Further Results on the Efficiency of Markets for Foreign Exchange

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I. Introduction

After more than five years of floating exchange rates, there remains serious and fundamental disagreement about how floating exchange rates have worked. It is convenient to consider this literature in two sections. First, there is the literature which considers the impact of floating rates on macroeconomic adjustment. Here, the concern is how well the floating rate system approximates an optimal system for linking the major industrial economies. A specific issue is whether the floating exchange rate system, per se, contributes as an exogenous variable to the level of inflation and degree of uncertainty in the system. A second body of research focuses on a more narrow aspect of positive economics. Given the market's knowledge of exogenous variables and economic structure, this research explores whether the foreign exchange market is efficient in the sense that prices fully reflect available information. This is a restatement of the efficient market hypothesis in the foreign exchange market.

In this paper, my emphasis will be on the second section of literature. The objective of this paper is to update both the theoretical and empirical arguments that pertain to efficiency in the foreign exchange market. Correspondingly, there are several general themes that will be developed in this paper. With respect to the theory of exchange rate determination, recent papers have examined the impact of (1) uncertainty concerning permanent shocks versus temporary shocks, (2) short-run changes in relative prices, (3) the time lag between contracting and delivery of internationally traded goods and (4) the positive costs associated with changing the fixed covenants of long-term contracts.

One interpretation of this literature is that exchange rates may fluctuate within a fairly broad range (say 5 percent) within a fairly short period (say, less than one week) without violating a rational pricing model and, therefore, without creating excess profit opportunities (inefficiencies) in the market. My first theme is that theoretical research is exploring fairly credible models of exchange rate behavior that are consistent with the recent exchange rate

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movements which the business and financial community would label as "erratic" — or perhaps "disorderly."

A second theoretical theme deals with the efficient market hypothesis. Early statements of this important hypothesis seemed to suggest that we could specify some criterion against which we could accept or reject the hypothesis. (In other words, market efficiency was considered an "either/or" concept.) Current research suggests that market efficiency is more aptly thought of as a process. Given that market participants have diverse opinions about future events, speculative markets will approach full efficiency in the long run but can never reflect all information in the short run.

My next theme examines empirical tests of foreign exchange market efficiency. Recent surveys of this literature by Kohlhagen (1978) and Levich (1979) have concluded that simple, risk-free profit opportunities are quickly arbitraged away. However, tests for risky profit opportunities through spot or forward exchange speculation have not been convincing (1) because the basic models of spot and forward exchange rate determination have not been satisfactory, (2) the techniques of analysis have borrowed too freely from the stock market literature and (3) the statistical power of the tests has been low and therefore unable to distinguish the market efficiency hypothesis from competing hypotheses.

Research reported within the last year has noted some evidence for market inefficiency, but these results are not totally convincing for the reasons cited above. Two other papers are especially interesting since they depart from the standard tests and obtain nonstandard results. Brillembourg (1978) reports evidence for a significant risk premium in forward exchange and Cornell (1978) suggests a new explanation for short-run exchange rate volatility that abstracts from price rigidity.

New empirical results for the floating rate period are also reported in this paper. These results show an increase in exchange-market volatility and the corresponding decrease in the forecasting accuracy of the forward rate. The data suggest three interpretations — (1) the foreign-exchange market has become less efficient, (2) the market is efficient but there are significant risk premiums for forward speculation, or (3) the market is generally efficient and the recent experience is a small sample result that was caused by unanticipated shocks. An implication of these results is that large profits were available for currency speculators. Data are reported which indicate the magnitude and other characteristics of these profits.

Each of these general themes is examined in more detail in the remainder of the paper. In section II we consider theoretical issues — first, those related to models of exchange rate determination and second, those related to tests and interpretations of the efficient market hypothesis. Empirical results on foreign exchange market behavior and efficiency are presented in section III. This section first surveys the previous literature and then reports new results on the current behavior of the foreign-exchange market. The final section presents a summary of the paper and conclusions.

II. Theoretical Issues in Exchange Rate Determination and Market Efficiency.

A. Exchange Rate Determination

The classic definition of an efficient market is a market where prices "fully reflect" available information. The operational significance of this definition is that all tests of market efficiency are testing a joint hypothesis — first, a hypothesis on the structure determining equilibrium prices or expected returns and second, a hypothesis about the available information set and the ability of agents to efficiently set actual prices or returns to conform to their expected values. Therefore, an empirical test based on an incorrect equilibrium model of the foreign exchange market or based on a model not generally available to agents might incorrectly reject market efficiency. The selection of the equilibrium process describing foreign exchange rates is obviously critical for a proper test of market efficiency.

Recent research on exchange rate determination has demonstrated the wide variety of exchange rate adjustments that may be consistent with rational behavior.[1] One popular approach (Dornbusch 1976, Calvo and Rodriguez 1977, Niehans 1977) examines an asset approach to the exchange rate with sticky prices in the short run but purchasing power parity (PPP) in the long run. One stylized result in this kind of model is the "overshooting" effect. For a simple numerical example which assumes the neutrality of money, if the domestic money supply increases by 1 percent, the foreign exchange value of domestic currency may immediately decline by say 2 percent; only in the long run does the exchange rate asymptotically approach its long-run equilibrium value.[2]

An alternate approach by Bilson (1978a) clearly illustrates that the current exchange rate depends on all the expected future values of the exogenous variables. As such, if information is received today that affects the expectation of future exogenous variables, the exchange rate will change immediately. When the percentage change in the exchange rate exceeds the observable percentage change in the contemporaneous exogenous variable, we can call this a magnification effect. An extreme case is when a government official announces that some policy (intervention or monetary) will be changed in the future; the exchange rate responds immediately while no change is currently observed and measured in any exogenous variable. In a less extreme case, the money supply growth rate may change from a historic level of 5 to 7 percent. If traders believe this change is permanent rather than temporary, the impact on the exchange rate will be larger than the observable change in the money supply — i.e., a magnification effect.

From these models it is clear that the nature of the disturbance, its expected duration and impact on future exogenous variables are critical deter-

[1]For a survey of popular models of exchange rate determination, see Isard (1978). An anthology of papers dealing with exchange rate determination and empirical tests is in Frenkel and Johnson (1978).

