CHAPTER 28

Exchange Rate Forecasting and Risk

Chapter 27 considered the macroeconomic determination of the exchange rate and explored the effects of monetary policy, particularly from the viewpoint of the monetary policy maker. This chapter begins by looking at this issue from the viewpoint of the individual market participant, who must take the movements in the exchange rate as given.

28.1 Forecasting the Spot Exchange Rate

Those who forecast the exchange rate for a living quickly discover that the real world is less straightforward than the theory of exchange rate determination might make it appear. Chapter 27 assumed that everyone knew with confidence what the correct model was, except perhaps for a disagreement between the flexible-price version of the monetary model and the sticky-price version. The fact is, there are many conflicting approaches to forecasting. One consequence is that investors can disagree widely on their exchange rate forecasts.[1]

Forecasting Methods in Actual Use and Their Performance

As distressing as it is for economists to admit, many professional exchange rate forecasters do not base their forecasts on any model of monetary policy or other fundamental economic variables, even simple ones. So-called technical analysts instead forecast by using computer techniques, or hand-drawn graphs in the case of more old-fashioned chartists, to try to uncover trends in the exchange rate. One of the most popular rules calls for buying a currency whenever the short-term moving average (the average over the preceding week, for example) rises above the longer term moving average (over the preceding month), and selling whenever the reverse happens. The *momentum* models call for buying when the current price exceeds the average price, for example, over the

[1]In one survey, market participants' forecasts of the exchange rate at a 6-month horizon vary over a high-low range that averages 15 percent. Jeffrey Frankel and Kenneth Froot, "Chartists, Fundamentalists, and Trading in the Foreign Exchange Market," *American Economic Review,* 80, no. 2 (1990): 181–185.

preceding six weeks. Such techniques, in effect, forecast by extrapolating past trends and thus generally fall into the category of expectations that are destabilizing if acted on by investors.[2]

The same can be true of an econometric forecasting approach called ARIMA (AutoRegressive Integrated Moving Average). A simple example of an ARIMA model is a prediction that if the spot rate went up 1 percent last week, then it will go up AR percent this week, where AR is the autoregressive coefficient.

How well do all these techniques forecast the spot rate? The answer is not well, if the criterion is to forecast with small errors. The generalization applies not just to economic fundamentals models, technical analysis, and ARIMA techniques, but to virtually any forecasting approach imaginable. This is because exchange rates are so volatile. Even spot traders who claim to be highly successful will admit that they lose money on many of their trades.[3]

We should not be surprised that a large proportion of the movement in the exchange rate cannot be forecast by any technique. Even if the spot rate behaved precisely as predicted by a model, such as the monetary equation of exchange rate determination developed earlier, one could not accurately forecast the future exchange rate without knowing the future values of the money supplies, income levels, and so on. If the exchange rate departs from the economic fundamentals because of a speculative bubble, then the forecast errors will be that much larger.

Professional forecasters intending to earn a return on their investment of time and expertise can, at best, hope to predict the direction of movement correctly slightly more than half the time. Thus, when testing the performance of the various techniques, we should keep in mind that we cannot hope to forecast a large proportion of the movement in the spot rate. A useful benchmark for comparison is the random walk. Forecasters would hope to be able to predict the future spot rate better than the current spot rate does.[4] In other words, although they should not be so ambitious as to hope to predict all or most of the movement in the exchange rate, neither should they be so unambitious as to expect to be able to predict *none* of the movement.

When Chapter 19 first introduced the concept of the random walk, we noted that the real exchange rate has a tendency to return over time to the long-run equilibrium dictated by purchasing power parity. In other words, the principle of regression to PPP

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[2]There are probably as many methods of technical analysis as there are technical analysts, but most fit this description. They tend to be used to forecast at short horizons of one month or less. Fundamentals are used at longer horizons. Mark Taylor and Helen Allen, "The Use of Technical Analysis in the Foreign Exchange Market," *Journal of International Money and Finance,* 11, no. 3 (1992): 304–314.

[3]The percentage of traders who can truthfully expect to make money is not as high as it sounds when listening to them talk. For every winner there must be a loser. There is a sample selection problem, however. If each month half the traders win and half lose, at random, and each month some of the ones who lose badly decide to abandon this line of work, then more than half the traders remaining in the sample at any time will truthfully be able to claim that they made money over the preceding month.

[4]Recall from Chapter 27 that there is no theoretical reason to expect the exchange rate to follow a random walk. This point is often misunderstood. As Section 28.2 will show, if some component of changes in the spot rate—such as that reflected in the forward discount—were predictable, it would not violate the rational expectations hypothesis. The hypothesis says only that the economist should not be able to forecast easily a greater percentage of movement in the spot rate than the market can.

might be used to obtain a better predictor than the random walk. This information is of some benefit in predicting the spot rate over the long term. Thus it might be used by a portfolio fund manager in deciding whether to buy (and hold) foreign securities or by a corporate executive in deciding whether to build a factory in a foreign country. The rule would be to invest in the country where the value of the currency is below its long-run PPP equilibrium because the currency can be expected to rise again in the future. However, because the speed of regression to PPP is so slow and large new disturbances come along so frequently, the information is not of much use in predicting the spot rate a few months or less into the future.

