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FORECASTING FOREIGN EXCHANGE RATES: A PEDAGOGICAL NOTE

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This note attempts to provide some insight into the esoteric activity of forecasting foreign exchange rates. There is little doubt that accurate forecasts of exchange rates can be of tremendous help to managers who must assess costs and set prices in the face of international competition, not to mention the speculative profits that investors with access to successful forecasts could reap. It is not surprising, therefore, that extensive efforts have been made to predict movements of exchange rates. But to what extent can such efforts be expected to be successful? What is the worth of forecasts, and how can they be evaluated?

The starting point of the following analysis is the concept of market efficiency and the potential use of the forward exchange rate as a forecast. Since the forward rate may be the market's aggregate prediction of the future spot exchange rate, it is necessary to ask how other forecasting services manage to co-exist when such an inexpensive forecast is available. This question is discussed in the first section. Then, specific forecasting techniques that have been developed will be analyzed in order to help users of such forecasts understand the nature of and the assumptions behind the various models. Thoughout, the forward exchange rate is used as a benchmark--both in the discussion of theoretical issues and in the performance appraisal of commercial forecasts.

I. Market Efficiency and Forecasting

Much of the literature on market efficiency has originated in connection with the analysis of stock prices. Unfortunately, when drawing analogies between the stock market and the foreign exchange market, one is apt to

generalize too quickly, ignoring some subtle differences.[1] In conjunction with stock price determination, three versions of the concept of efficiency are encountered: weak, semistrong, and strong. The concept of weak efficiency asserts that past price changes do not contain unexploited information about future price changes; the concept of semistrong efficiency requires that all publicly available information be reflected in the current prices; the concept of strong efficiency assumes that all available information, both public or private, is embedded in current prices.

Applied to exchange markets, the concept of strong efficiency may be too restrictive. Thus, it is possible to argue that transactors in the U.S. stock market have access to much more information of a standardized nature (required by the SEC) and much more information from insiders than is the case for traders in the foreign exchange markets. Moreover, foreign exchange traders may and do rely on inside information without having to disclose it. As a result, the requirement assumed in the strong efficiency concept, of perfect information at zero cost, is less likely to be fulfilled in foreign exchange markets than in stock markets. Another possible consequence of the stock market analogy may be the temptation to postulate a random walk hypothesis for the spot exchange rate when, in effect, the forward rate, by taking into account interest rates, is a better predictor of the future spot rate.

Notwithstanding these technical points, it can be shown on both theoretical and, to a lesser extent, empirical grounds that transactions costs,

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[1]The following points have been made by S. W. Kohlhagen, The Behavior of Foreign Exchange Markets--A Critical Survey of the Empirical Literature, New York University Monograph Series in Finance and Economics, 1978-3; and R. M. Levich, "Analyzing the Accuracy of Foreign Exchange Advisory Services: Theory and Evidence," in R. M. Levich and Clas Wihlborg, Exchange Risk and Exposure (Lexington, Mass.: Lexington Books, 1979).

political intervention, and risk premia can cause a deviation of the forward rate from the market's expected future spot rate without being indicative of inefficiency or market failure! One can therefore, as a point of departure, use the forward rate provided by an efficient market as a low-cost forecast.[2] This is, in fact, the basis of the class of forecasts called the "market model." However, it may be difficult, given the current state of theoretical and empirical knowledge, to ascertain the size and direction of any bias contained in the forward rate.

At this point it becomes possible to provide a theoretical justification for the existence of commercially available exchange rate forecast services. If the forward rate deviates from the expected spot rate, it might be worthwhile to devote resources to more precise estimates of future spot rates. Since a number of forecasting services have been in existence for some time, and since they have been using resources for the task, the pragmatic view would be to accept that they must be returning their costs, in the sense that they produce a better estimate of the future spot rate than that represented by the forward rate. This view is attractive at this point in the discussion because it obviates the need for a performance evaluation of the commercial services relative to the forward rate. With respect to the users of commercial forecasts, the implication is that they are earning speculative returns as a consequence. However, whether these returns are sufficiently large relative to the risk involved is a difficult empirical question. This issue will be raised again in section III below.