[2]An empirical study by Bilson (1978b) confirms that overshooting has occurred during the floating rate period although he rejects the model of long-run adjustment described by Dornbusch (1976).

minants of the current equilibrium exchange rate. An important new paper by Harris and Purvis (1978) attempts to incorporate many of these factors within a formal model. The Harris and Purvis model allows a very rich setting in which an n-sector economy experiences both monetary and real disturbances which can be either temporary or permanent. Each agent has complete knowledge of prices and real disturbances within his own sector, but incomplete knowledge of conditions in the other sectors. Therefore, there is diverse information across the n-sectors. Harris and Purvis demonstrate that when there is uncertainty whether disturbances are real or monetary and uncertainty whether the disturbance is permanent or temporary and, furthermore, this information is heterogeneous across investors, it follows that the realized time path of the spot exchange rate varies considerably from the "full information" time path.[3]

The Harris and Purvis paper is interesting for at least two reasons. First, it shows how the equilibrium exchange rate depends on the classification of the disturbance. In this regard, the authors argue that the distinction between permanent and transitory disturbances has been underemphasized. Second, the authors illustrate that in the context of their model, exchange rate changes may be positively or negatively autocorrelated without violating weak-form market efficiency. As the authors acknowledge, the demerits of using autocorrelation statistics to test for market efficiency have been noted previously. However, there appears no ready way to test the very general model which Harris and Purvis propose.

Using a very different approach with equally provocative results, Cornell (1978) argues against assuming rigid domestic prices in favor of maintaining the Law of One Price while allowing for changes in relative prices. Using this framework, if tradable goods constitute only a small part of the CPI, Cornell argues that the exchange rate will appear (highly) volatile vis-à-vis the CPI because of a diversification effect — very similar to the way an individual security can appear (highly) volatile vis-à-vis a large index such as the Standard and Poor's 500. In this framework the exchange rate may appear highly volatile, but the foreign exchange market is efficient, apparently by assumption.

A final theoretical consideration for exchange rate determination is suggested by the recent work of Magee (1978) on contracting. In Magee's model, all forward prices are set so that, ex ante, all profit opportunities from international arbitrage are eliminated. In other words, when agents make contracts in period t for delivery in period $t + k$, prices are set so that, ex ante, PPP holds. Magee then demonstrates that using realized exchange rates and contract pri-

[3]Models which allow for heterogeneous expectations may be especially helpful for the analysis of central bank intervention. As the problem is sometimes formulated, excessive central bank secrecy or open policy debates increase *uncertainty* as to the future value of international reserves, the money supply, and other policy variables (Meigs 1978, p. 63). However, most simple monetary models express the exchange rate as a function of the expected value of a few variables (Bilson, 1978a); changes in the variance or covariance of these variables should have no impact on the exchange rate. It seems that the impact of central bank intervention (both known and rumored) and central bank announcements (both clear and unclear) should be to increase the diversity of expectations across individuals rather than simply to widen the distribution of expectations in a similar manner for all individuals.

ces (the amounts actually received by exporters and the amounts actually paid by importers), substantial deviations from PPP can be measured. But these deviations cannot be exploited for profit because there is a lag in the delivery of and payment for goods. In fact, by assumption, contract prices continue to be set to remove expected profits in commodity arbitrage.

Spurious deviations from PPP can also be generated if there are fixed costs associated with changing the firm's price quotation. For example, suppose a company publishes a catalog of its merchandise. The catalog is published quarterly, requires a three-month lead time to produce, and contains price information on 1000 items. In response to an exchange rate change that affects, say, 200 items, the company may choose to forego the cost of republishing a new catalog and notifying customers and, instead, keep its prices unchanged.

The model becomes more rich and realistic if we allow for uncertainty in the time path of prices. Suppose we take a U.S. company which has been importing raw materials from a German company for 20 years. Implicitly we assume that this long-standing relationship has a value not reflected in the product price. If the DM appreciates sharply (say 5 percent in one week) against the U.S. dollar, the U.S. firm may not change its supply source if the exchange rate change is expected to be temporary and if there are costs associated with locating a new supplier. Only as the U.S. firm becomes convinced that the exchange rate disturbance is permanent will it be willing to incur the costs associated with recontracting with a new supplier.

In summary, we have argued (1) that exchange rate models incorporating rational expectations can easily generate large and variable exchange rate movements in response to small (if at all measurable) changes in exogenous variables, and (2) that new interpretations of PPP provide additional and rational arguments for sustained deviations from PPP. This argument does not necessarily lead us to the conclusion that the current floating exchange rate system, which has exhibited sharp price movements and (apparent) deviations from PPP, is efficient nevertheless.

It does suggest however that it may be difficult to reject the efficient market hypothesis in the foreign exchange market, precisely because there are so many credible models of exchange rate determination.[4] This suggests two

[4]A recent argument by Zellner (1978) may be relevant for this point. Addressing the issue of causality and econometric tests, Zellner argues that if we have a theory that X causes Y and that the two variables are related by the expression Y = F(X), then demonstrating that the data are consistent with the expression Y = F(X) is sufficient to demonstrate causality. We know that if our theory has omitted an exogenous variable (X') our conclusion on causality may be wrong. But Zellner's major point here is that the soundness of our conclusion concerning causality rests on the soundness of the original economic theory. Econometric technique cannot be substituted for economic theory in order to determine causality.

In our version of this argument, suppose we have a theory based on rational behavior which predicts that the spot rate is determined by S = F(X). If the data are consistent with the expression S = F(X), we conclude that the market is efficient. A problem arises if other models incorporating irrational behavior are also consistent with the data. Selecting the model which best describes the data may turn on the soundness of the economic theory and assumptions in each model, which departs from the traditional approach to positive economics.

conclusions: (1) It may be difficult or impossible to use a model of exchange rate determination to test for market efficiency, and (2) that it will be difficult for government policy which responds only to an inefficient (or disorderly) market to meet the burden of proof.

B. Market Efficiency

Early statements of the efficient market hypothesis tended to portray it in a manner similar to any statistical null hypothesis; the data may either reject or not reject market efficiency. A taxonomy was developed (weak-form, semi-strong-form and strong-form) to describe efficient market tests based on various information sets — historical prices, public information and all available information. So while the theory allowed for heterogeneous information and expectations, and some empirical tests supported weak-form efficiency but rejected strong-form, the theory was essentially static.

An important contribution was made by Grossman and Stiglitz (1976) who assume that information is costly to collect and analyze. Because of information costs, not all information will be collected, so markets will never be fully efficient (i.e., strong-form). Moreover, since the information industry will reach a competitive equilibrium, investments in information will earn only the normal competitive rate of return. As a consequence, marginal investors may choose to be informed (i.e., to buy information) or uninformed (i.e., not to buy information) with each state earning the normal rate of return. The market will have heterogeneous expectations and information.