Richard Meese and Kenneth Rogoff studied the ability of a number of models to predict the exchange rate at horizons of several months. Included were the monetary model (both the flexible-price or monetarist version of Section 27.2 and the sticky-price version of Section 27.4) as well as the ARIMA model. Their finding was that at horizons of one, six, or twelve months into the future, all models are outperformed by the simple random walk. That is, a forecaster would be more successful using the current spot rate.[5] This was a discouraging discovery for exchange rate modelers. In view of how frequently one hears of an econometric finding that the exchange rate follows a random-walk model, it is important to note that such outcomes are failures to find anything that explains movement in the exchange rate. Random walk results are useful because they remind economists of the extent of their ignorance. But they are not evidence *in favor* of a model, in any meaningful sense.

Others have found somewhat greater success by including the lagged value of the exchange rate in addition to the other variables on the right-hand side of the equation.[6] For a forecaster who must predict the future exchange rate, the conclusion seems to be as follows: It would be difficult to make any prediction using *only* information on macroeconomic variables such as the money supplies, income levels, interest rates, and inflation rates. There is more useful information in today's spot rate than in everything else combined. However, given that today's spot rate is known, the monetary model seems to contain additional information that is of some help in predicting the direction of future movement, especially at longer horizons. In short, the optimal predictor would use *both* the information contained in today's spot rate and the information contained in the monetary model. Evidently there must be important elements missing from the monetary equation of exchange rate determination, unobserved elements that behave much like a random walk and thus are picked up by the lagged spot rate. Possible missing elements include speculative bubbles and permanent shifts in the real exchange rate.

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[5]"Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample?" *Journal of International Economics,* 14 (February 1983): 3–24; and "The Out-of-Sample Failure of Empirical Exchange Rate Models: Sampling Error or Misspecification?" in Jacob Frenkel, ed., *Exchange Rates and International Macroeconomics* (Chicago: University of Chicago Press, 1983), pp. 67–105. The monetary model does begin to perform slightly better when forecasting more than 12 months into the future.

[6]Ronald MacDonald and Mark Taylor, "The Monetary Model of the Exchange Rate: Long-Run Relationships, Short Run Dynamics, and How to Beat a Random Walk," *Journal of International Money and Finance,* 13, no. 3 (1994): 276–290; Nelson Mark, "Exchange Rates and Fundamentals: Evidence of Long-Horizon Predictability," *American Economic Review,* 85 (1995): 201–218.

Does the Forward Exchange Market Give an Unbiased Predictor?

Consider the owner of a small company involved in international trade who must guess what the exchange rate will be in three months to decide what currency a payment should be made in or what price to set for a product. The owner is bewildered by the proliferation of different exchange rate models and by the knowledge that no single model performs particularly well. The owner also suspects that much relevant information comes out every day (for example, a speech by the chairman of the Federal Reserve Board) that is not captured in any of the statistical models, and he or she does not have the time or resources to monitor such news each day.

An easy strategy is to use the three-month forward rate as the forecast of the future spot rate. (Chapter 21 introduced the forward exchange market.) What makes this strategy so easy is that it simply means looking up the forward rate in the newspaper or on the computer.

Furthermore, this owner would not necessarily do any better than the forward rate by subscribing to a forecasting service or hiring a staff forecaster. All the useful information contained in the various models, along with the latest bits of news, may already be reflected in the forward rate if the *efficient markets hypothesis* holds. The efficient markets hypothesis is closely related to the rational expectations hypothesis.[7] It states that any excess profit opportunities in the financial markets based on publicly available information will be quickly eliminated. Imagine, for example, that it were possible to use an ARIMA model to forecast better than the forward rate. In such a circumstance many speculators would rush to take advantage of the profit opportunity. They would buy forward currency whenever the ARIMA model predicted a price higher than the forward rate, and vice versa; before long they would drive the forward rate into equality with the forecast of the model. Thus whatever useful information there is in the ARIMA model should already be contained in the forward rate. The same applies to whatever useful information there is in technical analysis, in the monetary models, and in the day's news.

There have been a great many studies testing whether the forward market offers an unbiased predictor of the future spot rate.[8] Unbiased means there is no obvious alternative predictor that performs better on average. Consider the following equation, which relates the observed change in the spot rate to the change the forward discount would have predicted ahead of time.

$$\Delta s_{t+1} = \alpha + \beta\, fd_t + \varepsilon_{t+1} \tag{28.1}$$

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[7]The efficient markets hypothesis not only requires that investors form their expectations rationally, but it requires a second condition as well: that there be few transaction costs or other market imperfections that prevent investors from buying and selling freely on the basis of these expectations. This allows investors' expectations to be fully reflected in the marketplace. Under normal circumstances, this second condition is easily met in well-developed financial markets. The small size of transactions costs can be shown directly, as it was in Chapter 21.

[8]Surveys of this literature include Robert Hodrick, *The Empirical Evidence on the Efficiency of Forward and Futures Foreign Exchange Markets* (Chur, Switzerland: Harwood Academic Publishers, 1988); and Charles Engel, "The Forward Discount Anomaly and the Risk Premium: A Survey of Recent Evidence," *Journal of Empirical Finance,* 3 (1996): 123–191.

The subscripts denote time: fd_t is the one-month percentage forward discount (on the domestic currency) observed at the present time, and Δs_{t+1} is the percentage change in the exchange rate (the percentage depreciation of the domestic currency) that takes place over the coming month.

