Lecture Notes for Chapter 7

# International Financial Markets and Institutions

Chapter 7

## The behavior of the spot and forward exchange rates II

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# Road Map

**12** Summary of international finance

**13** Revision classes

# 7.6 Forecasting exchange rates

Question: Is it possible to forecast the future value of nominal exchange rate?

Classification of tests to forecast the exchange rate:

**Weak form tests** — those that forecast the future exchange rate on the basis of the past exchange rate; these are tests of *technical* models.

**Semi-strong form tests** — those that predict the exchange rate on the basis of other available information, in addition to realized exchange rates. This is called *fundamental* analysis.

- The fundamental variables may include the inflation rate, money supply, industrial production and the forward exchange rate.
- The forecasts based on these fundamentals may be made using an **econometric model**, or on a **judgmental basis**.

**Strong form tests** — forecasts made by

- professional forecasting agencies who may be better than individuals at interpreting information, and
- central banks, who may have more information than that available to the typical investor.

# 7.7 Forecasting spot rate based on its past realizations

There are a number of possible forecasting techniques.

## 7.7.1 Autocorrelation models

- The goal of autocorrelation models is to see if one can predict the future exchange rate change based on the lagged exchange rate change.

- Autocorrelation models are similar to regressions where one regresses the left-hand side variable on its lagged values.

$$\underbrace{\ln\left(\frac{S_{t+1}}{S_t}\right)}_{\text{future change}} = a + b \cdot \underbrace{\ln\left(\frac{S_t}{S_{t-1}}\right)}_{\text{lagged change}} + e_{t+1} \tag{7.1}$$

or, more generally, with many lags on the right-hand side

$$\ln\left(\frac{S_{t+1}}{S_t}\right) = a + b_1 \cdot \ln\left(\frac{S_t}{S_{t-1}}\right) + b_2 \cdot \ln\left(\frac{S_{t-1}}{S_{t-2}}\right) + \ldots + b_k \cdot \ln\left(\frac{S_{t-k+1}}{S_{t-k}}\right) + e_{t+1}$$

- Then, one examines the autocorrelation coefficients, $b$, for significance.
- For example, if $b$ was positive and significant in (7.1), then it would imply that an above-average change in the exchange rate will be followed by another above-average increase.

- **Positive autocorrelation**, if observed, could be consistent with many explanations:
  - The bandwagon theory: When an increase in the spot rates is observed, following an exogenous event, investors think that more increases will follow. Thus, they buy the foreign currency, which reinforces the initial increase, and so on.
  - Slow dissemination of new information: At first, only well-informed players trade on good (or bad) news, and force a price change; then other groups gradually obtain the same information, and induce more price changes in the same direction, etc.
  - Slow changes in risk or in the degree of risk-aversion in the market.

- **Negative autocorrelation** (increases tend to be followed by drops, and vice versa) could be explained by
  - tendency for floating exchange rates to overreact to new information;
  - for ERM rates (or managed rates)—corrections needed to stay within the formal or informal band.

- Autocorrelation tests on the exchange market generally reveal
  - small, and typically significantly positive autocorrelations;
  - also, autocorrelation coefficients are frequently larger than for common stocks.

▶ **Conclusion:** For floating exchange rates the information content of past exchange rates is low: the $R^2$ statistics from such tests rarely exceed 5 percent, so the predictability of the change in the exchange rate, based on past changes, is not economically significant.

### 7.7.2 Runs Tests

- In runs tests, we represent the series of observed changes in the exchange rate by their signs, positive or negative.

- We then test whether the observed series could possibly be drawn from a model which randomly generates pluses, minuses, and zeros from a constant distribution.

- Such tests reveal that there is some tendency for increases to be followed by more increases, and drops in the exchange rate to be followed by further drops.

▶ **Conclusion:** Again, the deviations from a random pattern are not too impressive, but the results confirm the (weak) persistence in exchange rate movements found in autocorrelation test

### 7.7.3 Filter Rules and Charts

- To test whether stock market movements tend to persist through time, one can use a filter rule:
  - If increases tend to be followed by increases, then a policy of buying after observing an $x\%$ rise from a "low" would, on average, generate profits; and,
  - if price-drops tend to be followed by more down-ticks, then selling after observing an $x\%$ fall from a "high" would again pay, on average.
- The percentage $x$ used is called the size of the filter. The filter is meant to detect significant changes as opposed to meaningless changes generated by temporary fluctuations in demand and supply.

- **Conclusion:** While there is some persistence in exchange rates, of the more than 580 filters tested
  - less than 10% of the rules produced profits that are significant at the 10% level before transaction costs; and,
  - only 0.3% of the rules were profitable after transaction costs.