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[2]While the forward rate may be available at zero marginal cost to a market participant, it is not "free," in the sense that in the aggregate traders and others have devoted resources to its determination. This point is made by John H. Makin, "Techniques and Success in Forecasting Exchange Rates: Should It Be Done? Does It Matter? The Long and the Short of It," University of Washington, 1980 (unpublished).

II. Forecasting Techniques: What the User Should Know

1. Traders' Intuition

Forecasting of economic data requires a "model," i.e., a set of relationships among variables, one of which is the variable to be forecast. Such models may be unspecified; they are simply engrained in the mind of the long-term observer of the processes that generate the data. In the context of foreign exchange forecasting, this is particularly true of successful professional traders, who develop a "gut feel" for the implications of new pieces of economic and political information vis-à-vis the future spot rate. These models are so complex that the traders themselves are usually unable to describe them adequately, and their attempts to communicate how they arrive at certain opinions about future spot rates tend to yield answers that are either inconsistent or, at best, extremely naive. Nevertheless, their failure to make explicit the complex relationships that they have observed and assimilated as a result of their experience in the foreign exchange markets does not mean that their actions do not reflect a high degree of sophistication. Their success at surviving in a very competitive business is the best indicator of the quality of their respective "models."

2. Formal Models

Formal, structured models are the specific concern of this note. The widespread availability of computer facilities has promoted the development and use of forecasting models based on relationships that are stated in explicit mathematical terms. Because of the obvious usefulness of exchange rate

forecasts, there have been numerous attempts at building formal foreign exchange forecasting models.[3]

For analytical purposes, all forecasting models can be broadly divided into two categories--extrinsic and intrinsic. In extrinsic models, the underlying assumption is that there are some fundamental, causal factors which influence the variable of interest--i.e., the future spot rate. In intrinsic models, a forecast of the future spot rate is based on information derived from its own past values.

Extrinsic models can be further distinguished by the underlying theoretical framework. Specification of the theoretical framework is needed in order to identify the most appropriate factors, or variables, and in order to specify the precise nature of their interaction. Broadly, three subgroups of extrinsic models can be distinguished: (a) models based on balance of payments, (b) national economic models focusing on changes in aggregate demand, and (c) so-called monetary models. Exhibit 1 contains a schematic presentation of the forecasting models analyzed here.

Models based on fundamental balance of payments analysis endeavor to forecast the individual items in a country's external accounts, such as the current account balance. The rationalization for such an approach is the argument that it would capture the demand for and supply of foreign exchange, thereby providing indications as to its price, the exchange rate.

Balance of payments models are plagued by a number of inherent difficulties. One problem stems from the fact that any change in the exchange rate

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[3]In early 1978, there were several specialized firms offering foreign exchange forecasts. These organizations and their offerings have been extensively described in the article, "Mobbing Up the Treasurer," Euromoney, August 1978, pp. 13-41. See also "Forecasters are Tougher, More Mature--or Missing," Euromoney, August 1979, pp. 32-52.

Exhibit 1

Schematic Presentation of Foreign Exchange Forecasting Models

A. I N F O R M A L M O D E L S

B. F O R M A L M O D E L S

EXTRINSIC MODELS	INTRINSIC MODELS
(Based on Relationships of Foreign Exchange Rate with Other Variables)	(Based on Past Values of Foreign Exchange Rate)
1. PARTIAL EQUILIBRIUM MODELS (BALANCE OF PAYMENTS MODELS)	
2. EQUILIBRIUM MODELS (SIMULATION MODELS)	VARIOUS TIME SERIES MODELS e.g., Moving Averages, Box-Jenkins
AGGREGATE DEMAND MODELS; MONETARY MODELS	

C. M A R K E T - B A S E D "M O D E L"

(Based on the Assumption of Efficient Processing of Information)

tends to affect all the components of the balance of payments. Thus, while a deficit in the trade balance will put downward pressure on the exchange rate, the very change in the rate will, in turn, impact on the trade balance. And, while some of these feedback effects are reasonably stable and can be built into the model, others are not. Further, there are interactions among the components in the balance of payments which are quite elusive. For example, a change in the trade balance may be supplemented or supplanted by various capital flows. By the same token, exchange rate changes may induce offsetting or compounding changes in various kinds of capital flows.