As is usual in econometrics, we proceed by specifying a hypothesis and then seeing whether the data are favorable or unfavorable to it. In the present case, we are interested in the hypothesis that the forward discount is an unbiased predictor of the change in the exchange rate. This hypothesis, if true, implies in Equation 28.1 the condition $\beta = 1$. It might also include the condition $\alpha = 0$. Thus the hypothesis becomes:

$$\Delta s_{t+1} = fd_t + \varepsilon_{t+1} \tag{28.2}$$

The term ε is the error that investors make at predicting Δs. Under the efficient markets hypothesis, ε must be random, uncorrelated with any information available to investors at time t.[9]

The unbiasedness hypothesis actually consists of two hypotheses that are tested at the same time.

1. The *rational expectations hypothesis* is stated as

$$\Delta s_{t+1} = \Delta s_t^e + \varepsilon_{t+1} \tag{28.3}$$

In other words, the proposition is that investors predict the change in the exchange rate with an error term that is purely random. Notice that the hypothesis does not claim that the prediction error is necessarily small, only that it is unbiased—equal to zero on average.

2. The *zero exchange risk premium hypothesis* is stated as

$$fd_t - \Delta s_t^e = 0 \tag{28.4}$$

The exchange risk premium has been defined as the expression that appears on the left side of Equation 28.4 (in the appendix to Chapter 21, Equation 21.A.3). It will be zero if risk is not important to investors. That is, if investors care only about expected rates of return and nothing else, they will drive them into equality across currencies.

Check for yourself that Equations 28.3 and 28.4 together imply unbiasedness of the forward discount, Equation 28.2. It would be preferable to test the rational expectations hypothesis by itself. This is difficult, however, because it is difficult to observe investors' expectations. Instead, the two hypotheses are tested at the same time, by testing whether $\beta = 1$ in Equation 28.1. The major disadvantage of this strategy is that if it is decided that the data do not support $\beta = 1$, it is impossible to determine which of the two hypotheses fails to hold.

Of the many econometric studies performed on Equation 28.1 and others like it, most find that the data in fact do not support the unbiasedness hypothesis. Typically,

[9]The logic is the same as for the ε term in Equation 26.5, which represented the error that workers make at predicting inflation.

the estimate of β is not 1 but is significantly less. This indicates that the forward discount is a biased forecast of the future change in the spot rate. Some estimates put β in the vicinity of 0.5. This would mean that when the dollar sells at a forward discount of 4 percent per annum, the best guess is that it will depreciate at 2 percent per annum. Similarly, if the dollar sells at a forward *premium* of 4 percent per annum, the best guess is that it will *appreciate* at 2 percent per annum.

Many estimates put the coefficient even further from 1, in the vicinity of 0. If β were 0, this would mean that, regardless of the forward market, the best guess for the future spot rate is today's spot rate—in other words, no change. This is another random-walk finding, and it is much in line with the findings of Meese and Rogoff described previously.

How should economists interpret such findings? One possibility is that speculators are simply bad forecasters, that the rational expectations hypothesis 1 does not hold. One researcher, for example, interprets such findings as evidence that speculators are "overly excitable," that they have a false confidence in their ability to predict changes in the exchange rate. They would do better on average if they calmed down a bit, instead of always predicting that the exchange rate is about to shoot off in one direction or the other.[10]

Most economists, however, are extremely reluctant to accept this interpretation. They believe in hypothesis 1 on a priori grounds. The logic, once again, is that if it were so easy to make excess profits (on average), speculators would have already taken advantage of the opportunity. For this reason, most economists consider it more likely that the findings of bias are evidence against hypothesis 2—in other words, that the findings are evidence in favor of the existence of an exchange risk premium that separates the forward discount from investors' expectations of depreciation.[11]

28.2 The Role of Exchange Risk

Under the risk premium interpretation of the finding of bias (the finding of $\beta < 1$ in Equation 28.1), some positive part of the forward discount is a risk premium. Risk-averse investors will take a large position in a currency that they perceive as risky only if they are offered as compensation a higher expected rate of return than on other currencies. This can explain the difference between the forward discount and expected depreciation; it is the premium that the risk-averse investors demand to hold a risky currency.

The Exchange Risk Premium

The risk premium interpretation says that when the pound is selling at a forward discount, it must be because investors consider the pound riskier to hold than other currencies, and they therefore demand extra compensation for holding it. This is perhaps

[10]John Bilson, "The Speculative Efficiency Hypothesis," *Journal of Business,* 54 (1981): 435–451. Some direct evidence is offered by Kenneth Froot and Jeffrey Frankel, "Forward Discount Bias: Is it an Exchange Risk Premium?" *Quarterly Journal of Economics,* 104, no.1 (February 1989): 139–161.