### 7.7.4 Overall conclusion on weak-form efficiency of currency markets

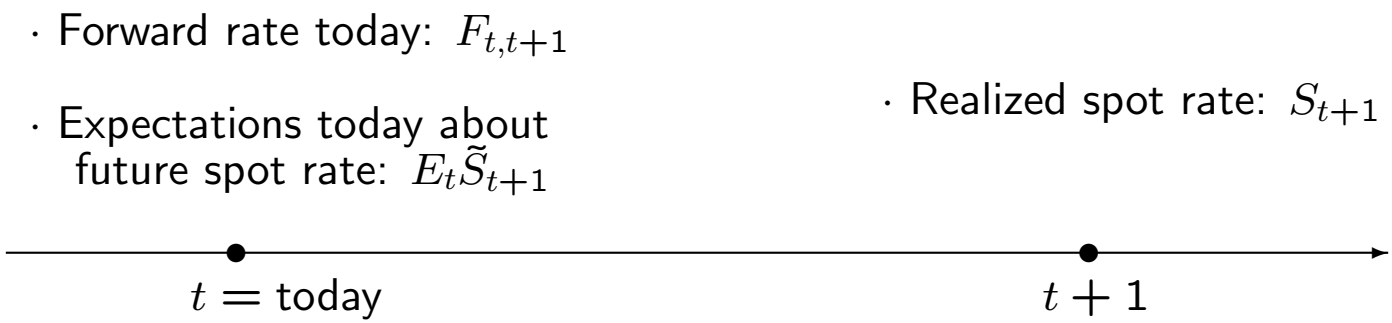
- There is some evidence of weak persistence in exchange rates
  - This does not necessarily imply that the market is inefficient.
  - The persistence could arise because of slow changes in risk and, therefore, expected returns.

- It is not clear whether it is possible to predict future changes in exchange rates based only on past information about exchange rates; and predictability, if any, is not economically impressive (low $R^2$).

# 7.8 Forecasting the exchange rate using the forward exchange rate

- The conjecture that the future spot rate is equal to the current forward rate is called the *Unbiased Expectations Hypothesis* (UEH):

$$E_t(\tilde{S}_{t+1}) = F_{t,t+1}.$$



- Clearly, this hypothesis would be true in a world without uncertainty (otherwise there would be arbitrage opportunities).

- This hypothesis would also be true (approximately) if

  – all investors were risk neutral, or
  – if all exchange risk was completely diversifiable,

  so that investors were indifferent between the certain forward rate and the random future spot rate.

Question: Is UEH true in the real world?

### 7.8.1 Regression Tests of the UEH

- We wish to test the hypothesis:

$$E_t(\tilde{S}_{t+1}) = F_{t,t+1}.$$

- Two problems in using regression analysis to test this relation:

1. The equation is in terms of expectations, which are *unobservable*. All one can observe is the realized value $S_{t+1}$;
   - But in an informationally efficient market, the deviation between the market's forecast and the actual outcome must be unpredictable.
   - This allows us to re-write the equation in terms of observed spot rate, $S_{t+1}$ and its forecast error, $\text{error}_{t+1}$:
     $S_{t+1} = F_{t,t+1} + \text{error}_{t+1}$

**2.** A second problem is that of *non-stationarity* of spot and forward exchange rates. (Non–examinable)

- A non-stationary time series does not have a well-defined unconditional expected value and variance.
- Thus, coefficients from such a regression are not be well defined.
- One way to deal with this is to consider (percentage) changes in the exchange rate rather than the levels of the spot and forward rates.
- That is, we subtract $S_t$ from both sides of the equation above, and divide by $S_t$ to get the following test equation.

$$\left(\frac{S_{t+1} - S_t}{S_t}\right) = \left(\frac{F_{t,t+1} - S_t}{S_t}\right) + \text{error}_{t+1}$$

- Alternatively, get the continuously compounded rate of change by dividing by $S_t$ and taking logs:

$$\ln\left(\frac{S_{t+1}}{S_t}\right) = \ln\left(\frac{F_{t,t+1}}{S_t}\right) + \text{error}_{t+1} \tag{7.2}$$

– From the CIP relation, $F_{t,t+1} = S_t \left(\frac{1+r_{t,t+1}}{1+r^*_{t,t+1}}\right)$,

$$\begin{aligned} \ln\left(\frac{F_{t,t+1}}{S_t}\right) &= \ln\left(\frac{1+r_{t,t+1}}{1+r^*_{t,t+1}}\right) \\ &= r_{t,t+1} - r^*_{t,t+1}, \end{aligned} \tag{7.3}$$

where we have used the results that $\ln(\frac{x}{y}) = \ln x - \ln y$, and that $\ln(1+z) = z$, when $z$ is small (you can verify this on a calculator).

