Rauli Susmel
Dept. of Finance
Univ. of Houston

Chapter 8 - Theories of FX Determination – Part 2

Goal get a formula for S_t. $S_t = f(i_d, i_f, I_d, I_f, \ldots)$

Last Lecture

Effect of LOOP (arbitrage through trade) on FX Markets.
Derive "equilibrium" (i.e., no-trade) S_t:

Absolute PPP: $S_t = P_d / P_f$ (Rejected, existence of transaction costs, borders a problem)
Relative PPP: $e_f \approx I_d - I_f$ (Rejected in the short-run, some long-run support)

This Lecture

Continue the search for a functional form that explains S_t.

8.2 International Fisher Effect (IFE)

IFE builds on the law of one price, but for financial transactions.

Idea: Expected returns to international investors who invest in money markets in their home country should be equal to the expected returns they would get if they invest in foreign money markets once adjusted for currency fluctuations. Exchange rates will be set in such a way that international investors cannot profit from interest rate differentials.

The "effective" T-day return on a foreign bank deposit is:

$$r_d(f) = (1 + i_f * T/360)(1 + e_{f,T}) - 1.$$

On the other hand, the effective T-day return on a home bank deposit is:

$$r_d(d) = i_d * T/360.$$

Setting $r_d(d) = r_d(f)$ and solving for $e_{f,T} = (S_{t+T}/S_t - 1)$ we get:

$$e_{f,T}^{IFE} = \frac{S_{T+t}}{S_t} - 1 = \frac{(1 + i_d * T/360)}{(1 + i_f * T/360)} - 1 \qquad \text{(IFE).}$$

Using a linear approximation: $e^{IFE}_{f,T} \approx (i_d - i_f) \times T/360$.

$e^{IFE}_{f,T}$ represents an expectation –i.e., $E[e_{f,T}]$. It's the expected change in S_t from t to t+T that makes looking for the "extra yield" in international money markets not profitable.

Since the investors equalize expected returns, IFE assumes the international investors are *risk neutral* – i.e., they pay no attention to the riskiness of a FC investment. Under risk-aversion, a risk premium would be demanded!

If $e_{f,,T} = e^{IFE}_{f,,T}$ $\Rightarrow$ No profits from *carry trades* –i.e., borrow the low interest rate currency, convert it to the currency with the higher interest rate and deposit at the higher interest rate. An investor would get the same expected return investing at the low interest rate, since the currency appreciation would compensate for the lower interest rate yield.

IFE Notes:
- ◊ Like PPP, IFE is built on implied assumptions (no barriers to capital mobility, no country risk, no default risk, no preference for domestic (certain) investments, etc.)
- ◊ IFE also produces an *equilibrium* exchange rate (EER). Equilibrium will be reached when there is no capital flows from one country to another to take advantage of interest rate differentials. The equilibrium S^{IFE}_{t+T} is:

  $S^{IFE}_{t+T} = S_t \times (1 + e^{IFE}_{f,T})$ (Again, S^{IFE}_{t+T} represents an expectation –i.e., $S^{IFE}_{t+T}=E_t[S_{t+T}]$.)

Example: Forecasting S_t using IFE.
It's 2015:I. You work for a Swiss Bank. You have the following information:
$S_{2015:I}$=1.0659 USD/EUR.
$i_{USD,2015:I}$=1.5%
$i_{EUR,2015:I}$=0.5%.
T = 1 semester = 180 days.

$$e^{IFE}_{f,,2015:II} = [1+ i_{USD,2015:I} \times (T/360)]/[1+ i_{EUR,2015:I} \times (T/360)] - 1 =$$
$$= [1+.015*(180/360))]/[1+.005*(180/360)] – 1 = 0.0049875$$
$$E[S_{2015:II}] = S_{2015:I} \times (1+e^{IFE}_{f,,2015:II}) = 1.0659 \text{ USD/EUR} *(1 + 0.0049875) = 1.0712 \text{ USD/EUR}$$

That is, you expect the USD to depreciate against the EUR by 0.5% to compensate for the higher US interest rates (the linear approximation works very well!).¶

• IFE: Implications
If IFE holds, the expected cost of borrowing funds is identical across currencies. Also, the expected return of lending is identical across currencies.

Carry trades –i.e., borrowing the low interest currency to invest in the high interest currency- should not be profitable. But, if departures from IFE are consistent, investors can profit from them.

Example: Mexican peso depreciated by 5% a year during the early 90s.
Annual interest rate differential (i_{MEX} - i_{USD}) ranged between 7% and 16%.
The $E[e_{f,T}]$= -5% > $e^{IFE}_{f,T}$ $\Rightarrow$ Pseudo-arbitrage is possible (According to IFE, the MXN at t+T is overvalued!)

Carry Trade Strategy:
1) Borrow USD funds (at i_{USD})
2) Convert to MXN at S_t
3) Invest in Mexican funds (at i_{MEX})
4) *Wait until T*. Then, convert back to USD at S_{t+T}. (<= There is risk in waiting!)