[11]For example, Eugene Fama, "Forward and Spot Exchange Rates," *Journal of Monetary Economics,* 14 (1984): 319–338.

most clearly shown by using the covered interest parity condition to substitute the nominal interest differential, $i - i^*$, in place of the forward discount, *fd,* obtaining the alternate (but equivalent) definition of the exchange risk premium:

$$rp_t \equiv i_t - i_t^* - \Delta s_t^e$$

Now it is readily apparent that if the risk premium on a particular currency is positive, then that means investors are receiving a higher expected return to compensate for holding assets in that currency. Consider the case of random-walk expectations ($\Delta s^e = 0$), for example. A British interest differential of 4 percent signifies that speculators demand an expected return 4 percent higher than the expected return on other currencies before they are willing to take an open position in pounds. It is analogous to the premium that the stock market pays relative to bonds: The rate of return on stocks is, on average, significantly higher than the interest rate, with the difference being interpreted as the premium that investors require to bear the greater risk that attaches to stocks.[12]

It might seem that investors would find holding foreign currency in general to be risky, that foreign currency must pay a positive risk premium to compensate domestic investors for holding it. No such general rule can hold for all currencies, however. If one currency pays a positive risk premium, then the other pays a negative risk premium. Viewed from the vantage point of the global investor, the dollar could be the riskier currency as easily as the pound.

What Makes a Currency Risky?

The dollar generally sells at a forward discount against the yen. As we would expect to follow, by covered interest parity, dollar assets generally pay a higher interest rate than yen assets. If the findings of bias are to be interpreted as evidence of a risk premium, it would follow that international investors must perceive the U.S. dollar as riskier than the yen. That would explain why they demand a higher interest rate to hold dollar assets.

What makes an investor perceive some currencies as more risky and others as less risky? Essentially three factors contribute to exchange risk. We are not including default risk and the risk of capital controls, which pertain to the identity of the issuer of a security, rather than to its currency of denomination.

First is the *variability* of the value of that currency, in terms of other currencies and in terms of purchasing power over goods (i.e., the variability of the price level).[13] The currency of a country with an unstable monetary policy, which leads to a highly variable price level and exchange rate, is viewed as risky.

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[12]It is easy to test Equation 28.1, with the interest differential, $i - i^*$, substituted for the forward discount, *fd.* Just as before, the results show biased predictions of the future exchange rate. Just as before, the finding of bias could be interpreted either as a bias in expectations or as a risk premium.

[13]By *variability* we mean the degree of uncertainty regarding the value of the currency next period. If an exchange rate were highly variable, but the movements were mostly predictable, then uncertainty would be low. In practice, however, exchange rate movements are mostly unpredictable. Therefore, uncertainty is almost the same as the measured variability in exchange rate changes.

It is easy, but wrong, to slip into the habit of viewing dollars as completely safe. It is wrong because investors ultimately care about the *real* value of their wealth, its purchasing power over the goods they consume, not about the dollar value per se. It follows immediately that a foreign citizen will consider the dollar risky if its exchange rate vis-à-vis the foreign currency is uncertain. (We are assuming here that the foreign investor cares about purchasing power over goods produced in the foreign country. To the extent that the investor also consumes some American goods, the real risk of holding dollars will be somewhat reduced.)

The fact that the investor cares about purchasing power over goods also implies that even an American who consumes only American goods should consider the dollar a bit risky to the extent that dollar prices of goods are uncertain. This is inflation uncertainty. As we have seen, the price level is actually much less variable than the exchange rate. For this reason, Americans would not go too far wrong by viewing their own currency as safe. However, exceptions arise in small, very open economies (such as those studied in Chapter 19) and in economies with a high degree of monetary instability. Residents of Russia, for example, should view foreign currency as less risky than their own.

We have been thinking of the potential holder of a foreign currency asset as an individual consumer or household. What if it is a corporation? In theory, this should not make any difference. Corporations are owned by people (the shareholders), who consume goods just like everybody else. If the manager of the corporation operates in the shareholders' interest, then the outcome should be the same as if the shareholders were making the investment decisions themselves.

In practice, however, corporate behavior can and does deviate from this theoretical ideal. If corporate managers do not have confidence that stock market investors can see through all the complexities of modern finance and accounting, they may be reluctant to make an investment that does not "look good on the books" even if they believe it is in the true interest of the company. To take one example, every March, Japanese banks rush to convert their foreign holdings into yen, to achieve mandated currency balances in time for the end-of-fiscal-year "book closing." To take a U.S. example, in 1976 when the Financial Accounting Standards Board adopted a rule (FASB 8) requiring companies to translate their overseas earnings into dollars at the current exchange rate, many companies suddenly altered their behavior so as to reduce exposure in foreign currency. They knew that such exposure would show up on their annual reports as earnings that were highly variable in terms of dollars. They sought to hedge their foreign earnings—for example, by selling foreign exchange on the forward market.[14] Although some hedging might always be prudent for a company with large overseas operations, in this case the change in corporate behavior in response to FASB

[14]Patricia Revey, "Evolution and Growth of the United States Foreign Exchange Market," *Federal Reserve Bank of New York Quarterly Review,* 6 (Autumn 1981): 32–44. Incidentally, the rule has since been abolished; the earnings reports of a multinational corporation need no longer show an overseas subsidiary's gains or losses from exchange rate changes.

8 was a sign that managers did not think that their shareholders would see through the accounting rule change. Such managers may err in the direction of the simple rule that the domestic currency is safe and the foreign currency is risky.

