *optimal* forecast of the next period's spot rate, ie. the actual and forecasted spot rate only differ by zero mean random forecast error
  - we cannot improve upon the forward rate by using other publicly available data
  - unbiasedness implies that the forward rate is thus the best forecast for the spot rate

# Random Walk (RW) Model

- Often time a *random walk* (for an asset price) has been associated with an efficient market:

$$S_t = S_{t-1} + u_t$$

or

$$\Delta S_t = u_t \tag{8}$$

where $\mathbb{E}u_t = 0$

- This is the *pure* random walk; one with the *drift* $d$ is defined as

$$S_t = d + S_{t-1} + u_t \tag{9}$$

which, by the way, implies that

$$S_t = d \cdot t + S_0 + \sum_{s=1}^{t} u_s$$

- However, RE, market efficiency or unbiasedness does not *require* the spot rate to follow a RW

# Random Walk

- Take e.g. the RE; say the (log of the) spot rate follows a random walk (with drift)

$$s_t = d + s_{t-1} + u_t$$

so that

$$\mathbb{E}_{t-1} s_t = \mathbb{E}_{t-1} \left[ d + s_{t-1} + u_t \right] = d + s_{t-1} \tag{10}$$

- But we could equally well postulate the following model for the spot rate

$$s_t = \alpha s_{t-1} + \beta s_{t-2} + \gamma Z_t + u_t$$

so that

$$\mathbb{E}_{t-1} s_t = \alpha s_{t-1} + \beta s_{t-2} + \gamma \mathbb{E}_{t-1} Z_t$$

where $Z_t$ is some other (set of) variable(s); RE does *not* force us to choose the RW over this model

# Random Walk

- But neither does efficiency or unbiasedness impose a RW on us; tomorrow's forward rate is, from eq. (3)

$$f_t^{t+1} - s_{t+1} = u_{t+1} + \rho_t$$

so that under RW, this reduces to

$$f_t^{t+1} = s_t + \rho_t \tag{11}$$

so that under unbiasedness, the forward premium is zero

- But under the more general model for the spot rate, the forward rate will be the sum of the corresponding expected spot rate and risk premium
- So, what's going on, ie. while expected return from holding a currency for a period (= exp. change of $s_t$) will be zero only if the spot rate follows a RW; in virtually all other cases, the return will be predictably non-zero
- How to reconcile with efficiency?

# Random Walk

- The crucial point is that as long as any predictable component in the spot rate depreciation is fully embodied in the forward rate, as it will be in an efficient market, the opportunity for profit is illusory
- Suppose the spot rate is generated by the more general model above, so that the forecast error - ie. the profit made by a speculator paying the rationally expected spot rate at time $t-1$ and selling it on the spot next period - for the spot rate is

$$s_t - \mathbb{E}_{t-1} s_t = \gamma \left( Z_t - \mathbb{E}_{t-1} Z_t \right) \tag{12}$$

- Now, although realized profits in period $t$ are likely to be non-zero, but they are zero *on average*

$$\mathbb{E}_{t-1} \left( s_t - \mathbb{E}_{t-1} s_t \right) = \gamma \mathbb{E}_{t-1} \left( Z_t - \mathbb{E}_{t-1} Z_t \right) = 0$$

sinceunder RE, the forecast error in forecasting $Z_t$ is zero

# Empirical Results

- What does the data say?
- Market efficiency is difficult to test, not least because of the desire to postulate RE
- Unbiasedness has been more widely tested often using the typical regression specification

$$s_t = \alpha + \beta f_{t-1}^t + u_t \tag{13}$$

- In this context, unbiasedness implies:
  - $\alpha$ should be insignificantly different from zero
  - $\beta$ should be insignificantly different from one
  - $u_t$ should be serially uncorrelated ($\text{corr}\left(u_t, u_{t+j}\right) = 0$, for $j \neq 0$)

# Empirical Results

- The data from the post-72 floating era is not that supportive of unbiasedness
- Note that evidence from fitting the above equation is relevant only for unbiasedness
- To be consistent with market efficiency, risk premium should be constant; hence in this context we should find two last of the above implications satisfied, but not the first one
- Why not use interest rate differential to test for unbiasedness? Remember that under UIP, interest rate differential equals the expected rate of depreciation of the domestic currency
- To turn this into an estimable equation under RE, we have

$$s_{t+1} - s_t = r_t - r_t^f + u_{t+1}$$

- Hence the coefficient on the interest differential should come out as one, when estimating this equation

# Empirical Results

- The empirical research is riddled with statistical technicalities, mainly trying to overcome specific estimation and inference problems, but the overall conclusion seems to be that data do not favour unbiasedness and, by and large, also the constant risk premium version of efficiency
- What about testing for the validity of RE?
- Use the strategy that

$$s_t^e = \mathbb{E}_t s_{t+1} = s_{t+1} + u_{t+1}$$

for a RE forecast error $u_t$

- Collect survey data to proxy the subjective expectations by the market $s_t^e$

$$s_t^e = s_{t+1} + v_{t+1}$$

for some random error term $v_t$

# Empirical Results

- In past times, survey data were difficult to obtain; easier recently
- Survey data are not easy to interpret, because e.g. it is ex post difficult to pin down exactly when expectations were formed
- There is also the problem of heterogenous market survey expectations, where the usual solution is to take the median expectations
- Other problems also are present with survey data, but earlier periods lend more support for RE, but there seems to have been a persistent bias in respondents' expectations, particularly in the mid-1980's
- The expectations bias tended to be associated with forward premium bias, so that risk premium is not the key; however, the gap tended to be too large to be explained this way
- The nature of the bias appears to have varied over different historical episodes
- Summarizing: the jury is still out there, particularly for market efficiency, somewhat less so for RE