A new and imaginative approach to market efficiency is developed in Figlewski (1978a, 1978b). Traders in Figlewski's model have heterogeneous information, but they also are allowed diverse price expectations, risk aversion, predictive ability and wealth. Based on these factors, traders make their investments in period 1. Traders with superior (inferior) ability generally incur an increase (decrease) in wealth in period 2. The transfer of wealth ("dollar votes") toward traders with superior track records gives the market its dynamic property and long-run tendency to full efficiency. Based on numerical simulation of his analytical model Figlewski concludes that

> The more risk averse the traders are, and the more homogeneous their information, the more efficient we expect the market to be. However, when there is a wide range of forecasting ability or a diversity of expectations among the participants, the market may deviate relatively far from (full or strong-form) efficiency.[5]

The recent theoretical literature on market efficiency supports several conclusions. First, it may be helpful to view market efficiency as a process rather than a hypothesis to accept or reject. Given that traders have diverse information, speculative markets will approach full efficiency in the long run but can never reflect all information in the short run. Since we live in a series of short runs, a related question is — what is the appropriate standard to use for a short-run analysis? We expect the short-run variation in prices to exceed the long-run, full information variation — but by what factor should they differ?

[5]Figlewski (1978a), p. 597.

A second question for policy concerns the optimal procedure for moving toward full-information efficiency in the short run. Should the government intervene directly in the market (presumably utilizing more complete information than is publicly available) or should the government simply release information to increase the homogeneity of expectations across traders?

III. Empirical Studies of Foreign Exchange Market Efficiency

A. Recent Literature-Results from an Earlier Survey

Recent surveys of the empirical literature have been reported by Kohlhagen (1978) and Levich (1979). Since one method of testing for market efficiency is to analyze the availability of unusual returns (where "unusual" is defined relative to some equilibrium risk-return model) Levich divides the literature into risk-free and risky investment opportunities. Both Kohlhagen and Levich agree that simple, risk-free profit opportunities (such as covered interest arbitrage in offshore markets) are quickly arbitraged away. However, research on the efficiency of arbitrage between onshore and offshore assets has not been conclusive. We are still unable to fully document whether it is risk factors (e.g., the possibility of capital controls which would reduce the realized return from covered arbitrage below the expected return) or cost factors (e.g., the known cost of existing taxes and capital controls) which determines the interest differential between onshore and offshore assets.

The research on risky profit opportunities has led to more ambiguous results. This is a direct result of the diversity in models of spot and forward exchange rate determination which we discussed in Section II. The essence of the problem can be put succinctly:

> . . . it is difficult to test if investors efficiently set the actual spot exchange rate equal to its equilibrium value unless there is some agreement on what the equilibrium value is. Similarly, it is difficult to test if risk bearing is efficiently compensated if there is no agreement on the fundamental nature of foreign exchange risk, an adequate measure of foreign exchange risk and a model which determines the equilibrium fair return for bearing foreign exchange risk.[6]

We proceed to discuss the research on risky profit opportunities by first briefly reviewing the survey by Levich (1979) and then updating this with more recent research. For convenience we first consider tests for spot market efficiency followed by tests for forward market efficiency. When the interest rate parity theorem holds, spot speculation and forward speculation are equivalent investments so our results should be consistent.

Spot Market Efficiency. Basically two techniques have been used to test spot market efficiency. The first considers the time series properties of the spot rate and very often tests the null hypothesis that changes in spot exchange rates are serially uncorrelated. As we discussed in Section II, the time series path of the spot rate depends on the time series path of the exogenous variables as well as the process which determines expectations. Any time series test which

[6] Levich (1979).

abstracts from these conditions cannot be the basis of a test of market efficiency, although it may be helpful for descriptive or forecasting purposes.

The second popular technique for testing spot market efficiency has relied on the profitability of simple filter rule trading strategies.[7] Some results indicate that small filters would have been profitable for some currencies during the floating rate period. However, there are many factors which cast doubt on the interpretation of these results. First, it is not clear, ex ante, that the size of the filter can be determined which assures or optimizes profits. Second, even a filter rule which earns a profit over a sustained period is likely to report losses during some interim periods. Thus there is an element of riskiness in these trading strategies which is difficult to measure and difficult to compare to some standard model.

Data considerations do not allow us to analyze another potential problem related to filter rule strategies. Market-maker quotations are typically valid only for a small and specified volume of contracts and for a limited time span. It is therefore possible that supply and demand elasticities are sufficiently large so that unusual profits would be eliminated quickly after a small volume of trading. This is important if we want to distinguish an inefficient market which permits $10 billion worth of profitable transactions in one hour, versus an inefficient market which eliminates a profit opportunity after $1 million of trade in one minute.

Forward-Market Efficiency. Empirical tests of forward market efficiency surveyed in Levich (1979) can be conveniently divided into four groups. First, there are regression tests which estimate models of the form

$$(1) \quad S_{t+n} = a + bF_{t,n} + u_t$$

or

$$(2) \quad \frac{S_{t+n}}{S_t} = a + \frac{bF_{t,n}}{S_t} + e_t$$

where S_{t+n} = Spot rate in period t + n.

$F_{t,n}$ = Forward rate in period t for delivery n periods in the future.

Generally these tests cannot reject the result that $a = 0$ and $b = 1$ so that the forward rate is an unbiased predictor of the future spot rate.

A second technique for analyzing forward bias has been to analyze the statistical properties of the forecast error

$$(3) \quad e_{t,n} = S_{t+n} - F_{t,n}$$

[7]An *x* percent filter rule leads to the following trading strategy: "Buy a currency, and then an interest-bearing asset denominated in that currency, whenever the currency rises *x* percent above its most recent trough; sell the currency, and the asset, and take a short position — in both the currency and the asset — whenever the currency falls *x* percent below its most recent peak." With profit-maximizing traders, and with currency expectations reflected in interest rates, the expected excess profit from this strategy is zero.

The important conclusion from this analysis is that first, over long periods and for most currencies, the mean errors are small — many times not significantly different from zero. When the mean is significantly nonzero, it is likely smaller than transaction costs. Second, forecast errors in independent time periods are serially uncorrelated. Therefore, watching linear patterns in past forecast errors will not improve future forecasting performance.

An important point to make regarding both the regression analysis and forecast error analysis approaches is that unbiasedness is very often taken as the null hypothesis and then often equated with market efficiency. Since several theories of forward market equilibrium are consistent with a forward rate bias (or forward risk premium) this approach is not correct.[8] And our conclusion about market efficiency must rest on which model of forward rate determination we assume to be correct.