Expected foreign exchange loss 5% ($E[e_{f,T}] = -5\%$)
Assume ($i_{USD} - i_{MXN}$) = -7%. (For example: i_{USD}= 5%, i_{MXN}=12%, (T=1 year).)
The $E[e_{f,T}]$= -5% > $e^{IFE}_{f,T}$ = -7% ⇒ "on average" strategy (1)-(4) should work.

Expected return (MXN investment): $r_d (f) = (1 + i_{MXN} x T/360)(1 + e_{f,T}) -1 = (1.12)*(1-.05) -1 = 0.064$
Payment for USD borrowing $r_d (d) = i_d \times T/360 = .05$ (Expected Profit = .014 per year)
Overall expected profits ranged from: 1.4% to 11%.

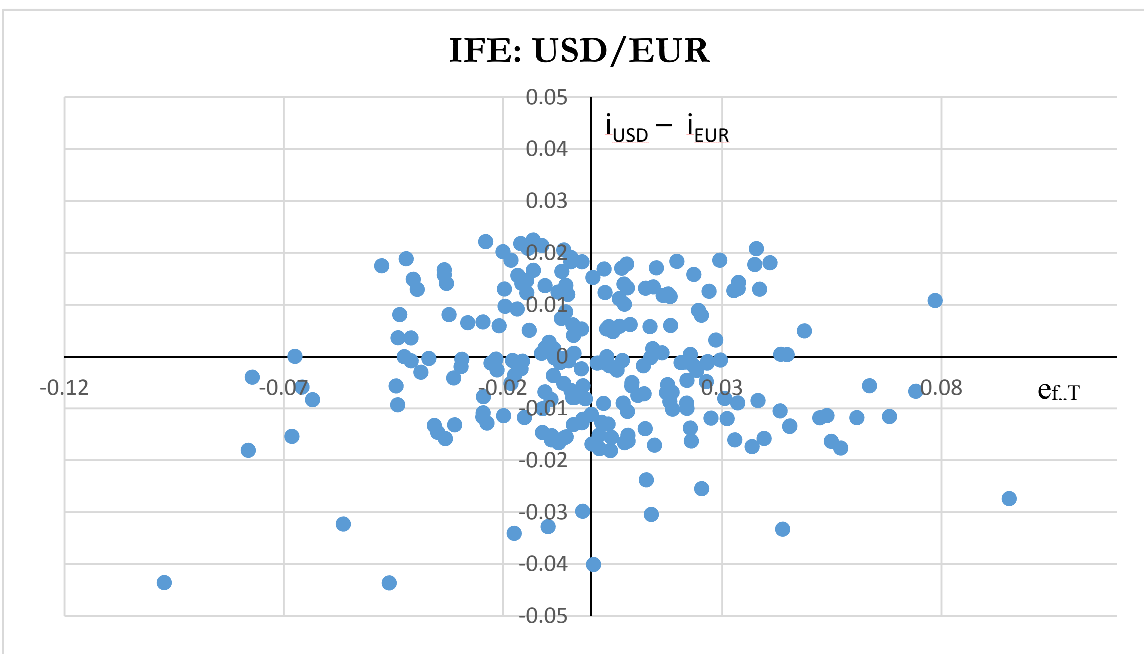
<u>Note</u>: Fidelity used this uncovered strategy during the early 90s. In Dec. 94, after the Tequila devaluation of the MXN against the USD, lost everything it gained before. Not surprised, after all the strategy is a "pseudo-arbitrage" strategy! These extreme risks are usually described as *crash risk*. ¶

The IFE pseudo-arbitrage strategy differs from covered arbitrage in the final step. Step (4) involves no coverage. It's an uncovered strategy. IFE is also called *Uncovered Interest Rate Parity* (UIRP).

• IFE: Evidence
Testing IFE: Similar to PPP.

1. *Visual evidence*. Based on linearized IFE: $e_{f,T} \approx (i_d - i_f) \times T/360$
Expect a 45 degree line in a plot of $e_{f,T}$ against ($i_d - i_f$) ⇒ usually, rejects IFE.

Example: IFE plot for the monthly USD/EUR exchange rate (1999:Jan – 2019:July).



No 45 degree line ⇒ Visual evidence rejects IFE. ¶

2. *Do a regression*

$e_{f,T} = (S_{t+T} - S_t)/S_t = \alpha + \beta\,(i_d - i_f)_t + \varepsilon_t$, (where ε_t is the regression error, $E[\varepsilon_t]=0$).