Last, but not least, the presumption behind this kind of forecasting is that it is easier to predict the components of the balance of payments rather than the exchange rate itself--an assumption that is questionable. To illustrate, it may be possible to forecast with a reasonable degree of accuracy that a country will experience a deficit in its current account. However, a relatively small percentage of deviation in that forecast may lead to a substantial difference between the actual and forecast spot rates in pecentage terms.

As long as there is systematic government intervention in the foreign exchange markets, as is the case when the rate is fixed, the feedback effects of changing exchange rates on the various components of the balance of payments can be neglected. But when exchange rates are changing in a system of free or managed floating, it is necessary to move toward so-called full equilibrium models,[4] where the predicted variable, the future exchange rate, is the result of the interactions of all those variables that are considered to be determinants of the future rate.

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[4]Partial equilibrium models neglect feedback effects.

The usual approach, well developed in economic model building, is to construct a set of equations that describes the economy (or several economies) and can be solved simultaneously to yield the desired variable, here the exchange rate. In its simplest form, the exchange rate, S, is expressed as a function of endogenous (Y) and exogenous (X) variables:

$$S = f[Y(1),\ldots,Y(n);X(1),\ldots,X(m)].$$

The distinction is important because one set of variables (Y) is determined by the model, but the forecaster must provide an estimate of the exogenous variables (X).

Depending on the choice of variables and the specification of their interrelationships, one can distinguish between aggregate demand models and monetary models. The former are more complex; since they rely on changes in output, it is necessary to specify many different relationships. One such foreign exchange model, for example, specifies relationships involving such variables as trade balances, relative inflation rates, real growth rates, relative capacity utilization, short-term interest rates, government deficits, foreign exchange reserves of central banks, relative wage and price performance, and others.[5]

It is important to recognize that the various relationships are specified on the basis of past experience. And one of the crucial determinants for the success or failure of such a forecasting model is the stability of such relationships over time. In defense of model builders, it must be said that they pay a great deal of attention to problems which could stem from this source. Thus, the more sophisticated models of this kind have built into them an elaborate analysis of errors produced by each equation in the model in order

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[5]Michael K. Evans and John F. Norris, "International Business and Forecasting," Columbia Journal of World Business, Winter 1976, pp. 28-35.

to adjust as soon as possible for changes in the hypothesized economic structures. Still, with so many relationships interacting, it is easy for errors to occur because of "misspecification" (a technical term which indicates that the model fails to represent reality properly because either the wrong variables have been chosen or the interrelationships are not correctly stated). Furthermore, it is extremely difficult to rank the performance of different models because of extensive correlation of forecast errors for the different variables predicted by the various models.[6] Monetary models, based on a more comprehensive view of exchange rate changes, try to avoid some of these problems by concentrating on considerably fewer variables. The fundamental notion underlying all of the monetary models is that an excess supply of money in the economy--measured in relation to other economies--will spill over into the external accounts and therefore affect the exchange rate.

The output of all equilibrium models--regardless of their theoretical base--depends on an estimation, i.e., forecast, of the exogenous variable(s) that must be provided by the user of the model. Thus, to make such models useful for forecasting, it is necessary either to forecast the exogenous variables or to find a lagged relationship between the exogenous variable(s) and the exchange rate. Typically, aggregate demand models treat government spending, taxes, exports, and investment as exogenous variables, while monetary models require either a forecast of the money supply or specification of a constant, lagged relationship between changes in the money supply and other variables.