A third approach for testing forward market efficiency is based on the returns from forward speculation

$$(4) \quad R_{t,n} = \frac{(S_{t+n} - F_{t,n})\, W_t}{M\, F_{t,n}}$$

where W_t is +1 or −1 to indicate long or short forward positions and M represents the initial margin. If the market is efficient there should be no method for selecting the W_t to earn unusual returns in excess of costs. Very few tests have used this approach. Even so, the test would not be conclusive since there is no adequate measure of risk to determine if speculative profits are unusually high.

A fourth, and final, approach is to test the forecasting accuracy of the forward rate against other models. In a world with free information and risk neutral traders (or fully diversifiable exchange risk) market efficiency requires that the forward rate should be the best available forecast of the future spot rate. Levich (1978a) reports that forecasts based on Euro-currency interest rates are often (marginally) superior to the forward rate. Other research (Bilson and Levich, 1977) concludes that both time series forecasts and composite forecasts constructed during a sample period do not outperform the forward rate in a post-sample period. Since these two popular alternative models could not improve on the forward rate forecast, the authors conclude that there is no firm evidence against the forecasting efficiency hypothesis.

B. Recent Literature — 1978 Papers

Several papers have been published within the past year which extend the testing described in the last section. The first set of papers (Cornell and Dietrich 1978 and Logue, Sweeney and Willett 1978) examines the time series properties of the spot exchange rate and the profits that result from using a filter rule trading strategy. The Cornell and Dietrich study examines daily data for six currencies over the period March 1973 - September 1975 while the

[8] For an analysis of the fundamental conditions which lead to a risk premium in the forward market, see Frankel (1978).

Logue, Sweeney and Willett research uses daily data on seven currencies for the period April 1, 1973 – January 7, 1976 (N = 692). Both studies find that the one-day rates of change in spot prices show little evidence of serial correlation. While this result says nothing about market efficiency, Logue, Sweeney and Willett (1978, p. 159) argue that it "contrasts sharply with the view that the markets 'overshoot,' or that there are 'bandwagon effects,' or that the amount of price stabilizing speculation is inadequate."

In their analyses of filter rule trading profits, Cornell and Dietrich calculate the percentage rate of return relative to a buy-and-hold (U.S. dollars) strategy while Logue, Sweeney and Willett report the dollar profits of a trader who begins with $100 and compare this to a buy-and-hold-the-foreign-currency rule.[9] Logue, Sweeney and Willett do not account for transaction costs "on the presumption that the direct cost . . . would be very low for any foreign exchange dealer." They also do not adjust for the interest earned or paid while maintaining a currency position. Cornell and Dietrich, however, adjust for transaction costs and note that "the existence of these costs substantially reduced profits when using the smaller filters"; they also adjust for interest earned in the Euromarket. Cornell and Dietrich calculate that filter rule profits in German marks, Dutch guilders and Swiss francs are significantly greater than the buy-and-hold alternative. However, the authors feel that given the unprecedented world economic events during this period and their other sample evidence, their evidence on market inefficiency "does not appear to constitute a strong case for official intervention in order to correct for under-or over-evaluation of currencies." (p. 120)

A second set of papers (Brillembourg 1978, Hakkio 1978 and Stockman 1978) examines the structure of forward rates and expectations of the future spot rate. Stockman decomposes the forward rate into three terms — the expected future spot rate, a risk premium, and a convexity term. The model is tested on weekly data for the period February 1973–May 1977. The data suggest that a risk premium exists for two currencies (the British pound and Swiss franc) but that it is significant only in smaller subperiods and may not be constant.

Brillembourg's analysis covers the period June 29, 1973–June 24, 1977 and examines the term structure of Canadian dollar and British pound forward rates at the 30–, 60–, 90–, 180–, 270– and 360–day maturities. Brillembourg utilizes this extensive term structure to test an error learning model for revisions in forward rates (e.g., the revision of the 360-day forward rate on January 1 to the 270-day forward rate on April 1). Brillembourg concludes that in his second sample period (10/24/75–6/24/77) the data do not reject the presence of a risk premium. Furthermore, the model allows Brillembourg to estimate a "risk premium curve" which has a humped shape, starting near zero for short maturities and rising to about 0.04 percent per week for the 30-40 week maturities before the risk premium curve declines.

As these authors note, the existence of a risk premium has important

[9] The authors explain that "the relevant alternative to the trading rule is not holding dollars; rather it is holding the foreign currency."

implications for both positive and normative issues in international finance. A major problem with this evidence is that it relies on relatively small sample periods. As we have noted earlier, "forward bias" tends toward zero as the sample size increases. Analyzing one-year sample periods between 1967 and 1975, Levich (1978a) reports many cases of bias, but the sign changes relatively often and in an (apparently) unpredictable way. Traders cannot benefit if bias exists but it cannot be predicted. All the authors agree that future research should be directed toward a theory of the fundamental determinants of spot and forward rates, and as a result, the determinants of the risk premium.

A third area of research in 1978 reports on the accuracy of foreign exchange forecasts prepared by foreign exchange advisory services.[10] Levich (1978b) analyzes the currency forecasts prepared by Predex Corporation in the 27-month period April 1975–October 1977. Predex publishes both judgmental and equation-based forecasts for the major industrial countries for horizons from one to six quarters ahead.

Overall, the data indicate that for two currencies (the DM and lira) the Predex forecasts appear significantly better than the forward rate. For two other currencies (the Canadian dollar and the yen) the Predex track record appears significantly worse than the forward rate. Forecasts of the final two currencies (the British pound and the French franc) showed mixed results not significantly different from the forward rate. However, for individual currencies the forecasts do exhibit some consistency over time. In other words, forecasts which led to a significant profit in a currency in the first nine months of the sample continued to be profitable (on average) in the remaining 18 months of the sample. Therefore, a user of the forecasts could have used this rule to make profits. A longer time series of observations would make these results more convincing.

A paper by King (1978) examines the combined accuracy of seven exchange rate forecasting firms versus the forward rate. The analysis is for the one-year-ahead forecasts of the quarterly average future spot rate. The forecasts were generated in the seven-quarter period 1975–1 to 1976–3 for six major currencies. The results suggest that the average professional forecast error is smaller than the average forward rate forecast error across all six currencies. However, only for the DM is this difference significant; here the average professional forecast error is roughly half as large as the forward rate forecast error. This is somewhat surprising since the DM is a key rate in the system and believed to be closely watched by a wide group of professionals.

Further analysis of advisory service forecasts will provide useful tests of semi-strong and strong-form market efficiency.