The null hypothesis is: H_0 (IFE true): $\alpha = 0$ & $\beta = 1$
H_0 (IFE not true): $\alpha \neq 0$ and/or $\beta \neq 1$

Example: Testing IFE for the USD/EUR
We collected monthly interest rates differentials ($i_{USD} - i_{EUR}$) and e_f (USD/EUR) from January 1999 to July 2019 (248 observations). We estimate the following regression:

$$e_{f,T} = (S_{t+T} - S_t)/S_t = \alpha + \beta\,(i_{USD} - i_{EUR})_t + \varepsilon_t$$

$R^2 = 0.00276$
Standard Error = 0.02819
F-statistic (slopes=0) = 0.6805 (p-value=0.4102)
F-test (α=0 and β=1) = 40.4855 (p-value= lower than 0.0001) $\Rightarrow$ rejects H_0 at the 5% level ($F_{2,246,.05}$=3.03)
Observations = 248

	Coefficients	*Stand Error*	*t-Stat*	*P-value*
Intercept ($\hat{\alpha}$)	0.000174	0.001791	0.097177	0.922665
($i_{USD} - i_{EUR}$) ($\hat{\beta}$)	-0.10094	0.12236	-0.82491	0.410224

Let's test H_0, using t-tests ($t_{104,.05}$ = 1.96) :
$t_{\alpha=0}$ (t-test for α **= 0**): (0.000174– **0**)/ 0.001791= 0.097 $\Rightarrow$ cannot reject at the 5% level.
$t_{\beta=1}$ (t-test for β **= 1**): (-0.10094– **1**)/ 0.12236= -8.998 $\Rightarrow$ reject at the 5% level.

Formally, IFE is rejected in the short-run (both the joint test and the t-test reject H_0). Also, note that β is negative, not positive as IFE expects.

Note: During the 1999-2019 period, the average monthly ($i_{USD} - i_{EUR}$) was 0.000365/12 = .00003. That is, $\mathbf{e_{f,t}^{IFE}}$ = **0.0003%** per month (IFE expects a 0.0003% monthly appreciation of the EUR, statistically speaking different from zero). But, the actual average monthly $e_{f,t}$ was .0001 ($e_{f,t}$ =0.01% per month; statistically speaking not different from zero), which is different from $e_{f,t}^{IFE}$.

If we use the regression to derive an expectation, the regression expects $E[e_{f,t}]$ = .000174-.10094*(.00036) = **0.00014**, which is statistically speaking not different from zero. That is, we expect a very close to zero monthly change in the EUR against the USD. This zero change is still different from $e_{f,t}^{IFE}$, but a bit closer to the actual $e_{f,t}$.

Recall that consistent deviations from IFE point out that carry trades are profitable: During the 1999-2019 period, USD-EUR carry trades should have been profitable. ¶

Similar to PPP, there is no short-run evidence. As pointed out above, consistent IFE departures make carry trades profitable: Burnside (2008) show that the average excess return of an equally weighted carry trade strategy, based on up to 20 currencies and executed monthly over the period 1976–2007, was about 5% per year. Lower than excess returns for equity markets, but with a Sharpe ratio twice as big as the S&P500! (Annualized volatility of the carry trade returns was much less than that for stocks).

Again, similar to PPP, some long-run support for IFE:

$\Rightarrow$ Currencies with high interest rate differentials tend to depreciate.
(For example, the Mexican peso finally depreciated in Dec. 1994.)

8.3 Expectations Hypothesis of Exchange Rates

Expectations hypothesis (EH) of exchange rates:

$E_t[S_{t+T}] = F_{t,T}$.

Example: Suppose that over time, investors do not behave according to EH.
Data: $F_{t,180} = 5.17$ ZAR/USD.
An investor expects: $E_t[S_{t+180}] = 5.34$ ZAR/USD. (A potential profit exists.)

Strategy for the non-EH investor:
1. Buy USD forward at ZAR 5.17
2. In 180 days, sell the USD at the expected rate. Get ZAR 5.34.

Now, suppose everybody expects $S_{t+180} = 5.34$ ZAR/USD

$\Rightarrow$ Disequilibrium: Everybody buys USD forward (nobody sells USD forward), $F_{t,180}\uparrow$. In 180 days, everybody will be selling USD, $E[S_{t+180}]\downarrow$. Prices should adjust until EH holds.

Since an expectation is involved, sometimes you'll have a loss, but, on average, you'll make a profit. ¶

Key question behind EH: Are forward rates good predictors of future spot rates?

• Expectations Hypothesis: IFE (UIRP) Revisited

EH: $E_t[S_{t+T}] = F_{t,T}$.
Replace $F_{t,T}$ by IRP, say the linearized version: $E_t[S_{t+T}] \approx S_t\,[1 + (i_d - i_f) \times T/360]$.
A little bit of algebra gives: $(E[S_{t+T}] - S_t)/S_t \approx (i_d - i_f) \times T/360$ <= IFE linearized!

• Expectations Hypothesis: Implications

$E_t[S_{t+T}] = F_{t,T} \Rightarrow F_{t,T}$ is an *unbiased* predictors of S_{t+T}.

That is, $S_{t+T} - F_{t,T}$ = unpredictable (surprise: $E_t[S_{t+T} - F_{t,T}] = E_t[\varepsilon_t] = 0$!). This result will be the basis for testing.

For a firm, EH means that the expected cash flows associated with hedging or not hedging currency risk are the same.

Example: You work for a company that wants to forecast the quarterly USD/GBP exchange rate. You are given the interest rate differential (in %) and S_t. Then, using IRP you calculate $F_{t,90}$:

$F_{t,90} = S_t\,[1 + (i_{US} - i_{UK})_t \times T/360]$.

