CHAPTER 7
FOREIGN EXCHANGE MARKET EFFICIENCY

Chapter Overview

This chapter has two major parts: the introduction to the principles of market efficiency and a review of the empirical evidence on efficiency as they apply to the foreign exchange market.

The importance of the concept of market efficiency is discussed at the beginning of the chapter. The concept plays an important role in the study of financial markets. As a theoretical matter, prices in a market economy are assumed to efficiently aggregate available information. As a practical matter, market efficiency is an important benchmark that has a strong bearing on policies in the private sector pertaining to risk management and forecasting and policies in the public sector pertaining to central bank intervention.

The theory of market efficiency is discussed in the first major part of the chapter. The characteristics of an efficient market including the equilibrium benchmark and available information set are defined. The text highlights the distinction between the efficient market hypothesis and the random-walk model of asset prices, which is sometimes incorrectly identified as requirement for market efficiency. It also illustrates that all tests of market efficiency are tests of a joint hypothesis -- (1) the hypothesis that defines market equilibrium prices or market equilibrium returns as some function of the available information set, and (2) the hypothesis that market participants have actually set prices or returns to conform to their expected values. Market efficiency requires that expectational errors follow a fair-game process. When markets are efficient, no excess profit opportunities are consistently available to market participants.

The second major part of the chapter reviews empirical evidence on market efficiency in the foreign exchange market. Rather than test directly whether prices or returns in foreign exchange market conform to their equilibrium-expected values, empirical studies have preferred to test for the availability of unusual or risk-adjusted profit opportunities. In the case of certainty or risk-free investment such as covered interest arbitrage, the empirical evidence is clear-cut and supportive of market efficiency. Once transaction costs and other factors are taken into account, most risk-free arbitrage opportunities in foreign exchange are quickly eliminated. However, in the case of uncertainty and risky investment such as spot speculation and forward speculation, empirical tests of market efficiency are difficult to interpret. Many studies have reported techniques for profitable trading or superior forecasting in both spot and forward markets.

One implication of these empirical results is the possibility of earning speculative profits by using technical trading models. A second implication is the possibility to “overforecast” the forward rate by building a composite forecast that combines additional information with the forward rate. The broader implications of the empirical evidence on market efficiency for private enterprises and public policy makers are examined in the final two sections of this chapter.
Chapter Outline

Theory of Market Efficiency
   Defining the Equilibrium Benchmark
   Pictures of Efficient Markets
   Interpreting Efficient Market Studies
   Defining the Available Information Set
Extensions of Efficient Market Theory
Empirical Evidence on Exchange Market Efficiency
   Market Efficiency with Certainty and Risk-Free Investment
   Market Efficiency with Uncertainty and Risky Investment
Policy Matters - Private Enterprises
Policy Matters - Public Policymakers
Summary
Supplementary Notes

Technical trading rules  (From Bruno Solnik, 1991)

The technical analysis of exchange rates bases predictions on price information. The analysis is technical in the sense that it does not rely on fundamental analysis of the underlying economic determinants of exchange rates, but only on extrapolations of past price trends. Technical analysis looks for the repetition of specific price patterns. Once the start of such patterns has been detected, it automatically suggests what the short-run behavior of an exchange rate will be.

Moving averages  Buy and sell signals are usually triggered when a short-run moving average (SRMA) of past rates crosses a long-run moving average (LMRA). An LRMA will always lag an SRMA because it gives a smaller weight to recent movements of exchange rates than an SRMA does.

Filter methods generate buy signals when an exchange rate rises X percent (the filter) above its most recent trough, and sell signals when it falls X percent below the previous peak.

Momentum models determine the strength of a currency by examining the change in velocity of currency movements. If an exchange rate climbs at increasing speed, a buy signal is issued.

