Get Real: Interpreting Nominal Exchange Rate Fluctuations

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What this Paper Does

Derives a structural relationship between the nominal exchange rate, national price levels, and observed yields on long maturity inflation indexed bonds.

Derives a novel, empirically observable measure of the risk premium that can open up a wedge between the observed level of the nominal exchange rate and its risk neutral fair value.

Takes our model to a dataset spanning the period 2001 – 2011 and studies high frequency, real time decompositions of pound, euro, and yen exchange rates into their risk neutral fair value and risk premium components.
Advantage of our approach is that it \textit{does not impose restrictive assumptions} (e.g. complete markets, representative agent) on financial market equilibrium...

\textit{Does not require estimation} of a stable linear time series model for short – term ex ante real interest differentials or expected future inflation, nor \textit{does it require that expectations hypothesis} of the term structure hold.

We find the relative importance of the \textit{risk premium} and \textit{risk neutral fair value} varies depending on the sub sample studied. However, sub samples in which 30 to 60 percent of the fluctuations in daily exchange rate changes are explained by contemporaneous changes in \textit{risk neutral fair value}, are not uncommon (and are counter to Meese-Rogoff (1983) puzzle).

We can also explain why correlation with risk neutral fair value \textit{goes negative} in periods with a large shock to risk premium.
The Model

Price today of a zero coupon bond that pays off random cash flow $N_{t+n}$ dollars in $n$ periods

$$
\rho_t = F_t(N_{t+n}, \Omega_{t,t+n}) = E_t(m_{t,n}N_{t+n}; \Omega_{t,t+n})
$$

Assumption: $m_{t,n}$ is homogenous in the price levels $P_t$ and $P_{t+n}$

$$
m_{t,n} = z_{t,n} \frac{P_t}{P_{t+n}}
$$

We do not require a representative agent, complete markets, or really any additional structure on $z_{t,n}$. An intuitive restriction on nominal asset prices that says that the real price of the asset today depends upon the real value of the cash flow it delivers state by state at maturity and not the price level at $t+n$ itself.
Pricing Dollar and Pound Inflation Linked Bonds

Price of Dollar Inflation Indexed Zero Coupon Bond

\[ \rho_t = E_t(m_{t,n} \cdot 1 \cdot \frac{P_{t+n}}{P_t}) = E_t(z_{t,n} \cdot 1) \]

Yield on Dollar Inflation Indexed Bond

\[ 1 = \{\exp nr_{t,n}\} E_t(z_{t,n}) \]

Dollar Price of Pound Inflation Indexed Zero Coupon Bond

\[ S_t \rho^*_t = E_t(m_{t,n} \cdot 1 \cdot S_{t+n} \cdot \frac{P^*_{t+n}}{P^*_t}) \]

Let \( Q_t = S_t P^*_t / P_t \) denote the real exchange rate. Then we have

\[ 1 = \exp nr^*_t,n E_t(z_{t,n} \cdot 1 \cdot \frac{Q_{t+n}}{Q_t}) \]
A Structural Exchange Rate Equation

So long as inflation linked bonds are traded, the nominal exchange rate must satisfy period by period

\[
S_t = \frac{P^*}{P_t} \frac{\exp nr^*_{t,n} \exp nr_{t,n}}{\exp nr_{t,n}} \frac{QE_t(z_{t,n} \cdot 1 \cdot \frac{Q_{t+n}}{Q})}{E_t(z_{t,n})}
\]

Define the risk premium term

\[
\exp - q_t = \frac{E_t(z_{t,n} \cdot 1 \cdot \frac{Q_{t+n}}{Q})}{E_t(z_{t,n})}
\]

For intuition, consider log normal case

\[
-q_t = \text{cov}_{t,n} (\ln z_{t,n}, q_{t+n} - q) + \text{var}_{t,n} (q_{t+n} - q) + E_t (q_{t+n} - q)
\]

\[
\text{Risk Premium} \quad \text{vol} \quad \text{Long Run PPP Deviation}
\]
Interpreting the Risk Premium

When the covariance is negative, an unhedged position in a UK linker pays off less (because of realized real appreciation of dollar relative to the pound) when the stochastic discount factor is high.

Thus a *negative theta* corresponds to a *positive risk premium* on the UK linker. That is, the known real return on the US linker is less than the expected real return to the US investor, inclusive of expected appreciation of the pound, of holding a UK linker when θ is positive.

An increase in the expected excess return on the UK linker will require some combination of an increase in $r^*_{t,n}$ and or an appreciation of the dollar that is sufficient to set up the expectation of future dollar deprecation.