The second factor that makes a currency appear risky from the viewpoint of an individual investor is related to the quantity of assets the investor already holds denominated in that currency. The principle of *portfolio diversification* states that investors can reduce the risk in their overall wealth by diversifying their portfolio among many different assets. Even if each of several currencies has the same degree of variability, investors will be less vulnerable if they hold some of each than if they put all their eggs in one basket. This assumes the movements of the various currencies are at least partly independent, and thus it is very unlikely that all of them will sharply lose value at the same time. Usually some will go up and some down, and the overall return on the diversified portfolio will be much more stable than if the entire portfolio were allocated to just one of the assets.[15]

Thus, if investors already hold a large amount of Australian dollar bonds in their portfolio, they will consider it risky to acquire additional Australian dollar assets. It would be safer to add to their holdings of other assets, to remain well diversified. They will be willing to accept additional Australian dollar assets only if the return is sufficiently high as to compensate for the risk of going further out on a limb, of being further exposed in Australian dollar.[16]

The third factor is the extent to which movement in the currency value is *correlated* with movement in the values of other assets that investors hold. Correlation refers to the tendency for both assets to go up at the same time and go down at the same time. If the currency is highly correlated with other assets that the investors already hold, then it should be viewed as risky. The Swiss franc, for example, is highly correlated with the euro. If investors already hold many euros, then even if they hold no Swiss francs, they should realize that the prospect of acquiring some Swiss currency would add to their overall risk as much as would the acquisition of more euros. In this case the Swiss franc offers little opportunity for diversification: When the euro falls, the Swiss franc will fall right along with it.[17] Conversely, if the currency has a low correlation with other assets

[15]The optimal degree of portfolio diversification is derived in the supplement to this chapter.

[16]Consider another example, like the FASB 8 story, of how a corporation's behavior in practice can deviate from the theoretical ideal of diversification. Imagine that the New York office is highly exposed in yen and the London office is highly exposed in euros. The company in the aggregate may in fact be well diversified. Yet if each office does not know what the other is doing—or if each manager is more worried about the variability of his own performance and the risk of being terminated if he suffers large losses than he is about the big picture—then each may anxiously hedge or unload his or her holdings, even at a loss. As communications and computer technology and risk management techniques become more and more sophisticated, however, corporations get better and better at keeping track of changes in their global currency exposure and at responding appropriately. In this sense, actual corporate financial practices are becoming more like the theoretical ideal.

[17]Similarly, although a well-diversified portfolio would hold both stocks and bonds, the return on Swiss bonds is correlated with the return on Swiss stocks; thus an investor who already holds a lot of one should regard the other as risky. The return on a country's bonds is correlated with the return on its stocks and other assets, not just because of the exchange rate factor, but for another reason as well. If the country's economy turns out to do poorly, it may be reflected not only in its stock market but also in increased probability of default on bonds.

that investors already hold, they should view it as subtracting from their overall risk because it offers a valuable opportunity for diversification.[18]

This is especially true if the correlation happens to be negative. The returns on gold and the dollar, for example, are negatively correlated with each other. In those months when the value of the dollar goes up, the price of gold goes down, and vice versa. Thus, even if the dollar and gold are each highly variable when considered alone, a portfolio that holds some of each will be less variable. In the limit, imagine that the two were perfectly negatively correlated: For every 1 percent that the dollar moved, the price of gold could be relied on to move 1 percent in the opposite direction. In this special case, a portfolio allocated half to dollars and half to gold would be completely safe. The return on the overall portfolio would be guaranteed beforehand, regardless of price fluctuations, because the returns on the two halves would cancel each other out.

We have now seen that, from the viewpoint of the individual investor, it is important to look at more than just the expected return when deciding whether to acquire a country's currency. It is also important to look at the risk of the asset, where the risk that a given asset would bring to the portfolio is determined not only by (1) uncertainty regarding its future value, but also by (2) the assets that the investor already holds, and (3) the correlation of the return on the currency in question with the return on the other assets.

We have also seen that the existence of risk causes investors to view domestic and foreign bonds as imperfect substitutes, with the result that expected returns need not be equalized internationally. If we return to the issue of the determination of the exchange rate by aggregate behavior in the marketplace, it is now apparent that a condition assumed by the monetary models in Chapter 27, uncovered interest parity, need not hold. Thus we must go back and modify the model of exchange rate determination.

28.3 Portfolio Balance Effects on the Exchange Rate

In the monetary models of Chapter 27, the stock of government debt had no effect on the exchange rate. Only the stock of money did. In this section we examine possible effects of the stocks of debt and other non–money assets. To do so, it is necessary to introduce the portfolio balance model.[19] To gain the insights provided by this new model, it is not necessary to jettison what you learned in Chapter 27. Rather, we are adding some possible effects in the foreign exchange market to what we have previously studied.

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[18]Financial analysts speak of the *beta* of a stock or other security, which reflects the correlation of its return with the return on the overall portfolio of securities that the market holds. A security with a high beta is risky for investors; it should pay a high expected return to compensate them for holding it. This is the lesson of what finance theorists call the capital asset pricing model.

[19]Important early applications of the portfolio balance model to the subject of floating exchange rates include William Branson, "Asset Markets and Relative Prices in Exchange Rate Determination," *Sozialwissenschaftliche Annalen,* 1 (1977): 69–89; Stanley Black, "International Money Markets and Flexible Exchange Rates," *Studies in International Finance,* 32 (Princeton, NJ: Princeton University Press, 1973); Pentti Kouri, "The Exchange Rate and the Balance of Payments in the Short Run and in the Long Run: A Monetary Approach," *Scandinavian Journal of Economics,* 78, no. 2 (1976): 280–304.