Foreign Exchange Market Efficiency

Efficient Markets Hypothesis

An efficient market is one where all new information is quickly understood by market participants and becomes immediately incorporated into market prices (Samuelson and Nordhaus 1985). The current price of an asset will fully reflect available information with regard to its valuation.

\[ E \left[ x_{t+1} - x_{t+1}^e \right] = 0 \]  

where \( x_{t+1} \) is the expectation derived from the one-period-ahead forecast of the actual value \( x_{t+1} \), and \( E \) is the expectations operator conditioned on the information set \( \Omega_t \) available at the end of period \( t \). If we designate \( x_{t+1} \) as series of asset returns, and \( x_{t+1}^e \) as market expectations of these returns, the above equation implies that there are no systematic unexploited profits over time. An optimal forecast of asset prices is consistent with rational expectations behavior.
Rational expectations

Rational expectations are expectations that are self-fulfilling on average. That is, expectations are rational if by holding and acting on the basis of these expectations, traders would bring about an economic equilibrium that confirms their original expectations. (Grabbe, p. 180)

Suppose:

$$S(t+1) = a \cdot E[S(t+1) | I(M,t)] + b \cdot S(t) + e(t + 1)$$

where $I(M,t)$ is the "market" information set and $a + b = 1$. Rational expectations means that

$$E[S(t+1) | I(M,t)] = S(t)$$

The above formulation is known as the random-walk hypothesis, meaning that the expected one-period-ahead exchange rate is also the current spot rate. It suggests that if the market is efficient, the current price of a currency will reflect all the available information. The unexpected change in the spot rate, $S(t+1) - S(t)$, is essentially caused by the random shock, $t+1$, which hits the market between time $t$ and time $t + 1$. Market rationality suggests that the investor finds no particular pattern from the history of $t+1$.

The speculative efficiency hypothesis (unbiased forward rate hypothesis)

$$E[S(t+1) | I(M,t)] = F(t,T)$$

The speculative efficiency hypothesis is the proposition that the $T$-period forward rate is the best unbiased predictor of the spot rate $T$ periods in the future (Grabbe, p. 183).

Empirical Test:

"Simple efficiency" joint hypothesis

$$E[S(t+T)] = S(t+T) \quad \text{and} \quad F(t,T) = E[S(t+T)]$$

"General efficiency" joint hypothesis

$$E[S(t+T)] = S(t+T) \quad \text{and} \quad F(t,T) = E[S(t+T)] + \text{risk premium}$$
where \( a \) and \( b \) are the coefficients to be estimated and \( e \) is an error term. \( a \) is expected to be zero and \( b \) is expected to be 1.

Bilson (1981) results:

\[
\hat{a} = 3.123(+1.18) \\
\hat{b} = .178(+.18)
\]

This implies that the forward rate does not give any additional information about the future spot rate that is not already contained in the current spot rate, at least for the forward rates that Bilson investigated.
Answers to end-of-chapter questions

1. Describe three forms of market efficiency. Give an example of each one in the context of the foreign exchange market.

The original classification divided market efficiency tests into weak form, semi-strong form and strong form tests. Weak form tests rely solely on an historical price series. Tests of technical trading models for profitability are one example. Semi-strong form tests are based on public information. Tests of purchasing power parity as a trading strategy are an example. Strong form tests examine whether inside or private information can be used for earning unusual trading profits. A proprietary forecasting model or advance notice of money supply announcements are examples of inside information that might be used to generate unusual trading profits.

2. Describe the joint hypothesis that underlies all tests for market efficiency.

A joint hypothesis implies two hypotheses tested at the same time. In the case of market efficiency, we are testing (1) a particular model of equilibrium asset pricing or returns, and (2) the ability of market participants to set prices in conformity with that equilibrium model.

3. Define filter rules and moving average cross-over rules for trading in the foreign exchange market. Under what circumstances would these methods be profitable for a currency trader?

A filter rule is a method of identifying buy and sell signals for trading in foreign exchange. An x% filter rule produces a buy signal when the currency is up x% from its last trough; and it produces a sell signal when the currency is down x% from its last peak. A moving average cross-over rule is another method for identifying buy and sell signals based on a comparison of short-term and long-term moving averages of recent spot exchange rates. When the short-term moving average first exceeds (falls below) the long-term moving average, the model produces a buy (sell) signal. When markets are efficient these techniques should not produce unusual profits. If exchange rates follow persistent trends that are not reflected in the interest differential, then technical trading rules may produce profitable results.

4. How would you determine whether the profits earned by a currency trader were "excessive" and indicative of market inefficiency?