Suppose today it is the end of the second quarter of 2014 (2014:II). Data available:
$S_{t=2014:II}$ = 1.6883 USD/GBP
$(i_{US}-i_{UK})_{t=2014:II}$ = -0.304%.
Then,

$$F_{t,90} = 1.6883 \text{ USD/GBP} \times [1 - 0.00304 \times 90/360] = \mathbf{1.68702 \text{ USD/GBP}}$$

Then, you use $F_{t,90}$ to forecast S_{t+90} ($E_t[S_{t+90}]=S^F_{t+90}$). That is, S^F_{t+90}= 1.68702 USD/GBP.

You can also calculate the forecasting error, $\varepsilon_t = S_t - S^F_t$, which you can use later to compare different forecasting models.

Doing this forecasting exercise each period generates the following quarterly forecasts and forecasting errors, ε_t:

Quarter	$(i_{US}-i_{UK})$	S_t	$S^F_{t+90} = F_{t,90}$	$\varepsilon_t = S_t - S^F_t$
2014:II	-0.304	**1.6883**		
2014:III	-0.395	**1.6889**	**1.68702**	0.0019
2014:IV	-0.350	**1.5999**	**1.68723**	-0.0873
2015:I	-0.312	**1.5026**	**1.59850**	-0.0959
2015:II	-0.415	**1.5328**	**1.50143**	0.0314
2015:III	-0.495	**1.5634**	**1.53121**	0.0322
2015:IV		**1.5445**	**1.56146**	-0.0170

Calculation of the forecasting error for 2014:III: $\varepsilon_{t=2014:III}$ = **1.6889 - 1.68702 =** 0.0019. ¶

• Expectations Hypothesis: Evidence
In general, expectations are unobservable. However, some companies and organizations survey "experts" and compile FX expectations (*Bloomberg*, in the U.S., *Japan Center for International Finance*, in Japan, *Banxico*, in Mexico, etc.). EH is not tested based on these surveys, but on the implications of the EH.

Under EH, $E_t[S_{t+T}] = F_{t,T} \rightarrow E_t[S_{t+T} - F_{t,T}] = 0$

Empirical tests of the EH are based on a regression:

$$(S_{t+T} - F_{t,T})/S_t = \alpha + \beta Z_t + \varepsilon_t, \quad \text{(where } E[\varepsilon_t]=0)$$

where Z_t represents any economic variable that might have power to explain S_t, for example, (i_d-i_f).

The null hypothesis is H_0: α=0 and β=0. (Recall $(S_{t+T} - F_t)$ should be unpredictable!)

Usual Finding: $\beta < 0$ (and significant) when $Z_t=(i_d-i_f)$. R^2 is low. In general, as the horizon increases (say, from 3-months to 5 years), β increases toward zero (also the significance of β decreases with the time horizon).

Note: EH can also be tested based on the Uncovered IRP (IFE) formulation:

$(S_{t+T} - S_t)/S_t = e_{f,T} = \alpha + \beta\,(i_d - i_f) + \varepsilon_t.$

The null hypothesis is H_0: α=0 and β=1.

Usual Result: $\beta < 0$ $\Rightarrow$ when $(i_d - i_f)$=2%, the exchange rate appreciates by (β x .02)
(instead of depreciating by 2% as predicted by UIRP!)

Example: Check the IFE test for the monthly USD/EUR. The estimated β was negative and significant (-0.26342). The R^2 was also low (0.057), but not 0! ¶

Summary: Forward rates have little power for forecasting spot rates $\Rightarrow$ Puzzle!

• Explanations for the Forward Bias

Explanation 1: Risk Premium

The risk premium of a given security is the return on this security, over and above the risk-free return.

Q: Is a risk premium justified in the FX market?
A: Only if exchange rate risk is not diversifiable.

After some simple algebra, we find that the expected excess return on the FX market is given by:

$$(E_t[S_{t+T}] - F_{t,T})/S_t = P_{t,t+T}.$$

A risk premium, P, in FX markets implies: $E_t[S_{t+T}] = F_{t,T} + S_t\, P_{t,t+T}.$

In general, we think of $P_{t,t+T}$ as a function of uncertainty related to S_{t+T} and the risk attitudes of investors (under risk neutrality, $P_{t,t+T}$=0).

If $P_{t,t+T}$ is consistently different from zero, say positive, markets will display a forward bias.

Evidence for a risk premium: Weak.

Explanation 2: Errors in Forming Expectations

Investors make consistent errors in forecasting exchange rates.

$\Rightarrow$ It takes time for investors to learn about new market conditions.

Example: There is a new chairman on the Bank of Japan. It might take years to learn the Bank of Japan's new monetary policy. ¶

Explanation 3: The "Peso Problem"

For long periods of time investors assign a small (positive) probability to certain infrequent events (such as devaluations) which may never materialize in a limited sample period.

The expectation of such rare and extreme events will be reflected in today's forward exchange rate. The events may never materialize, but markets show a forward bias.