Previous chapters assumed that investors were willing to absorb indefinitely large quantities of a country's bonds as long as the country was willing to pay the world interest rate. The quantity of bonds issued did not in itself necessarily have any effects on the financial markets. Now, however, we recognize that investors care, not just about expected return, but about risk as well. Investors will not willingly hold increasing quantities of a country's bonds at an unchanged interest rate. Individual investors can, of course, simply decide not to hold an asset denominated in a currency viewed as risky. (They could also decide to hold it but to sell the currency risk to somebody else on the forward exchange market.) In the aggregate, however, assets exist, and someone has to hold them. When the Australian government issues bonds, for example, even if the original buyer resells them or hedges the currency risk on the forward market, someone somewhere must end up with increased exposure in Australian dollars. Risk aversion on the part of investors thus implies that when governments change the supplies of bonds denominated in various currencies, it does have an effect in the financial markets. It has an effect on the equilibrium prices at which investors are willing to hold these assets.[20]

In the portfolio balance approach, the exchange rate is viewed not simply as the relative price of domestic and foreign money supplies but as the relative price of bonds and other assets as well. The model allows us to study two new effects on the exchange rate: *sterilized foreign exchange intervention* by central banks and what we might call *satiation* of investor holdings of a country's assets.

Sterilized Foreign Exchange Intervention

Part IV introduced intervention in the foreign exchange market—central bank purchases or sales of foreign currency in exchange for domestic currency. At that point the discussion focused on the system of fixed exchange rates, under which central banks are obligated to intervene as often as necessary to maintain the parity. The larger countries, of course, operate under flexible exchange rates, except within the EMU. Nevertheless, all central banks do intervene from time to time. Often they *lean against the wind:* Central banks sell a currency when it is appreciating and buy when it is depreciating, to try to dampen the fluctuations.

Chapter 19 discussed in particular the option of sterilizing intervention: offsetting it by central bank operations in the domestic open market so as to leave the overall money supply unchanged. Assume that the intervention consists of buying up dollar currency that private agents want to get rid of (and giving them yen in exchange), as it will if the aim is to increase the value of the dollar. In this case, sterilization involves following this up by buying dollar bonds from private agents (and giving them dollar currency in exchange), so as to restore the amount of dollar currency in the hands of

[20]Two qualifications are needed. First, for simplicity we have made the assumption here that governments denominate their bonds in their own currency. In practice, governments sometimes denominate their bonds in other currencies. Second, we are also ruling out Robert Barro's "Ricardian equivalence" (discussed in the appendix to Chapter 22). This is the proposition that for every dollar of bonds Australia's government sells to the public, Australian taxpayers feel an offsetting liability in the form of future taxes, with the result that behavior is unaffected. If this proposition held, then it is possible that no investor would need to incur exposure to the exchange risk of holding Australian dollars because such risk is fully diversifiable.

the public to its original level. On those occasions when the Federal Reserve intervenes, it routinely and immediately sterilizes its intervention in this way.[21] The other central banks do not sterilize quite as completely as the Fed does.

Chapter 23 showed that when perfect capital mobility ties the domestic interest rate to the foreign interest rate, successful sterilized intervention is impossible. If the Bank of Sweden were to try to support the krona in the foreign exchange market without allowing the domestic money supply to fall, it would quickly find that for every krona it created through the purchase of domestic bonds, it lost another krona of foreign exchange reserves: This is called complete offset of domestic credit creation. The Swedish central bank would have to abandon the attempt to determine simultaneously the exchange rate and the money supply or face rapid depletion of its foreign exchange reserves.

If investors treat domestic and foreign bonds as imperfect substitutes because of exchange risk (or for any other reason), then the possibility of successful sterilized intervention is resurrected. The reason is as follows. When the central bank has completed its sterilization, the supply of domestic money in the hands of the public has not changed (by the definition of sterilization), but the supply of domestic bonds in the hands of the public has decreased. In the monetary model, the supply of bonds had no effect. As noted, only the supply of money had an effect. In the portfolio balance model, however, the change in the supply of bonds does have an effect. The exchange rate is the relative price of dollar bonds as much as it is the relative price of dollar currency; it is determined by the supply of and demand for all assets (domestic versus foreign). Thus a decrease in the supply of dollar assets can cause an increase in the price of dollar assets, that is, an appreciation of the dollar, even if the currency component has not changed.[22]

At the Versailles Summit of 1982, the United States agreed to study the effectiveness of intervention, as a concession to the French. The report released the following year concluded that intervention that is sterilized does not have significant effects on exchange rates, except perhaps very briefly. It is believed that domestic and foreign bonds, although not literally perfect substitutes, are close enough that relatively little effect results from changes in their relative supply, especially on the scale that is relevant.

In 1985 the U.S. Treasury, in response to an ever-worsening trade deficit and resultant protectionist fever in Congress, made an abrupt about-face. The Treasury's newfound support for coordinated foreign exchange intervention to bring the value of the

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[21]Even though the Federal Reserve trading desk in New York sterilizes any foreign exchange intervention on the same day it occurs, the Federal Reserve Open Market Committee that meets every six weeks or so in Washington may sometimes take the exchange rate into account when setting monetary policy (for example, when giving the open market trading desk in New York its instructions for the subsequent six weeks).