"Excessive" profits are profits in excess of the equilibrium return commensurate with the riskiness of the investment. There is no general consensus on an equilibrium standard for foreign exchange risk. Most benchmarks are, therefore, ad hoc. For example, the Sharpe ratio for the equity market could be used as an ad hoc benchmark.
5. How does a currency risk premium affect the notion of efficiency in the foreign exchange market?

When a currency risk premium exist, the equilibrium return on currency trading is higher. Profits in currency trading do not indicate a market inefficiency if these returns are less than the appropriate risk premium.

6. "If the foreign exchange market is efficient, a corporation does not need to hedge at all." True or false? Explain.

False. A corporation that hedges will reduce its financial exposure to currency risk. If there is no risk premium, the firm does not sacrifice any return while it reduces risk. This reduction in volatility may benefit the firm, especially if it faces high costs of financial distress. (See Chapter 16) If there is a currency risk premium, the firm sacrifices some expected return when it hedges. So it must gauge whether the trade-off in lost expected return is worth the benefit of reduced costs of financial distress.

7. "When the market is inefficient, a corporation should actively manage its currency positions to capture extra-ordinary returns." True or false? Explain.

True. When the market is not efficient, profit opportunities from active currency trading are available.

8. How could government intervention in the currency market impact foreign exchange market efficiency?

Certain types of government intervention could reduce the efficiency of the foreign exchange market. For example, intervention characterized as "leaning against the wind" could slow the adjustment of exchange rates from one level to the next. This could create an opportunity for technical trading profits. Intervention that is successful in reducing exchange rate volatility, such as in a successful target zone, could reduce the opportunities for technical trading profits.

9. What is the "peso problem?" How does the presence of a "peso problem" affect our ability to test for efficiency in the foreign exchange market?

A "peso problem" describes a situation in the foreign exchange market where there is a large probability of little or no change in the rate, and a small probability of a large change in the rate. The peso problem makes it difficult to test for efficiency since, by definition, low probability events happen very infrequently. An efficient market must factor in the likelihood of low probability events, even if they seldom occur.
Answers to end-of-chapter exercises

1. This exercise is based on the simulation of exchange rates in Box 7.1.
   
a. Using Excel or other statistical software, replicate the graph in Figure A. Recall that the data were generated using a starting exchange rate $S_0 = 50$, and subsequent exchange rates determined by $S_t = S_{t-1} + u_t$, where $u_t$ are random numbers drawn from a normal distribution with mean $= 0$ and standard deviation $= 1$, and the “random seed” is 3,388.

b. Pick another random seed value, generate another set of $u_t$, and plot the new values for $S_t$ and the percentage change in $S_t$. Do you observe any patterns in your new graphs? Would you feel confident building a technical trading rule on the basis of these patterns?

c. Now, select another set of $u_t$ but now with a mean $= 0.2$ and a random seed of 3,388. Plot these new values of $S_t$ and the percentage change in $S_t$. Do you observe any patterns in your new graphs? Would you feel confident building a technical trading rule on the basis of these patterns?

SOLUTIONS:

a. FIGURE A  Exchange Rate Levels (mean = 0, seed = 3,388)
FIGURE B  Exchange Rate Percentage Changes (mean = 0, seed = 3,388)

b. FIGURE A  Exchange Rate Levels (mean = 0, seed = 1,234)
It may look as if there are patterns in the series, but there are none because every successive change is the result of a random number. Therefore,
It may look as if there are patterns in the series, but there are none because every successive change is the result of a random number. Therefore,
2. Examine the daily closing price data on the DM/$ rate in file E07.WK1 that was used to construct Figure 7.5. Suppose you were using a 1% filter rule to trade the DM and US$.

http://www.mhhe.com/levich2e
“Cases and Assignments”

a. On what day would the 1% filter rule have issued its first signal? Was this a buy or a sell signal? At what price did the trade occur?

b. On what day would the 1% filter rule have issued its second signal. Was this a buy or a sell signal? At what price did the second trade occur?

c. Calculate the profit from the first trade. Assume that transaction costs are 0.02% and that the interest rates were constant over the period with \( i_{DM} = 3.0\% \) and \( i_{S} = 5.5\% \).

d. Repeat questions a, b, and c assuming a 2 percent filter rule.