Example: The Mexican peso used to show a real and continuous appreciation until the Mexican government finally devalued the peso (generally after an election). Before the devaluation, the Mexican peso used to have a strong forward bias. ¶

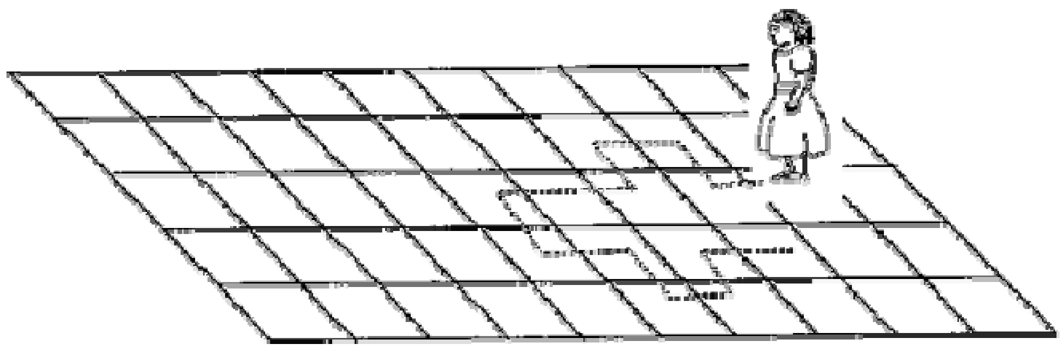
Note: Relation to IFE.

$E_t[S_{t+T}] = F_{t,T} = S_t\,(1 + i_d \times T/360)/(1 + i_f \times T/360)$.	- Using IRP formula for $F_{t,T}$
$\Rightarrow E_t[S_{t+T}] / S_t = (1 + i_d \times T/360)/(1 + i_f \times T/360)$	- Dividing both sides by S_t
$\Rightarrow e^{IFE}_{f,,T} = (1 + i_d \times T/360)/(1 + i_f \times T/360) - 1$	- Recalling $e_{f,,T} = S_{t+T} / S_t - 1$.

8.4 The Martingale-Random Walk Model

A random walk is a time series independent of its own history. Your *last step* has no influence in your *next step*. The past does not help to explain the future.

(Technically, in a random walk process the uncorrelated steps are *independently and identically distributed* –i.e., they are independent and come from the same distribution. A martingale process only requires the steps to be uncorrelated.)



Intuitive notion: The FX market is a "*fair game*" –i.e., there are no exploitable trends.

• Martingale-Random Walk Model: Implications

The Martingale-Random Walk Model (RWM) implies:

$E_t[S_{t+T}] = S_t$.

If S_t follows a RW, exchange rates cannot be forecasted: S_t is the forecast! That is, a firm should not spend any resources to forecast S_{t+T}.

Powerful theory: At time t, all the info about S_{t+T} is summarized by S_t. Only relevant information to forecast S_{t+T}: S_t $\Rightarrow$ Changes in S_t are unpredictable.

The RWM is an old model. It was first proposed by the French mathematician Bachelier in 1900 to describe the behavior of French bonds.

Theoretical Justification: Efficient Markets Hypothesis (EMH): All available information is incorporated into today's S_t. Under the practical version of the EMH, it is very difficult for investors to consistently obtain above average returns –i.e., forecast S_{t+T} consistently better than the competition.

Example: Forecasting with RWM
$S_t = 1.60$ USD/GBP
$E_t[S_{t+7\text{-day}}] = 1.60$ USD/GBP
$E_t[S_{t+180\text{-day}}] = 1.60$ USD/GBP
$E_t[S_{t+10\text{-year}}] = 1.60$ USD/GBP.

Note: The forecast error is the change in exchange rates. That is, $\varepsilon_{t+T} = S_{t+T} - E_t[S_{t+T}] = S_{t+T} - S_t$. ¶

• Martingale-Random Walk Model: Evidence
Meese and Rogoff (1983, *Journal of International Economics*) tested the short-run forecasting performance of different models for the four most traded exchange rates. They considered economic models (PPP, IFE/UIRP, Monetary Approach, etc.) and the RWM.

⇒ They found that the RWM performed as well as any other model.
Metric used: MSE (mean squared error) ⇒ $MSE = \Sigma_t (S_{t+T}^{Forecast} - S_{t+T})^2/Q$, $t=1,2,...,Q$.

Cheung, Chinn and Pascual (2005) checked the Meese and Rogoff's results with 20 more years of data
⇒ RWM still the best model in the short-run.

The results from Meese and Rogoff (1983) were very surprising. The paper started a big literature; which, in general, confirms the results in the short-run (say, up to 6-months or 1-year), but for longer horizons (say, 4 years), some models can do better. These long-horizon successes are based on models such as PPP and IFE and incorporate statistical features of FX rates and the predictable behavior of Central banks.