C. *New Empirical Results*

In this section we report new empirical results on the relationship

[10]A survey of the foreign currency advisory service industry is in *Euromoney* (August 1978). A somewhat related study by Giddy (1978) concludes that black-market exchange rates may have significant predictive power at the one-year horizon, but they are rather poor predictors in the short run.

between the forward rate and the future spot rate during the period January 1967–May 1978. The purpose of this section is to update the results in Levich (1978a) and to illustrate the time pattern of forecasting accuracy over the five-year floating rate period. The sample period includes 590 weekly observations for nine major currencies. The data are from the Harris Bank *Weekly Review* which reports end-of-week bid quotations from the interbank market.

The statistics which we calculate are standard and can be summarized as follows:

Table 1: Mean squared forecasting error
Table 2: Frequency distribution of forecasting errors
Table 3: Mean forecasting error
Table 4: Serial correlation of forecast errors
Table 5: χ^2 test for forecasting bias
Table 6: Mean absolute forecast error
Table 7: Regression analysis of forecasting

The main statistic we are analyzing is the percentage forecast error (e_t) of the three-month forward rate, which we calculate as[11]

$$e_t = (S_{t+n} - F_{t,n})/S_{t+n}$$

Therefore, positive (negative) forecast errors indicate underestimation (over-estimation). Note also that the forecast errors are subscripted for time t:the time when the forecast was made. Therefore, when forecasts are aggregated over some time period, say 1974, the summary statistics describe errors of forecasts which were *formulated* in 1974.

Broadly speaking, the data suggest that after the initial shock of generalized floating, some calm returned to the market and the forecasting accuracy of the forward rate improved. In the last two years this "trend" has been reversed for many currencies. In what follows we will consider whether this implies market inefficiency.

Table 1 presents the mean squared forecasting error (MSE) classified by time period and currency. For most countries the MSE peaks in a year with a discrete change in the spot rate, however in several cases (Canada, the United Kingdom, Switzerland and Japan) the MSE appears on the rise in 1977-78 and headed toward its recent high. Overall however, the average MSE across all nine countries appears on the decline from the peak reached in 1973.

Part of the frequency distribution of forecast errors is presented in Table 2. Analysis of the frequency distribution is an alternative, and perhaps superior, technique for assessing forecast accuracy since we avoid the effect that extreme outliers can have the mean and MSE. Table 2 illustrates the large forecast errors associated with the devaluations in 1971 and 1973. Forecasting accuracy increased for most currencies in 1975-76, except for three countries — Canada, the United Kingdom, and Italy. A substantial decrease in forecast-

[11]Since the data are weekly, we compare today's three-month forward rate with the spot rate 13 weeks from today. Our statistics were also calculated for the one-month and six-month forward rates but the results, which are generally consistent, are not reported here.

Table 1
MSE by Year and Country for 3-Month Horizon

Period	Method	Canada	United Kingdom	Belgium	France	Germany	Italy	The Netherlands	Switzerland	Japan	Average (σ)
1967	Forward	0.281	68.853	0.085	0.255	0.297	0.060	0.098	0.272	0.0	8.78 (24)
1968	Forward	0.526	0.901	0.523	1.769	1.161	0.123	0.385	0.201	0.0	0.70 (0.6)
1969	Forward	0.104	1.642	2.359	27.140	9.799	0.324	0.800	0.283	0.0	5.31 (9.4)
1970	Forward	4.544	0.533	0.008	0.184	0.470	3.565	0.100	0.233	0.006	1.07 (1.7)
1971	Forward	0.813	5.362	12.272	9.768	10.605	4.228	9.406	6.714	11.710	7.88 (3.8)
1972	Forward	1.574	17.599	13.947	17.704	17.512	3.102	16.515	29.957	18.493	15.16 (8.5)
1973	Forward	1.501	22.456	70.124	80.194	100.691	36.533	60.940	67.586	37.497	53.06 (31)
1974	Forward	2.247	19.398	41.053	35.320	47.228	16.610	32.563	61.590	29.237	31.69 (17)
1975	Forward	4.669	21.856	25.706	26.199	27.445	58.819	27.898	16.639	3.482	23.63 (16)
1976	Forward	6.315	43.902	19.567	7.252	7.300	84.235	17.987	6.135	7.901	22.29 (26)
1977	Forward	3.980	17.634	20.230	6.760	15.249	13.877	15.501	52.142	25.051	18.94 (14)
1978	Forward	8.167	36.080	9.228	28.288	7.992	12.921	8.263	17.994	36.955	18.43 (12)
1967–1978	Forward	2.527	19.624	19.001	19.792	21.698	20.707	16.719	22.159	18.181	17.82 (6.0)

Table 2
Percentage of 3-Month Forward Rate Forecasts Within 0.5, 1.0, and 2.0 Percent of Future Spot Rate

Country	1967			1971			1972			1973			1974			1975			1976			1977			1978			1967–78		
	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0
Canada	57	83	100	45	61	100	31	43	92	33	60	87	16	36	92	13	25	44	13	23	40	23	37	63	38	38	50	37	56	79
United Kingdom	66	68	70	4	37	50	12	24	34	2	6	14	6	14	38	13	25	35	4	9	21	0	0	19	0	0	0	20	35	50
Belgium	91	100	100	34	38	42	47	68	86	6	14	20	4	8	16	23	40	56	15	26	47	8	15	35	0	12	50	38	50	62
France	57	100	100	53	61	71	22	47	75	4	10	16	2	4	26	8	17	35	15	59	80	2	6	37	0	0	0	23	40	56
Germany	54	98	100	8	12	24	29	56	72	6	8	12	4	10	16	8	27	52	11	25	53	4	19	46	0	12	50	22	39	58
Italy	98	100	100	36	42	74	59	69	85	10	20	34	8	18	40	10	21	35	6	6	15	0	0	2	25	38	38	36	47	58
The Netherlands	94	100	100	14	28	42	22	42	77	6	10	20	6	10	20	25	33	54	8	25	40	25	42	58	0	12	50	31	49	64
Switzerland	64	94	100	25	29	56	12	30	72	4	8	16	4	8	14	15	35	48	23	38	62	2	6	19	0	38	38	31	49	63
Japan	—	—	—	47	57	57	15	28	43	10	14	31	10	18	30	13	29	58	15	28	53	2	2	13	0	0	0	21	29	44
Average	73	93	96	30	41	57	28	45	71	9	17	28	7	14	32	9	26	46	12	27	46	7	14	32	7	17	31	29	44	59

Table 3

Mean Forecasting Error by Year and Country for 3-Month Horizon (T-Value in Lower Panel)