[22]The decrease in the supply of domestic bonds should also cause the domestic interest rate to fall, to induce investors to hold a smaller share of their portfolio in the form of domestic bonds. As a consequence of imperfect substitutability, the domestic expected rate of return is no longer perfectly tied down to the world interest rate. Dale Henderson, "Exchange Market Intervention Operations: Their Effects and Their Role in Finance Policy," in J. Bilson and R. Marston, eds., *Exchange Rate Theory and Policy* (Chicago: University of Chicago Press, 1984).

dollar down produced the Plaza Accord. The day after the agreement was announced (September 22), the dollar fell more than 4 percent. As already noted, the dollar depreciation continued over the next few years. Many observers consider this to have been a successful initiative on the part of the U.S. Treasury. Others believe there were good reasons why the dollar would have come down anyway. However, even those who believe that intervention efforts, like the one agreed under the Plaza Accord, are effective do not believe that the primary effect comes from the changed asset supplies that investors must absorb in their portfolios. These *portfolio effects* are still considered relatively small.

The major effect must come instead via investors' expectations regarding the future exchange rate. The 1985 announcement by the U.S. government that it now considered the dollar to be too high and wanted it to fall, for example, may have caused investors to expect a more expansionary monetary policy in the future.[23] As we saw in Chapter 27, even a small change in expectations can cause a relatively large change in demand for a currency and therefore in the exchange rate. This is why a major announcement by central bank governors or treasury secretaries can have a major effect even on a day when no intervention actually takes place, whereas intervention with no public announcement is likely to have little effect. Central banks continue periodically to intervene, sometimes with success and sometimes without it. In mid-1995, when the yen/dollar rate had reached a record low of 80, G-7 intervention succeeded in reversing the depreciation of the dollar.

Satiation in Holdings of a Country's Debt and the Hard Landing

The only way that the public's holdings of bonds (or money, for that matter) can change suddenly is through operations in the financial markets on the part of the central bank, such as the intervention operations just discussed. However, the public's holdings of bonds change steadily over time whenever a country borrows to finance deficits. The budget deficit is the yearly change in the government debt outstanding. In Chapter 22 we examined the effects of a fiscal expansion. One effect was a current-account deficit financed by a capital inflow from abroad. However, we ignored any further effects of the stock of government debt that builds up over time via a budget deficit, or the stock of national indebtedness to foreigners that builds up over time via a current-account deficit. The country illustrated in Figure 23.1 apparently could go on running a budget deficit and current-account deficit forever.

In reality, a country that borrows must eventually pay back. What mechanism forces this result if a profligate country is inclined to go on borrowing indefinitely? The portfolio balance model says that investors will become increasingly reluctant to hold larger and larger quantities of a given country's bonds. The problem may be small under normal conditions, but if the magnitude of the debt becomes large enough, investors will eventually become *satiated* with their holdings. If investors are forced to

[23]This has been called the signaling effect of foreign exchange intervention. Michael Mussa, *The Role of Official Intervention,* Occasional Paper No. 6 (New York: Group of Thirty, 1981).

absorb ever-greater quantities in their portfolios despite their reluctance, one of several outcomes must occur. First, the exchange value of the currency may fall. Recall the assumption that the debt is denominated in the currency of the issuing country. If the nominal quantity of the debt is increasing at 10 percent per year, then the exchange rate must also change 10 percent per year, if international investors do not wish to allow that country's debt to grow as a share of their portfolios. This relationship between the supply of bonds and the exchange rate is the portfolio effect or *valuation effect.* Second, the interest rate may be driven up, to make the assets more attractive to investors.[24]

Until recently, there was some reason to believe the portfolio balance model might have only limited relevance for large industrialized countries. The United States, Japan, Germany, and the United Kingdom were all creditor countries that held foreign assets more than they issued liabilities to foreigners. It seemed that they could borrow large amounts at the world interest rate if they so chose. Smaller countries were more likely to find that their cost of borrowing rose with the amount borrowed. (This is especially true of developing countries.) However, because smaller countries usually borrow in foreign currency rather than in their own currency, the portfolio balance model in its simple form does not apply.[25]

The massive increase in U.S. borrowing from abroad since 1980, however, has raised the question whether the world's investors might not become satiated with their holdings of dollars. The United States continues to run current-account deficits. It follows that the country must continue to borrow from abroad, one way or another. This leaves unresolved the issue of the terms under which this borrowing takes place. If international investors at some point become reluctant to accept ever-larger quantities of dollars into their portfolios, one of the following will result: (1) an increase in U.S. interest rates to induce them to increase the share of their portfolios allocated to U.S. assets, or (2) a further depreciation of the dollar to keep that share from rising, or (3) both could happen, which would be an unpleasant "hard landing" for the dollar.

28.4 Summary

This chapter covered three topics regarding international finance under floating exchange rates: exchange rate forecasting, the exchange risk premium, and portfolio balance.

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[24]The portfolio-balance model has recently been resurrected to consider the valuation effect in the context of the need to finance the U.S. current-account deficit. U.S. net international indebtedness has not risen as much as one might expect because rising debt has been partly offset by a rise in the value of U.S. assets held abroad when measured in dollars, which in turn is partly attributable to a depreciation of the dollar. Pierre-Olivier Gourinchas and Helene Rey, "From World Banker to World Venture Capitalist: The U.S. External Adjustment and the Exorbitant Privilege," and Philip Lane and Gian Maria Milesi-Ferretti, "A Global Perspective on External Positions," both published in Richard Clarida, ed., *G7 Account Imbalances: Sustainability and Adjustment* (Chicago: University of Chicago Press, 2006).