Example: MSE - Forecasting with Forwards and the RWM
You work for a company that wants to forecast the quarterly USD/GBP exchange rate. You are given the interest rate differential (in %) and S_t, which you used above to calculate the forward rate, $F_{t,90}$, and, then, to forecast $E_t[S_{t+90}]=\mathbf{S^F_{t+90}}$. You also use the RWM to forecast $E_t[S_{t+90}] = \mathbf{S_t}$. Then, to check the accuracy of the forecasts, you calculate the MSE.

Quarter	$(i_{US}-i_{UK})$	S_t	Forward Rate		Random Walk	
			$S^F_{t+90} = F_{t,90}$	$\varepsilon_{t\text{-}FR} = S_t - S^F_t$	$S^F_{t+90}=S_t$	$\varepsilon_{t\text{-}RW} = S_t - S^F_t$
2014:II	-0.304	**1.6883**				
2014:III	-0.395	**1.6889**	**1.6870**	0.0019	**1.6883**	0.0006
2014:IV	-0.350	**1.5999**	**1.6872**	-0.0873	**1.6889**	-0.0890
2015:I	-0.312	**1.5026**	**1.5985**	-0.0959	**1.5999**	-0.0973
2015:II	-0.415	**1.5328**	**1.5014**	0.0314	**1.5026**	0.0302
2015:III	-0.495	**1.5634**	**1.5312**	0.0322	**1.5328**	0.0306
2015:IV		**1.5445**	**1.5615**	-0.0170	**1.5634**	-0.0189
MSE				**0.00319**		**0.00327**

Both MSEs are similar, though the Forward Rate's MSE is a bit smaller (2% lower).

Calculation of MSE for Forward Rate:
MSE = $[0.0019^2 + (-0.0873)^2 + (-0.0959)^2 + 0.0314^2 + 0.0322^2 + (-0.0170)^2] / 6 =$ **0.00319.** ¶

• Martingale-Random Walk Model: Many Empirical Models Trying to Compete
As illustrated above, models of exchange rates determination based on economic fundamentals have problems explaining the short-run behavior of S_t (though, there is ope for the long-run behavior of S_t). This is not good news if the aim of the model is to forecast S_t in the short-run.

As a result of this failure, a lot of empirical models, modifying the traditional fundamental-driven models, have been developed to better explain *equilibrium exchange rates* (EERs). Some models are built to explain the medium- or long-run behavior of S_t, others are built to beat (or get closer to) the forecasting performance of the RWM.

A short list of the new models includes CHEERs, ITMEERs, BEERs, PEERs, FEERs, APEERs, PEERs, and NATREX. Below, I include Table 8.1, taken from Driver and Westaway (2003, Bank of England), which describes the main models used to explain EERs.

Table 8.1: Summary of Empirical Approaches to Estimating Equilibrium Exchange Rates

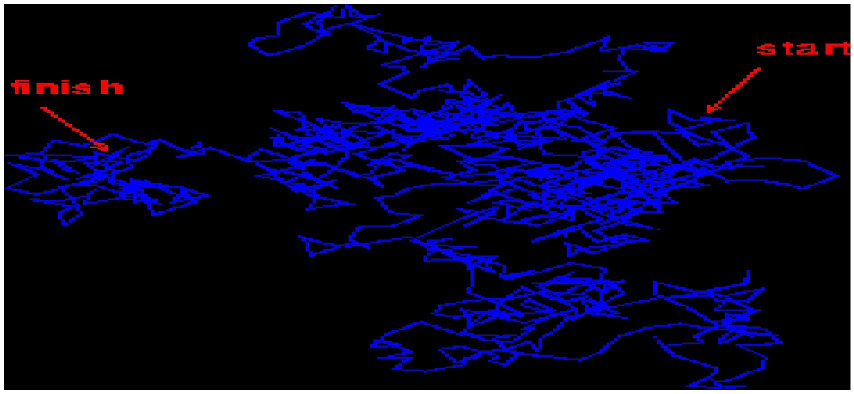
	UIP	PPP	Balassa-Samuelson	Monetary Models	CHEERs	ITMEERs	BEERs
Name	Uncovered Interest Parity	Purchasing Power Parity	Balassa-Samuelson	Monetary and Portfolio balance models	Capital Enhanced Equilibrium Exchange Rates	Intermediate Term Model Based Equilibrium Exchange Rates	Behavioural Equilibrium Exchange Rates
Theoretical Assumptions	The expected change in the exchange rate determined by interest differentials	Constant Equilibrium Exchange Rate	PPP for tradable goods. Productivity differentials between traded and nontraded goods	PPP in long run (or short run) plus demand for money.	PPP plus nominal UIP without risk premia	Nominal UIP including a risk premia plus expected future movements in real exchange rates determined by fundamentals	Real UIP with a risk premia and/or expected future movements in real exchange rates determined by fundamentals
Relevant Time Horizon	Short run	Long run	Long run	Short run	Short run (forecast)	Short run (forecast)	Short run (also forecast)
Statistical Assumptions	Stationarity (of change)	Stationary	Non-stationary	Non-stationary	Stationary, with emphasis on speed of convergence	None	Non-stationary
Dependent Variable	Expected change in the real or nominal	Real or nominal	Real	Nominal	Nominal	Future change in the Nominal	Real
Estimation Method	Direct	Test for stationarity	Direct	Direct	Direct	Direct	Direct