*We assume that expected deviations from PPP at a 10 years horizon are sufficiently close to zero so as to be ignored.* Importantly, however, researchers who have a view on long horizon PPP deviations can include that view directly in our framework.
Risk Neutral Fair Value

We define the risk neutral fair value ($rnfv$) of the exchange rate

$$
\tilde{S}_t = \frac{P^*_t}{P_t} \frac{\exp nr^*_{t,n} Q}{\exp nr_{t,n}}
$$

Or in log terms

$$
\tilde{s}_t = p_t - p^*_t + n(r^*_{t,n} - r_{t,n}) + q
$$

So period by period we can decompose in real time the fluctuations in the spot rate into the parts accounted for by shifts in $rnfv_t$ and shifts in the risk premium $\theta_t$

$$
s_t = \tilde{s}_t - \theta_t
$$
Comparison with Fama (1984) Risk Premium

In a classic paper Fama (1984) defined the currency risk premium reflected in holding short maturity nominal bonds

\[ rp_{t,1} = E_t s_{t+1} - s_t + i^*_{t,1} - i_{t,1} \]

Notice the level of the Fama premium is reflected in the forecastable change in the spot rate. Adding and subtracting the expected foreign minus home inflation differential this can be expressed

\[ rp_{t,1} = E_t q_{t+1} - q_t + er^*_{t,1} - er_{t,1} \]

where \( er_{t,1} = i_{t,1} - E_t \pi_{t,1} \) is the ex ante short term real interest rate at home and similarly abroad.
Comparison with Literature

Solving forward (Campbell and Clarida (1987); Engel (2010))

\[ s_t = p_t - p^*_t + \sum_{i=0}^{\infty} (t e r^*_{t+i,1} - t e r_{t+i,1} - \mu) + q - \sum_{i=0}^{\infty} (t r p_{t+i,1} - \lambda) \]

Ex ante short term real interest rates are not observable. Thus the literature has used estimated time series models / vars to forecast sum of ex ante short real rate differentials. Alternatively (Shafer – Loopesko (1983)) can assume expectations hypothesis of the term structure and estimate time series model / var for expected inflation.

Note we must have

\[ n(r^*_{t,n} - r_{t,n}) = \sum_{i=0}^{n} (t e r^*_{t+i,1} - t e r_{t+i,1}) + \theta_t - \sum_{i=0}^{n} t r p_{t+i,1} \]

Or period by period

\[ r p_{t,1} = nE_t \{(r^*_{t+1,n} - r^*_{t,n}) - (r_{t+1,n} - r_{t,n})\} + \theta_t - \theta_{t+1} + (i^*_{t,1} - i_{t,1}) + \pi^d_{t,1} \]
Data: High Frequency Real Time Study

Our data set is comprised of daily observations on spot exchange rates, inflation indexed bond yields, and monthly observations on consumer price indexes for the US, UK, and Euro area for the period January 2001 though January 2011 and for Japan since January 2005 shortly after inflation indexed bonds were introduced.

Inflation indexed bonds are typically issued in coupon form. However, in the US there is a market in which inflation indexed coupon Tips are stripped of their coupons and trade in zero coupon form. We use daily data on constant 10 years to maturity yields on zero coupon Tips provided by Barclays. In the other countries, zero coupon linkers do not trade actively. We use the data from Barclays that are available for coupon bearing inflation indexed bonds with 10 years to maturity.

Results are robust if we proxy zero coupon inflation indexed bond yields with zero coupon inflation swaps rates and yields on zero coupon nominal bonds which are actively traded in Europe UK.
Results: Euro

risk premium in favor of USD

risk premium in favor of EUR
Correlation with $RNFV$

\[ s_t = p_t - p^*_t + n(r^*_{t,n} - r_{t,n}) + q - \theta_t \]

So a positive shock to $\theta_t$ requires some combination of a rise in $r^*_{t,n} - r_{t,n}$ and a fall in $s_t$
Until 2004, Value of EUR was Depressed by Large Risk Premium
Results: Pound

Risk premium in favor of USD

Risk premium in favor of Pound

GBP

RNFV
Correlation with \textit{RNFV}

Correlation between Daily \textit{Change} in Gbp and Daily \textit{Change in} RNFV - 60 Day Window

![Graph showing correlation between Daily Change in Gbp and Daily Change in RNFV - 60 Day Window](image-url)
Results: Yen

Risk Premium in Favor of Yen
Risk Premium in Favor of USD

RNFV
JPY
Correlation with \textit{RNFV}

Correlation of Daily \textit{Changes} in JPY and RNFV - 60 day Window
Concluding Remarks

Our framework should be useful to Central Banks who already use present value models such as

\[ s_t = p_t - p^*_t + \sum_{i=0}^{\infty} (t er^*_{t+i,1} - tr_{t+i,1} - \mu) + q - \sum_{i=0}^{\infty} (trp_{t+i,1} - \lambda) \]

to interpret exchange rate fluctuations between monetary policy reports (Brigden, Martin, and Salmon “Decomposing Exchange Rate Movements According to the Uncovered Interest Rate Parity Condition” *Bank of England Quarterly Bulletin, November 1997*).

Our decomposition of the spot rate level into risk neutral fair value and risk premium components is potentially superior to the traditional Fama approach in that it does not require one to take a stand on how much of the change in the spot rate was – or was not – forecastable. Who knows? Instead we take a stand that at a long horizon (10 years) relative PPP holds in expectation.