SOLUTIONS:
3. Examine the daily closing price data on the DM/$ rate in file E07.WK1 that was used to construct Figure 7.5. Suppose you were using a 1/200 moving average rule to trade the DM and USS.

   a. On what day would the 1/200 moving average rule have issued its first signal? Was this a buy or a sell signal? At what price did the trade occur?

   b. On what day would the 1/200 moving average rule have issued its second signal. Was this a buy or a sell signal? At what price did the second trade occur?

   c. Calculate the profit from the first trade. Assume that transaction costs are 0.02% and that the interest rates were constant over the period with $DM = 3.0% and $S = 5.5%.

   SOLUTIONS:

   a. On August 3, 1987, the spot rate rises and exceeds the 200 day moving average creating a buy signal, that is Buy $ and Sell DM. The trade price is 1.875 DM/$.

   b. On August 18, 1987, the spot rate falls below the 200 day moving average creating a sell signal, that is Sell $ and Buy DM. The trade price is 1.843 DM/$.

   c. Profit has three components: (1) Gain on transaction = 1.843/1.875 = 0.983 => -1.7%. (2) Transaction costs = 2 x 0.02% = 0.04%. (3) Interest earned from long $ / short DM position at 2.5% per year for 15 days = 0.10%. Total = -1.70% - 0.04% + 0.10% = -1.74% in 15 days.

4. Under the simple efficiency hypothesis, the relationship between the future spot rate ($t+n), the current three-month forward rate ($t,3), and other information ($Xt) should be given by equation (7.8)

   \[ S_{t+3} = a + bF_{t,3} + cX_t + \epsilon_t \]

   with a=0, b=1, and c=0. Assume that you analyze a set of data for the $/£ exchange rate, and you can estimate quite precisely that a=0, b=0.85, and c=0.15 when Xt is the PPP rate for the $/£.

   a. Does the above information help confirm or reject the simple efficiency hypothesis?
b. Suppose that the current spot rate (\(S_t\)) is $1.50/£$, the 3-month forward rate is $1.46/£$ and the PPP exchange rate is $1.54/£$. What is your forecast of the $/£$ spot rate three months from now?

c. Based on your forecast, would you speculate by taking a long or short position in the pound? Would you prefer to take your speculative position in the spot market or in the forward market?

**SOLUTIONS:**

a. It helps to reject the simple efficiency hypothesis.

b. \[
\begin{align*}
S_t &= $1.50/£ \\
F_{t,3} &= $1.46/£ \\
X_t &= $1.54/£ \\
S_{t,3} &= 0 + 0.85 ($1.46/£) + 0.15 ($1.54/£) + 0.15 ($1.54/£) = $1.472/£
\end{align*}
\]

c. Based on my forecast, I’ll take a short position in the pound since the forecast future spot rate is lower than the current spot rate. I prefer to take speculative position in the spot market since it is more profitable to speculate in the spot market ($1.50 - 1.472 = 0.028$) than to speculate in the forward market ($1.472 - 1.46 = 0.012$).

5. Suppose that a technical trading rule leads to profits of 10% per annum (after transaction costs and interest expense) over a 5-year period. The trader's initial stake which he can commit to his trading activity is $100,000.

a. Calculate the expected ending wealth of the trader after 5 years if he puts his *entire* stake (including interim gains and losses) at risk in each trade.

b. Now suppose that the trader uses his $100,000 as a 10% margin in order to take an initial position of $1,000,000. Calculate the expected ending wealth of this trader after 5 years if he puts his *entire* stake (including interim gains and losses) at risk in each trade.

c. Discuss the risks associated with the trading style in question (b) that are not present with the trading style in question (a).

d. What assumptions underlay the calculation in question (b)?

**SOLUTIONS:**

a. $100,000 \times (1.10)^5 = $161,051.00$
b. $1,000,000 (1.10)^5 = $1,610,510.00 or ten times as much as in question (a).

c. The trading positions in (b) are ten times as great as the positions in (a). The profits are ten times as great and the volatility of profits is ten times as great. The losses in (b) could exceed $100,000. If this happens, the value of the trading position (b) might not be sufficient to pay off the margin loans -- in other words, the trader would be technically bankrupt and unable to complete the five-year speculative trading program unless more capital is added to the account.

d. We are assuming that the trader can meet all of his margin calls to get to the end of the five-year trading program.