Period	Method	Canada	United Kingdom	Belgium	France	Germany	Italy	The Netherlands	Switzerland	Japan
1967	Forward	0.006	-4.459	0.135	0.098	-0.382	0.010	0.075	-0.264	0.0
1968	Forward	0.550	0.748	-0.567	0.488	-0.771	-0.192	-0.417	-0.313	0.0
1969	Forward	-0.094	1.054	0.731	-1.076	1.147	-0.079	-0.455	-0.383	0.0
1970	Forward	1.395	0.271	0.008	0.405	0.385	1.254	0.083	-0.273	-0.023
1971	Forward	0.034	1.992	2.653	1.489	2.976	1.490	2.525	1.904	2.057
1972	Forward	0.221	-1.465	1.087	1.579	0.910	0.818	0.630	1.968	0.542
1973	Forward	0.093	-0.620	-0.666	-1.103	1.126	-2.478	0.882	0.540	-1.834
1974	Forward	-0.562	2.319	4.708	4.933	3.030	2.889	3.645	5.691	1.326
1975	Forward	0.282	-3.336	-2.832	-0.849	-3.124	-3.384	-3.139	-1.614	-0.554
1976	Forward	0.035	-2.076	3.235	-0.938	1.375	0.622	2.003	-0.464	1.607
1977	Forward	-1.528	3.533	3.556	2.398	3.049	3.533	2.627	5.630	4.317
1978	Forward	-2.041	-5.819	0.852	5.110	0.030	2.687	0.935	-1.030	5.969
1967–1978	Forward	0.013	-0.210	1.118	0.744	0.890	0.455	0.785	1.114	1.065

Period	Method	Canada	United Kingdom	Belgium	France	Germany	Italy	The Netherlands	Switzerland	Japan
1967	Forward	0.072	-4.179	3.384	1.292	-6.585	0.275	1.657	-3.991	0.0
1968	Forward	8.297	9.042	-8.771	2.707	-7.177	-4.461	-6.290	-6.818	0.0
1969	Forward	-2.173	10.341	3.712	-1.493	2.757	-0.983	-4.178	-7.364	0.0
1970	Forward	6.243	2.881	0.640	20.711	4.893	6.410	1.971	-4.945	-1.679
1971	Forward	0.270	11.918	8.115	3.833	16.080	7.363	10.259	7.737	4.188
1972	Forward	1.266	-2.635	2.151	2.863	1.590	3.709	1.109	2.752	0.862
1973	Forward	0.544	-0.942	-0.564	-0.886	0.807	-3.179	0.812	0.470	-2.174
1974	Forward	-2.888	4.422	7.735	10.628	3.509	7.177	5.930	7.521	1.807
1975	Forward	0.939	-7.274	-4.809	-1.202	-5.306	-3.511	-5.277	-3.077	-2.219
1976	Forward	0.099	-2.379	7.735	-2.678	4.264	0.490	3.864	-1.376	5.024
1977	Forward	-8.505	11.117	9.222	17.050	8.928	21.336	6.398	8.890	12.176
1978	Forward	-2.700	-10.326	0.773	9.159	0.028	2.978	0.910	-0.662	13.723
1967–1978	Forward	0.190	-1.134	6.285	4.034	4.651	2.383	4.668	5.829	4.982

ing accuracy during 1977-78 is clear for five countries — the United Kingdom, France, Italy, Switzerland and Japan. These results are substantial evidence for the recent decline in forecasting accuracy of the forward rate. The contrast with 1967, a quiet year under pegged rates, is very sharp.

Table 3 presents mean forecast errors and their associated t-statistics. Mean forecast errors in 1977-78 are generally as large in absolute value as errors at any time in the last 12 years. Furthermore, all t-statistics for 1977 and many for 1978 are significant.[12] Throughout the floating period, the bias appears unstable. For many currencies the bias changes from being positive (and significant) to negative (and significant). All currencies go through periods of significant and insignificant bias. A formal runs analysis of the positive and negative bias in each series was not performed, however, since a dependent sample of weekly forecasts was aggregated to calculate yearly bias.

Instead, our approach calculates the serial correlation of forecast errors in an independent sample. For example, at the three-month horizon, the sample consists of every thirteenth forecast error.[13] These results are summarized in Table 4.

Table 4 reports statistics for the entire sample period in the upper panel and the floating rate period in the lower panel. For each currency we report the autocorrelation of forecast errors at lags one through ten and the Box-Pierce Q(k)-statistic, which is a general test for the presence of autocorrelation through k lags.[14] The asymptotic standard error of the autocorrelation is approximately $1/\sqrt{N}$ while the Q-statistic is distributed as X^2 with (k−1) degrees of freedom.

Both panels of Table 4 present a total of 148 autocorrelation statistics. Eleven of these, or 7.4 percent, are significant at the 5 percent level. The autocorrelations are typically positive at the initial lag and turn negative at lags two through five or six. This pattern suggests that the forward rate is initially somewhat conservative in adjusting to expected exchange-rate changes. However, then there is a reversal (perhaps the spot rate hits a turning point) and the sign of the forecast error changes from its value several periods ago. While this

[12]It is important to note that the standard errors were calculated using a dependent sample of roughly 52 observations per year. The t-statistics were then calculated as $t = \bar{X}/(\sigma/\sqrt{52})$. If we assume there are only four independent observations in each year, we should compute

$$t' = \bar{X}/(\sigma/\sqrt{4}) = t/\sqrt{13} = .28(t).$$

So for the yearly periods, the reported t-values should be reduced by 72 percent. Also note that for a t-distribution with three degrees of freedom the 10 percent and 5 percent significance levels are 2.132 and 2.776, respectively. In this case, only t-values in Table 3 greater than 7.69 and 10.0 are significant at the 10 percent and 5 percent levels. Even with this adjustment, all t-values in 1977 are significant at least at the 10 percent level, except for the Netherlands.

[13]Such an independent sample could be formed by taking observations 1, 14, 27, . . . or observations 2, 15, 28, . . . etc. Our procedure was to select only *one* independent series for each currency. As a theoretical matter, there is likely to be some sampling error around our particular autocorrelation estimates. It might therefore be worth the additional effort to calculate the autocorrelation of errors for other independent samples.

[14]We draw an analogy with standard multiple regression tests where a t-test is used to test each separate coefficient and an F-test is used to test the significance of the entire regression.