[25]If a country's international borrowings are denominated in the same currency as other assets held by investors, then the exchange rate is not the relative price of foreign and domestic assets and, therefore, cannot be determined by the valuation effect. However, it can still be determined by the need to pay back debt in the long run. An increase in foreign indebtedness will still cause the country's currency to depreciate. Investors realize that a depreciation will be needed sooner or later to improve the trade balance and service the debt.

In practice, forecasters do not all use monetary models, such as the one developed in Chapter 27. Many use other approaches, including technical analysis.

Even within the theory presented in Chapter 27, a large fraction of exchange rate changes should be unpredictable. However, the forecasting performance of exchange rate models is worse than it should be. Often it seems that the fraction of exchange rate changes that can be predicted is zero, that is, the exchange rate follows a random walk. At longer horizons, however, the exchange rate does tend to move in the direction of the equilibrium dictated by monetary fundamentals.

A popular way of forecasting the future spot rate is by using the forward rate. However, "the random-walk spot rate" characterization of other forecasting methods applies to the forward rate as well: Tests show that the forward discount is a biased forecaster, that the forward rate is a worse forecaster than could be achieved by placing more weight on the spot rate alone. One possible interpretation of this finding is a failure of rational expectations and of the efficient markets hypothesis. Most economists, however, interpret the finding of bias in the forward discount as evidence of an exchange risk premium.

An exchange risk premium arises when risk-averse investors look not only at the expected return in deciding whether to acquire a country's currency, but also at risk. The theory of portfolio diversification says that the risk a given asset would bring to the investor's portfolio is determined not only by uncertainty regarding its future value, but also by the asset quantities that the investor already holds and by the correlation of the return on the currency in question with the return on the other assets.

If investors treat domestic and foreign bonds as imperfect substitutes in their portfolios because of risk, then the portfolio balance model applies. This framework makes it possible to talk about two effects on the exchange rate that have previously been omitted. First is the effect of sterilized foreign exchange intervention. Second is the effect of investor satiation with holdings of a given country's bonds. Even though both effects probably exist, the degree of substitutability among countries' bonds is generally thought to be high enough that the effects are small.

CHAPTER PROBLEMS

1. You are the treasurer of a U.S. company that holds open positions (working balances or accounts payable) in foreign currencies. Your bank levies a small but appreciable charge for hedging these positions in the forward market. If you believe the foreign exchange market is efficient, and your company is neutral about risks, will you hedge? What if your company is risk averse? What if your company also has obligations in foreign currencies (bills for imported inputs or employees' wages at foreign subsidiaries)? What if you think that the market sometimes is a poor forecaster of future exchange rates?
2. If the dollar is selling at a forward discount of 4 percent per annum and you think the dollar is going to depreciate at 2 percent over the next year, should you "go long" in dollars, or "sell the dollar short"? (Assume you are risk neutral.)

3. The chapter supplement shows that when two assets each have the same variance, V, the variance of the overall portfolio is given by $V(r) = x^2V + (1 - x)^2V$, where x and $(1 - x)$ are the shares of the portfolios allocated to the two assets, and the returns on the two are assumed to be independent.
- **a.** Calculate $V(r)$ for $x = 0, .4, .5, .6$ and 1.0. Draw a graph of $V(r)$.
- **b.** If you know calculus, differentiate $V(r)$ with respect to x, to find the allocation of the portfolio that minimizes risk.

Extra Credit

4. If you know how to use the mathematical expectation, show how to go from Equation 28.S.1 for the return on the portfolio (in the supplement)

$$r = xr^{€} + (1 - x)r^{\$}$$

to Equation 28.S.3

$$V(r) = x^2\,V(r^{€}) + (1 - x)^2\,V(r^{\$}) + x(1 - x)2\text{Cov}(r^{€}, r^{\$})$$

You will need to use the definition of the variance of r,

$$V(r) = E(r - Er)^2$$

and the covariance,

$$\text{Cov}(r^{€}, r^{\$}) = E[(r^{€} - Er^{€})(r^{\$} - Er^{\$})]$$

5.
- **a.** If you know calculus, show how to use Equation 28.S.3 and 28.S.4 in the derivative of the welfare function, Equation 28.S.6, to obtain the expression for the optimally diversified portfolio, x. (This derivation is carried out in the supplement for the special case where the dollar is viewed as completely safe, but now we want to see it applied to the more general case.)
- **b.** What is the optimal x if the real value of the dollar is completely certain? Why?
- **c.** What is x if the real value of the euro is completely certain? Why?
- **d.** Assuming that both the real values of the euro and yen are uncertain, what is x if the investor is infinitely risk averse? (This is called the minimum variance portfolio.) How do you think it might be affected by the share of European goods in the consumption basket of the investor in question? How might it be affected by uncertainty regarding the European inflation rate?

SUGGESTIONS FOR FURTHER READING

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MacDonald, Ronald, and Mark Taylor. "Exchange Rate Economics," *International Monetary Fund Staff Papers,* 39, no. 1 (1992): 1–57. A survey of the literature on exchange rate determination, including the portfolio-balance model.

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