The role of the government with respect to exchange rate forecasting models is particularly important because governmental actions can produce the

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[6]This point is made by W. Allen Spivey and William J. Wrobleski, Econometric Model Performance in Forecasting and Policy Assessment (Washington, D.C.: American Enterprise Institute, 1979), p. 3.

crucial lags needed to make models that simulate the "equilibrium exchange rate"[7] into true forecasting models. Under a system of "fixed" but adjustable exchange rates (typical of the Bretton Woods system) or even a system of managed floating where the authorities "lean against the wind" by intervening in the foreign exchange market, it is government action that provides for the delays in the reaction of the exchange rate to changes in the economic fundamentals, and this permits successful forecasting.[8]

In fact, when government intervention is predictable, not only will econometric models be quite successful, but much cruder models will also yield successful forecasts. In such an environment, simple examination of balance of payments trends and other "fundamentals," such as relative rates of inflation and trade patterns, provides a measure of the pressure on the value of a currency. Then, changes in the level of foreign exchange reserves of the central bank, as well as an analysis of the country's access to credit facilities by the IMF or the international markets, indicate the time when a situation would become critical. The final and crucial step is to predict which of the limited policy options decision makers of the particular country will resort to in a crisis: reinforced attempts at internal deflation, imposition of additional exchange controls, or devaluation.

The success or failure of foreign exchange forecasting under such circumstances depends very much on that final step. An investment in analysis of

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[7]The exchange rate that would prevail for given exogenous variables, provided the model is correctly specified.

[8]A point clearly recognized in M. Murenbeeld, "Economic Factors for Forecasting Foreign Exchange Rate Changes," Columbia Journal of World Business, Summer 1975, p. 81.

the power structure and of the economic ideology of key decision makers in various countries could pay off in the form of very successful forecasts.[9]

With the move toward a system of flexible exchange rates in the international financial environment, the so-called intrinsic class of formal forecasting models has attracted renewed attention. Unlike extrinsic models, which rely on causal relationships among two or more exogenous variables, intrinsic models rely on statistical relationships between the variable to be forecast and past values of the same series. The idea is to identify and extricate from the historical data the underlying processes that generate new data.

Applied to exchange rate forecasting, this concept implies that the future exchange rate can be predicted from the behavior of the exchange rate in the past. Specifically, forecasting models of this type assume the existence of some pattern, or relationship, that can be identified and subsequently used for forecasting. This has led to the application of a number of time series techniques, each of which is designed to identify the "pattern," or statistical dependence, of foreign exchange rates over time. Essentially, such techniques range from naive fitting of trendlines to sophisticated time series models, where, through a sequence of filtering models and diagnostic analysis, the forecaster attempts to detect any dependencies that can be used for forecasting.

As an illustration of a time series forecast, an outline will be given of foreign exchange forecasts based on autoregressive, integrated moving-average

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[9]For a report by one of the most successful practitioners of the art of currency forecasting in this era, see Robert B. Shulman, "Are Foreign Exchange Risks Measurable?," Columbia Journal of World Business, June 1970, pp. 57-58.

(ARIMA) processes, generally referred to as Box-Jenkins models.[10] ARIMA models incorporate many other time series techniques and are therefore representative of all forecasts models based on such methods.

The first step involves the preliminary specification of a model that tentatively identifies the underlying process. Often, it is necessary subsequently to perform first-order differentation to obtain a zero trend in the means of the time series, which is a prerequisite for the application of this technique. Once the model has been selected, its parameters are estimated, using, for example, nonlinear least squares methods. The autocorrelations of the residuals and the significance of the variables are then carefully checked. If the residuals show any autocorrelation, it indicates that systematic economic information remains in the series and the model must be adjusted. The final model, having filtered out of the time series all systematic relationships, thus leaving only random disturbances, or "white noise," can subsequently be used for forecasting. The model is projected forward and the expected values of future exchange rates are computed.

The application of such forecasting techniques is greatly facilitated nowadays by the many forecasting "packages" that are available in large-scale computer systems. The focus here is on the assumptions that are crucial for the user of such exchange rate forecasts, who is contemplating venturing his own funds or those of his company's shareholders on the output of such models.