Table 8.1: Summary of Empirical Approaches to Estimating Equilibrium Exchange Rates (continuation)

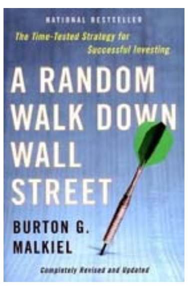
FEERs	DEERs	APEERs	PEERs	NATREX	SVARs	DSGE
Fundamental Equilibrium Exchange Rates	Desired Equilibrium Exchange Rates	Atheoretical Permanent Equilibrium Exchange Rates	Permanent Equilibrium Exchange Rates	Natural Real Exchange Rates	Structural Vector Auto Regression	Dynamic Stochastic General Equilibrium models
Real exchange rate compatible with both internal and external balance. Flow not full stock equilibrium	As with FEERs, but the definition of external balance based on *optimal* policy	None	As BEERs	As with FEERs, but with the assumption of portfolio balance (so domestic real interest rate is equal to the world rate).	Real exchange rate affected by supply and demand (but not nominal) shocks in the long run	Models designed to explore movements in real and/or nominal exchange rates in response to shocks.
Medium run	Medium Run	Medium / Long run	Medium / Long run	Long run	Short (and long) run	Short and long run
Non-stationary	Non-stationary	Non-stationary (extract permanent component)	Non-stationary (extract permanent component)	Non-stationary	As with theoretical	As with theoretical
Real Effective	Real Effective	Real	Real	Real	Change in the Real	Change relative to long run steady state
Underlying Balance	Underlying Balance	Direct	Direct	Direct	Direct	Simulation

CHAPTER 8 - BONUS COVERAGE I: A Random Walk

This is a computer generated random walk of 1,000 steps going nowhere:



The RW model does not only appear in Finance and Economics. Many physical processes such as Brownian motion, electron transport through metals, and round off errors on computers are modeled as a random walk. In the above computer generated RW, many steps are taken with the direction of each step independent of the direction of the previous one.



The RWM is an old model. It was formally introduced by the French mathematician Bachelier (1900), who used it to study bond prices on the Paris Bourse. Since then it has been proposed for all financial assets. Malkiel's (1973) *A Random Walk Down Wall Street* popularized the idea of the unpredictability of asset prices. (BTW, the book is in its 11th edition and sold over 1.5 million copies). Lo and MacKinlay's (2002) *A Non-Random Walk Down Wall Street* summarized results that show that financial assets display statistically significant deviations from the RWM. There are some predictable components. Nonetheless, from a forecasting point of view, beating the RWM, in the short-run, is very, very difficult.

BONUS COVERAGE II: The man behind IFE - Irving Fisher (1867–1947)

Today, Fisher is remembered in neoclassical economics for his theory of capital, investment, and interest rates, first exposited in his *The Nature of Capital and Income* (1906) and elaborated on in *The Rate of Interest* (1907). His 1930 treatise, *The Theory of Interest*, summed up a lifetime's research into capital, capital budgeting, credit markets, and the factors (including inflation) that determine interest rates.

The Fisher equation, where the nominal interest rate is approximated by the real interest rate, k, plus the (expected) inflation rate, is named after him:

$$i = k + E[I]$$

But, for investors, he may be best remembered for predicting, three days before the October 1929 crash: *"Stock prices have reached what looks like a permanently high plateau."*

BONUS COVERAGE III: Asset Approach to Exchange Rates

The flows (exports and imports) approach to exchange rate determination was very popular until the late 1960s. But, these models did not work well. During the 1970s, economists began to think of currencies as any other asset. Thus, exchange rates are asset prices that adjust to equilibrate international trade in financial assets. Exchange rates are relative prices between two currencies and these relative prices are determined by the desire of residents to hold domestic and foreign financial assets. Like other asset prices, exchange rates are determined by expectations about the future. Therefore, past or present trade flows cannot influence exchange rates to the extent that they have already been expected. This approach, which treats currencies as assets, is called the *asset approach*.

• Monetary Approach (MA)

The asset approach assumes a high degree of capital mobility between assets denominated in different currencies. We need to specify the domestic and foreign assets to be included in the portfolio of a domestic resident. Since exchange rates are relative prices between two currencies, a simple model is to consider domestic money and foreign money. This simple asset model is called the *monetary approach* (MA) model.

BC.1 A Simple Monetary Approach Model

The traditional MA is a long-run theory that assumes that prices are flexible. Through PPP, the monetary approach relates the factors that affect prices with exchange rates. The determination of prices is based on the Quantitative Theory of Money (QTM):

$M_S\ V = P\ Y$,

V: velocity of money,
P: price level
Y: real output
M_S: Money supply (in equilibrium, M_S: L_d, L_d: Money demand, L stands for liquidity.)

This equation assumes that prices are fully flexible. If M_S changes then prices adjust instantaneously.

Solving for P, we obtain: $P = (M_S\ V)/Y$.