Table 4

Tests for Serial Correlation of Forecast Errors

Country	N	1	2	3	4	5	6	7	8	9	10	Q(6)	Q(12)
Canada	42	0.217	-0.100	-0.011	-0.153	-0.104	-0.100	0.135	0.267	-0.027	-0.203	3.657	7.346
United Kingdom	42	0.226	-0.039	0.018	-0.342[a]	-0.326	-0.151	0.220	0.322	0.077	0.179	10.749[b]	17.546[b]
Belgium	42	-0.176	-0.117	0.210	-0.311	-0.002	-0.094	0.103	0.020	-0.248	0.275	6.994	11.190
France	42	0.154	-0.359[a]	-0.164	0.043	-0.139	0.104	0.435[a]	0.072	-0.360[a]	-0.175	7.611	17.024
Germany	42	0.424[a]	-0.215	-0.342[a]	-0.212	-0.162	0.002	0.262	0.195	-0.155	-0.257	14.900[a]	18.794[b]
Italy	42	0.109	-0.321	-0.152	0.195	-0.116	-0.174	0.053	0.188	-0.004	-0.130	7.686	8.625
The Netherlands	42	0.201	-0.307	-0.281	-0.055	-0.099	0.003	0.104	0.101	-0.108	-0.086	8.151	8.737
Switzerland	42	0.438[a]	-0.284	-0.389[a]	-0.225	-0.113	0.008	0.137	0.106	-0.057	-0.028	17.522[b]	16.366
Japan	25	-0.170	0.045	-0.008	-0.310	0.070	-0.117	0.154	0.208	-0.423	-0.121	2.767	6.421
Canada	31	0.283	-0.160	-0.070	-0.025	-0.138	-0.197	0.123	0.262	0.055	-0.022	4.232	6.332
United Kingdom	23	0.242	-0.068	-0.037	-0.338	-0.467	-0.302	—	—	—	—	8.297	—
Belgium	20	-0.125	-0.114	0.139	-0.375	0.140	-0.130	—	—	—	—	3.154	—
France	20	0.100	-0.246	0.006	-0.085	-0.374	-0.010	—	—	—	—	3.046	—
Germany	20	0.360	-0.114	-0.211	-0.365	-0.466	-0.116	—	—	—		7.710	—
Italy	20	0.071	-0.309	-0.252	-0.121	0.353	0.167	—	—	—	—	4.643	—
The Netherlands	20	0.320	0.246	-0.284	-0.082	-0.552	-0.501	—	—	—	—	11.286[a]	—
Switzerland	20	0.677[a]	0.182	-0.282	-0.522	-0.726[a]	-0.828[a]	—	—	—	—	28.793[a]	—
Japan	20	0.239	-0.041	-0.264	-0.096	-0.013	-0.380	—	—	—	—	3.955	—

NOTE: Top Panel is 1968-78 period except Japan.
Lower panel is floating rate period, March 20, 1973 — date, for all countries except Canada and the United Kingdom.
a) significant at 5 percent level
b) significant at 10 percent level

Table 5

Summary of χ^2 Tests for Forward Bias: Floating Rate Period

Country	1-Month		3-Month		6-Month	
	χ^2	N	χ^2	N	χ^2	N
Canada	69.4	102	14.9	31	11.4	15
United Kingdom	39.2	76	6.6	23	0.8	11
Belgium	42.6	66	20.0	20	10.0	10
France	46.3	66	12.4	20	6.4	10
Germany	45.6	67	15.9	20	10.0	10
Italy	40.7	66	7.6	20	6.7	10
The Netherlands	31.7	66	10.0	20	2.6	10
Switzerland	33.0	67	7.1	20	1.7	10
Japan	42.0	66	10.9	20	4.3	10

description may be a general pattern, it is significant in the floating rate period only for Switzerland. Tests to see if knowledge of this pattern could lead to an unusual profit, which would suggest a market inefficiency, have not been attempted.

In Levich (1977), a theory of the time pattern of forecast errors is developed. The theory predicts that positive forecast errors (underestimates) will be most common when the spot rate is rising and negative forecast errors (overestimates) will be most common when the spot rate is falling.

One way to test the theory statistically is to classify each time period along two dimensions: (1) the forecast error, positive or negative, and (2) the change in the spot rate, positive or negative. Accordingly, a 2 x 2 contingency table can be constructed for each country-horizon episode. The null hypothesis is that the sign of the forecast error is independent of the rate of change in the spot rate. The test statistic,

$$\sum_{I=1}^{2} \sum_{J=1}^{2} (A(I,J) - E(I,J))^2 / E(I,J)$$

where A (.) and E (.) are the actual and expected values in cell (I, J), is approximately chi-square with one degree of freedom. Table 5 summarizes these chi-square statistics for all nine countries. Independent samples were selected for each horizon so the observations are nonoverlapping.

The data confirm that the type of bias described in the theory is still present in the floating rate period.[15] The bias shows some tendency to decline in longer term forward contracts, but for the one-month maturity, the effect appears very strong.

We present calculations of the mean absolute forecast error in Table 6.

[15]The critical values of $\chi^2(1)$ are 3.84 and 6.63 at the 5 percent and 1 percent significance levels. All of the entries in Table 5 are significant except for the United Kingdom, the Netherlands, and Switzerland at the six-month maturity.

Table 6: Mean Absolute Forecast Error by Year and Country for 3-Month Horizon

Period	Method	Canada	United Kingdom	Belgium	France	Germany	Italy	The Netherlands	Switzerland	Japan
1967	Forward	0.428	4.677	0.229	0.406	0.445	0.200	0.272	0.420	0.0
1968	Forward	0.599	0.772	0.581	1.149	0.898	0.283	0.584	0.380	0.0
1969	Forward	0.283	1.054	0.892	3.695	2.093	0.477	0.757	0.429	0.0
1970	Forward	1.485	0.585	0.073	0.405	0.477	1.274	0.249	0.364	0.060
1971	Forward	0.724	1.992	2.728	1.909	2.976	1.539	2.549	2.047	2.352
1972	Forward	1.052	3.463	1.848	2.402	2.320	1.062	2.378	3.208	2.946
1973	Forward	0.927	4.249	6.614	7.379	8.603	4.572	6.208	7.096	4.944
1974	Forward	1.318	3.448	5.587	4.933	6.093	3.342	4.835	6.409	4.416
1975	Forward	1.886	3.733	3.321	4.068	3.552	5.219	3.452	2.943	1.637
1976	Forward	2.198	5.643	3.323	2.277	2.223	6.719	3.331	1.928	2.321
1977	Forward	1.628	3.652	3.577	2.400	3.128	3.533	2.803	6.060	4.369
1978	Forward	2.203	5.819	2.600	5.110	2.410	2.753	2.497	3.468	5.969
1967–1978	Forward	1.163	3.046	2.668	2.894	3.006	2.637	2.527	2.881	3.130