The attractiveness of Box-Jenkins forecasting techniques is that the sophisticated fitting of the model captures all information in the series of

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[10]For an illustration, see Ian H. Giddy and Gunter Dufey, "The Random Behavior of Flexible Exchange Rates," Journal of International Business Studies, Spring 1975, pp. 17-39. For another early application of Box-Jenkins techniques to foreign exchange forecasting, see Rolf Mirus, "Speculation in the Forward Exchange Market: The Canadian Dollar Since 1970," Recherches Economiques de Louvain, Fall 1975, pp. 303-311.

historical data. This is an improvement over extrinsic models, in which important information may be left out as a result of choosing the wrong variables, or misspecifying the interrelationships of variables. Unfortunately, like all time series models, Box-Jenkins techniques rely on information contained in the data of the past. And this information set may or may not hold for the future.

III. Performance Criteria and Related Problems

The question inevitably arises: are forecasts worth their costs? To some cynics, the corporate managers who buy foreign exchange forecasts are simply buying "handholding services;" the forecast of a prestigious institution can, after all, serve as a convenient scapegoat. To other observers, it is not clear even what the costs of the forecasts are, because they may be part of a bundle of services provided to clients by financial institutions.

If exchange markets are not strong-form efficient, advisory services may be able to uncover information leading to the identification of structural change in the economy, resulting in better forecasts than the forward rate. For example, it might be possible to predict changes in the stance toward and mode of official intervention in the exchange market on the basis of information acquired from private sources. Since the theory explaining systematic deviations of the forward rate from the expected future spot rate is of relatively recent vintage, and because empirical tests may be going on for some time, it is likely that forecasting services will continue to exist side by side with the forward rate.

But what constitutes a good forecast? How well has the forward rate performed? What is known about the performance of forecasting services? The following is an attempt to provide answers to these questions.

1) Criteria for Performance

What constitutes a good forecast may be considered a trivial question. To illustrate that it is not quite so simple, a numerical example, which compares the forward rate and two other forecasts of the future spot rate to the actual later spot rate,[11] is shown in Exhibit 2.

Exhibit 2

Hypothetical Constellation of Spot, Forward, Forecast, and Future Spot Rates

Spot rate S(t)	Forward rate F(t)	Forecast 1 E1(S(t+1))	Forecast 2 E2(S(t+1))	Future spot rate S(t+1)
2.00	1.95	1.94	1.99	1.96

The mean absolute forecast error (MAFE) is one possible criterion for forecasting accuracy. By this standard, the ranking of the three forecasts would be

F, E1, E2.

When the mean squared forecast error (MSFE), which is also a possible criterion, is used, the ranking remains unchanged: the first forecast service is to be preferred to the second. However, a closer look reveals that while the mean absolute and squared forecast errors for Forecast 2 are greater, the forecast is on the "right" side of the forward rate. When the forward rate is 1.95 and Forecast 2 is 1.99, the signal is to buy foreign currency forward for 1.95 and later to sell it at 1.99, for a .04 profit per unit (if unlevered). The actual profit will turn out to be .01. By contrast, both MAFE and MSFE Forecast 1 are smaller, but the signal for action is in the wrong direction:

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[11]These ideas are expressed in Sangkee Min, "Performance Evaluation of Foreign Exchange Forecasting Techniques," The Seoul National University Economic Review 13, 1 (1980), pp. 83-96.

to sell forward at 1.95 and later to buy at 1.94. When the spot rate turns out to be 1.96, a loss of .01 will actually be incurred.

From the point of view of the hypothetical speculator in the example above, it is crucial whether the direction of the forecast is on the right side of the forward rate. By this criterion, Forecast 2 is ranked ahead of Forecast 1.

This point can be made differently by following the considerations of a financial manager with a long or short position in the foreign currency. He would have to assess the constellation of the forward rate relative to the commercial forecast, in order to make the decision of whether or not to hedge.

In such a situation, even though both forecasts are in the right direction (here, both are forecasting a depreciation of the foreign currency), they can have different impacts. On the basis of Forecast 1, a financial manager with a 100 long position in the foreign currency would sell 100 forward. The result would be an <u>actual</u> loss of

$$F(t) - S(t) = 1.95 - 2.00 \text{ per unit, plus an } \underline{\text{opportunity}} \text{ loss of}$$

$$F(t) - S(t+1) = 1.95 - 1.96 \text{ per unit,}$$

in the sense that if he had not hedged, the loss would have been smaller. However, on the basis of the forecast, hedging was indicated.