– The advantage of using logs is that if the exchange rate is inverted from HC/FC to FC/HC, only the sign of each term has to be changed (from $+$ to $-$).

– Based on equations (7.2) and (7.3), we can write the following test regression, with the null hypothesis that $a = 0, b = 1$:

$$\ln\left(\frac{S_{t+1}}{S_t}\right) = a + b\left(r_{t,t+1} - r^*_{t,t+1}\right) + e_{t+1}.$$

- **Conclusion:** Over 75 empirical studies test this regression, and reject it.
  - The average value of $b$ in these studies is $-0.88$.
  - The $R^2$ value is also very small, so there is little evidence of predictability in forward exchange rates.

- There are at least three possible interpretations of the result that $b < 1$.
  - Investors are not risk neutral and that the bias in the forward rate's prediction of the spot rate reflects a risk premium.
  - Investors make errors in forming expectations.
  - the transactions costs may be sufficiently large to obscure the link between the forward rate and the future spot exchange rate.
  - None of these explanations get much support in the data—and this is an ongoing area of investigation. Recent work finds that
    * sign of slope coefficient depends on whether USD at discount/premium;
    * slope coefficient is not negative in emerging countries.

# 7.9 Forecasting the exchange rate using macroeconomic variables

## 7.9.1 Theoretical models

[We shall cover these theoretical models and newer ones in more detail later]

- There are several *theoretical* models relating fundamental variables to the nominal exchange rate. All these models
  - *agree* that since the exchange rate is the price of the money of one country relative to that of another, the exchange rate should depend on the relative demand for the money of the two countries;
  - *disagree* about the the source from where demand for money originates.

**Purchasing Power Parity** assumes that the

- demand for money originates from the demand for exports and imports, and hence,
- relates the exchange rate to relative prices (or inflation rates) in the two countries.

**Balance of Payments** (BOP) model is a Keynesian model that relates the exchange rate to variables affecting not just demand for goods (reflected in the Current Account) but also to demand for portfolio and direct investment abroad, which is given in the Capital Account of the BOP.

- Variables affecting the current account are assumed to be
  - the real exchange rate ($SP^*/P$), and
  - the national income in the two countries, $Y$ and $Y^*$.
- Variables affecting the capital account are assumed to be
  - the exchange rate and
  - the interest rates, $r$ and $r^*$.

**Monetary** model extends the PPP and BOP models to include a role for investors' expectations about future inflation. According to this model, the exchange rate depends

- on the money supplies, $M$ and $M^*$,
- national incomes, and
- the velocity of money in the two countries
  (which is determined by interest rates and inflation rates).

**Portfolio** model extends the monetary model so that the exchange rate depends on not just the relative demand for money but for all risky assets (stocks and bonds).

- The supply of risky assets is the (world) market portfolio;
- The demand is obtained by solving a mean-variance portfolio problem (as in the single-country Capital Asset Pricing Model (CAPM));
- Expected returns on foreign-currency denominated assets will depend on expectations of the future exchange rate;
- Thus, the spot rate is a function of the expected returns, variances, and covariances of all returns on all risky assets that are available.

### 7.9.2 Empirical evidence

First, compare the standard deviation (Std. Dev.) of the exchange rate with the properties of the fundamental variables.

| Variable | Std. Dev. (of level) | Std. Dev. $\times$ 100 (of first difference) |
|---|---|---|
| Log of spot USD/JPY | 0.262 | 3.340 |
| Log of spot USD/DEM | 0.178 | 4.181 |
| US-Japanese interest differential | 0.026 | 0.801 |
| US-German interest differential | 0.016 | 0.785 |
| Log of US-Japanese CPI | 0.127 | 0.671 |
| Log of US-German CPI | 0.126 | 0.329 |
| Log of US-Japanese M1 | 0.110 | 4.289 |
| Log of US-German M1 | 0.085 | 2.203 |
| Log of US-Japanese industrial production | 0.064 | 1.479 |
| Log of US-German industrial production | 0.072 | 2.056 |

- The above statistics are computed using IMF monthly data from January 1975 to December 1989. The total number of observations is 174.

▶ **Conclusion:** Observe that the variation (standard deviation) in exchange rates is much larger than that for the fundamentals, with the exception of the change in the US-Japanese money supply growth rates.