The MA model needs an equation that relates the QMT to exchange rates. We already know a theory that relates domestic and foreign prices to exchange rates: PPP. Using the subscripts d and f to denote domestic and foreign quantities, and after simple substitutions, the spot rate is determined by:

$$S_t = P_d/P_f = (V_d/V_f) \times (Y_f/Y_d) \times (M_{Sd}/M_{Sf}). \qquad \text{(BC.1)}$$

BC.1 assumes not only fully flexible prices, but also that PPP holds continuously. Assume V is constant in the short-run and after some algebra (taking logs and creating log differences), we get:

$s_{t+T} = e_{f,t+T} = y_{f,T} - y_{d,T} + m_{Sd,T} - m_{Sf,T}$,

where small letters represent percent changes (growth rates) in the underlying variables.

BC.2 A More Sophisticated Monetary Approach Model

The previous monetary model was very simple. Implicitly, we have paid no attention to money demand and, implicitly, assumed that monetary variables are exogenous variables. However, in equilibrium, monetary variables are jointly determined by supply and demand. Let's complicate the MA model by introducing the demand for real-money holdings, L_D. In equilibrium, L_D equals M_S/P:

$M_S/P = L_D$.

Now, let us model L_D as a function of income, Y, and interest rates, i. For example,

$L_D = k\ Y^a\ e^{b\,i}$,

where k represents the inverse of velocity of money, V.

After some substitutions and using PPP, we obtain:

$\ln(S_T) = a[\ln(Y_{f,T}) - \ln(Y_{d,T})] + b(i_{f,T} - i_{d,T}) + [\ln(k_f) - \ln(k_S)] + [\ln(M_{Sd,T}) - \ln(M_{Sf,T})]$.

Again, like in the IFE model, interest rate differentials play a role in the determination of exchange rates. Under the MA, interest rate differentials play a role through the impact on L_D. The same can be said about income growth rate differentials, they influence S_t through L_D.

Note: Expectations about future S_t into the MA model. Recall the interest rate differentials provides information about the expected change in exchange rates, $\{E(S_{t+T})/S_t - 1\}$. That is, the S_t today depends on expectations about the expected S_{t+T}. Through several substitutions, it is easy to see that the exchange rate today depends on the expected path of future exchange rates.

BC.3 Monetary Approach: Implications

The MA presented has very precise implications. It predicts that S_t behaves like any other speculative asset price; S_t changes whenever relevant information is released.

"Relevant information": i_d, i_f, y_d, y_f, M_{Sd}, M_{Sf}. (Expectations about the future these variables matter.)

Example: Suppose the money supply in the U.S. market increases unexpectedly by 2% and all the other variables remain constant. According to the monetary approach, an increase in the money supply of 2% leads to an increase of 2% in S_t (a depreciation of the USD).

Now, suppose that investors expect the U.S. Fed to quickly increase U.S. interest rates to offset this increase in the money supply, then the USD might appreciate instead of depreciate. ¶

CHAPTER 8 – BRIEF ASSESMENT

1. Assume the following cost for the CPI baskets:
CPI-basket$_{USA}$ = USD 755.3
CPI-basket$_{CAD}$ = CAD 928.8

(A) Calculate S_t^{PPP}.
(B) Suposse = 1.31 CAD/USD. Calculate $\mathbf{R_t}$. Which country is more efficient?
(C) Describe how market forces act when S_t and $\mathbf{S_t^{PPP}}$ move towards convergence.

2. Suppose you have the following data:
S_{t-1} = 1.40 USD/GBP.
$I_{GBP,t}$ = 1.50%
$I_{USD,t}$ = 2.00%
(A) According to relative PPP, what should be S_t?
(B) Suppose S_t = 1.37 USD/GBP, according to relative PPP, is the GBP overvalued or undervalued?

3. Suppose you have the following information:
$S_{2017:I}$ = 1.31 USD/CAD.
$i_{USD,2017:I}$ = 2.00%
$i_{CAD,2015:I}$ = 2.5%.
T = 1 semester = 180 days.
(A) Using IFE, calculate E[$S_{2017:II}$].
(B) Using the RW model, calculate E[$S_{2017:II}$].

4. Suppose you have the following data:
E[$S_{2017:II}$] = 1.31 USD/CAD.
$F_{t,\ 2017:II}$ = 1.30 USD/CAD.
Describe how you can take advantage of this violation of the EH.

5. You run the following regression: changes in the JPY/USD exchange rate against inflation rate differentials (I_{JPY}-I_{US}). Below, you have the excel regression output. Let RSS(H_0)= 0.5214. Using individual t-tests and a joint F-test, test relative PPP.

Regression Statistics	
Multiple R	0.082399
R Square	0.00679
Adjusted R Square	0.004707
Standard Error	0.03282
Observations	479

ANOVA

	df	SS	MS
Regression	1	0.003512	0.003512
Residual	477	0.513811	0.001077
Total	478	0.517323	

	Coefficients	Standard Error
Intercept	-0.00302	0.00153
X Variable 1	-0.62455	0.33511