The second forecast implies a smaller depreciation than the forward rate; hence no hedging is indicated. The <u>actual</u> loss is

$$S(t+1) - S(t) = 1.96 - 2.00,$$

and an opportunity loss (or gain) does not result.

The conclusion that follows from these examples is that a useful criterion for the evaluation of a forecast service should be its ability to predict the direction of exchange rate movement, relative to either the current spot rate or the current forward rate. But that would be only the first test a given

forecast would have to pass. Subsequently, the relevant questions become: how large are the profits earned relative to alternatives, and how risky are such investments? The nature of these questions indicates how difficult it will be, in practice, to provide conclusive answers.

2. Empirical Evidence

In contrast, it is relatively easy to say something about the directional accuracy of the forward rate as a predictor of future spot exchange rates. Recent research,[12] covering the period 1967-1979 and the currencies of nine major trading nations, finds that the forward rate is successful in anticipating the direction of change approximately 50 percent of the time; in other words, it is not a very good predictor. Managers relying on the forward rate as an estimate of the future spot rate, therefore, are exposed to substantial risks.

Some preliminary evidence finds commercial services inferior to the forward rate when judged in terms of mean squared forecast errors.[13] When the proportion of correct predictions of the direction of change is assessed, however, there is evidence that some commercial services have outperformed the forward rate. As shown in the previous section, the direction of change is a more appropriate performance standard than mean absolute or squared forecast errors; and so the question remains of whether the profits obtained from successful commercial forecasts are sufficiently large to justify the risk involved.

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[12]Richard M. Levich, "Are Forward Exchange Rates Unbiased Predictors of Future Spot Rates?," Columbia Journal of World Business, Winter 1979, pp. 49-61.

[13]Richard M. Levich, "Analyzing the Accuracy of Foreign Exchange Advisory Services: Theory and Evidence," in Richard M. Levich and Clas G. Wihlborg, Exchange Risk and Exposure (Lexington, Mass.: Lexington Books, 1979).

Given the preliminary nature of the performance evaluation of commercial forecasts, and given the unsettled theoretical issue of the nature of the bias separating the forward rate from the expected spot rate, the conclusions for the practitioner are somewhat less than clear cut:

1) It is possible that the forward rate is just about as good a forecast as one can find. However, its accuracy is poor because unexpected events swamp its predictions.

2a) It is possible that the forward rate does not reflect the expected future spot rate. If the expected deviation represents the price of risk it is again not worthwhile to purchase forecasts.

2b) Only if and when the ex ante deviation exceeds the risk premium is it worthwhile to forecast.

Either way, substantial risks are likely to remain, not the least being the difficult task of "forecasting" the successful forecasting service.

IV. Summary and Conclusions

Throughout this overview, the fact that forward exchange rates are readily available for many currencies, was used as a justification for studying the information possibly contained in them. In this respect, the forward rate is the approximate forecast in an efficient market.

If forward rates represent the market's expected future spot rates, then they do indeed provide low-cost forecasts. If not, it is important to determine whether there is a systematic and predictable bias, for in that event it could be taken into account, thus preserving the low-cost nature of this forecast. If the bias is highly variable and in itself difficult to predict, additional justification for purchases of forecasts may exist.

What holds true for markets that are approximating efficiency holds even more true for inefficient markets or currencies for which forward markets do not exist. After scouting the "low-cost" forecast of, perhaps, the black

market exchange rate, it may become apparent that expenditures for forecasts are worthwhile; if government has historically reacted in a certain fashion, there could be very large payoffs to discovering and acting on such knowledge. The large foreign exchange losses reported in the past by a number of central banks[14] would appear to be evidence in support of this conclusion.

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[14]Dean Taylor, "Betting Against the Central Banks," Euromoney, Nov. 1980, pp. 121-123.

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