Next, examine correlations between the first differences for the same set of variables.

| Correl. | $\frac{\text{USD}}{\text{JPY}}$ | $\frac{\text{USD}}{\text{DEM}}$ | JPY $r$ | DEM $r$ | JPY Price | DEM Price | JPY M1 | DEM M1 | JPY IndProd | DEM IndProd |
|---|---|---|---|---|---|---|---|---|---|---|
| USD/JPY | 1.00 | | | | | | | | | |
| USD/DEM | 0.61 | 1.00 | | | | | | | | |
| JPY Interest | -0.07 | -0.11 | 1.00 | | | | | | | |
| DEM Interest | 0.00 | -0.05 | 0.08 | 1.00 | | | | | | |
| JPY Price | -0.05 | -0.09 | 0.01 | 0.04 | 1.00 | | | | | |
| DEM Price | 0.07 | -0.09 | 0.09 | 0.02 | 0.24 | 1.00 | | | | |
| JPY M1 | -0.05 | -0.02 | -0.10 | -0.09 | -0.07 | 0.00 | 1.00 | | | |
| DEM M1 | 0.08 | -0.09 | -0.05 | -0.01 | -0.06 | 0.00 | -0.01 | 1.00 | | |
| JPY IndProd | 0.01 | -0.04 | 0.31 | -0.25 | 0.01 | 0.10 | -0.16 | 0.04 | 1.00 | |
| DEM IndProd | -0.02 | -0.02 | 0.15 | 0.16 | 0.18 | 0.04 | 0.04 | -0.04 | 0.13 | 1.00 |

- **Conclusion:** These correlations are very low, between 0.001 and 0.11 and none of them are statistically significant.

Finally, consider a regression where the right-hand side includes many of the fundamental variables proposed by models of the exchange rate.

$$\begin{aligned}\ln\left(\frac{S_{t+1}}{S_t}\right) = a &+ b_1\left(r_{t,t+1} - r^*_{t,t+1}\right) \\ &+ b_2\left(\ln I_{t,t+1} - \ln I^*_{t,t+1}\right) \\ &+ b_3\left(\ln M_{t,t+1} - \ln M^*_{t,t+1}\right) \\ &+ b_4\left(\ln Y_{t,t+1} - \ln Y^*_{t,t+1}\right) + e_{t+1}.\end{aligned}$$

- For the case of US versus Japan, the $R^2$ statistic is 0.0098; and for the case of US versus Germany, the $R^2$ is 0.0118;

- None of the slope coefficients in either regression is significant even at the 10% level. fundamental variables give similar results.

- Fundamental models do not seem to provide a good way of predicting exchange rates.

- Recent evidence finds that order flow may help explain the spot rate.
  - But, what explains order flow?
  - And, this still does not help $forecast$ the exchange rate.

# 7.10 Forecasting record of professionals

## 7.10.1 The record of forecasting services

- Forecasting services using technical models to predict the future spot rate have a superior record compared to those analyzing fundamental variables.

- **Conclusion:** However, the record of technical forecasting services with a superior record initially appeared to deteriorate over time; that is, it was not the same services that had the superior record over time.

- Forecasting services using fundamental variables may have some ability to predict whether the future spot rate will be greater than or smaller than the current forward rate.
  - This is the information needed to make the correct hedging decision and to undertake the correct speculative strategy (to go long or short).
  - However, the forecasting services that perform well in the first study are not the same as those that do well in later studies.

▶ **Conclusion:** Thus, it seems that no service can consistently predict the future spot rate relative to the forward.

### 7.10.2 The forecasting record of central banks

- Central banks claim that
  - they intervene in currency markets to maintain an orderly market and to smooth out excessive swings in exchange rates;
  - they also claim that they do not try and move the exchange rate away from its fundamental value.
  - If this is true, it means that central banks must be quite good at predicting exchange rates.

- When the profits from intervention are measured for eight central banks, it was found that seven central banks actually made substantial losses from currency trading.

- Studies undertaken by the Dutch central bank and the Canadian central bank find that intervention has been modestly profitable, though there have been long periods during which the banks incurred substantial losses.

▶ **Conclusion:** Thus, the evidence is mixed and one cannot conclude that central banks can predict the future spot rate, even though they have access to private information about monetary and exchange-rate policy.

## 7.11 Summary

- There is strong evidence of frequent, significant and persistent deviations from PPP, indicating the presence of real exchange rate risk.

- The overall evidence suggests that it is quite difficult to predict future exchange rates accurately.
  - Predictions based on fundamental variables do not seem to be very accurate.
  - Technical forecasts seem to do better, though even their record is not impressive.
  - While economic theory may be useful for explaining the past, and for making broad predictions about the long-run effects of government policy, it has only limited successful in making precise predictions about the exchange rate in the short run.