Table 7a

Regression Statistics for Equation (1), $S_{t+n} = a + b\,F_{t,n} + u_t$

Country	Constant (a)	Slope (b)	R^2	F	s.e.	D.W.	NOBS
Canada	-0.025	1.025	.93	402.0	.009	1.47*	31
	(.051)	(.051)					
United Kingdom	0.017	0.980	.81	87.6	.019	1.51	23
	(.103)	(.105)					
Belgium	0.001	0.993	.87	121.9	.001	2.40	20
	(.002)	(.090)					
France	0.004	0.864	.59	25.5	.002	1.79	20
	(.004)	(.171)					
Germany	0.001	0.997	.99	20,469	.002	1.40*	20
	(.001)	(.009)					
Italy	0.003	0.992	.92	213.9	.004	1.97	20
	(.014)	(.068)					
The Netherlands	0.051	0.771	.58	24.7	.008	1.33*	20
	(.033)	(.155)					
Switzerland	0.068	0.709	.66	35.4	.012	0.57**	20
	(.027)	(.119)					
Japan	-0.009	1.029	.99	2,568	.007	1.84	20
	(.007)	(.020)					

This statistic is useful as a standard of comparison because it represents the maximum average per period return if one had correctly made the decision to be long or short (W = +1 or W = −1).[16]

Table 6 suggests a similar story as Table 1. Potential profits in forward speculation are significantly higher under the floating rate system. Forecasting errors, and therefore potential profits, are near the historical high levels for several countries — the United Kingdom, France, Switzerland and Japan. The results for the entire 1967-78 period suggest that the potential rate of return from currency speculation is roughly the same across currencies, except for the Canadian dollar.

Finally, Table 7 presents ordinary least squares regression estimates of equations (1) and (2). As in our test of serial correlation of forecast errors, we estimate equations (1) and (2) on independent sample observations.[17] The results for equation (1) indicate that the constant (1) and slope coefficient (b) are generally close to 0 and 1 and the estimated equations have high R^2 values. In no case (even for Switzerland), can we reject the joint hypothesis that a = 0 and b = 1. The low Durbin-Watson statistic for Switzerland indicates positive first order correlation of residuals, consistent with what we showed earlier in

[16]One application is to test the speculative profits based on a currency advisory forecast relative to the profits by this standard. See Levich (1978b).

[17]We should note again, as in footnote 13, that the results in Table 7 are for one independent sample of observations. Using our weekly data base, we could have selected 12 other series of independent observations. Our results assume that our sample is representative.

Table 7b

Regression Statistics for Equation (2), $\frac{S_{t+n}}{S_t} = a + b\frac{F_{t,n}}{S_t} + e_t$

Country	Constant (a)	Slope (b)	R^2	F	s.e.	D.W.	NOBS
Canada	0.196 (0.992)	0.804 (0.992)	.02	0.6	.009	1.41*	31
United Kingdom	0.418 (0.858)	0.578 (0.860)	.02	0.4	.019	1.53	23
Belgium	1.906 (1.330)	-0.903 (1.333)	.02	0.5	.024	2.50	20
France	2.507 (1.110)	-1.507 (1.116)	.09	1.8	.051	2.15	20
Germany	1.795 (1.091)	-0.784 (1.100)	.03	0.5	.068	1.71	20
Italy	3.515 (1.118)	-2.522 (1.122)	.22	5.1	.014	1.39*	20
The Netherlands	2.047 (0.959)	-1.054 (0.969)	.06	1.2	.034	1.74	20
Switzerland	2.310 (0.797)	-1.325 (0.809)	.13	2.7	.052	0.68**	20
Japan	1.484 (2.148)	-0.477 (2.144)	.01	0.1	.018	1.74	20

Notes: Standard errors are in parentheses below each coefficient.
s.e. is the standard error of the equation.
*implies D.W. statistic is in uncertainty interval at 5% significance level
**implies D.W. statistic is significant at 5% level.
Sample is Floating Rate Period, March 20, 1973 — Date, for all countries except Canada and the United Kingdom.

Table 4. Equation (1) was reestimated for Canada, Germany, the Netherlands and Switzerland using the Cochrane-Orcutt procedure which corrects for serially correlated residuals. Using the Cochrane-Orcutt procedure did bring the Durbin-Watson statistic to within the acceptable range without significantly changing the parameter estimates or reducing the standard error of the equation.[18]

The results for equation (2) are reported in the second panel of Table 7. The results illustrate that the parameters a and b can take on a wide range of values. In several cases, individual parameters differ from their expected values under the null hypothesis. However, in no case does the constrained model (with $a = 0$ *and* $b = 1$) result in a significantly higher standard error (s.e.) than those reported in Table 7. In other words, we cannot reject the version of equation (2), with $a = 0$ and $b = 1$, which states that the forward premium is an

[18]In general, the significant D.W. statistic suggests that equation (1) is misspecified. The problem could result from omitting a variable (a risk premium term or government intervention term), selecting a nonstationary period for analysis or an errors-in-variables problem to name only a few.

unbiased forecast of the future exchange rate change. It is equally true, however, that the predictive power of this relationship, as measured by R^2, is very low and not significant.[19]

IV. Summary and Conclusions

We now approach the difficult job of finding some regularities in the many studies and statistics which we have reviewed. With respect to theories of exchange rate determination, we now have a range of models which can accommodate large and abrupt changes in the exchange rate. My personal bias favors a rational explanation of the exchange rate and my casual reflection suggests that there is a great diversity of opinion about future economic events, that public and private institutions often act so as to increase this diversity of opinion, and that realized economic events can be very far from their expected values. Given these reflections and the models in section II, the current behavior of floating rates becomes rather credible.

With respect to the empirical results, two preliminary remarks are important. First, the current experience with floating rates contains only 20 independent quarterly observations. While several authors (Bilson and Levich 1977, Brillembourg 1978, Stockman 1978) have developed methods that attempt to get around this constraint, the experience with floating may be too young for testing important hypotheses. Second, we have observed that exchange rates sometimes trade within a 1 or 2 percent daily range; recently for the Swiss franc and Japanese yen, the range has approached 4–5 percent.[20] This observation raises the question, what is a reasonable standard for forecasting accuracy? For example, on January 1 at 9:00 A.M., the three-month forward rate may be $2.00. On April 1 at 9:00 A.M. the spot rate may be $2.00 and then proceed to close at $2.06. Is this a 3 percent forecast error even if the trader could have sold his position during the day at a favorable rate?

The empirical results surveyed in this paper and the new statistics which we present do provide evidence that the market is volatile and that large profit opportunities are possible. However, they do not provide convincing evidence that the market is inefficient. In part, this may reflect a problem in statistical methodology. The statistical tests may not be powerful enough to reject market efficiency, even if they should. This may be because it has been difficult to specify precisely the alternative hypothesis. Alternatively, it may be, as Figlewski (1978a) suggests, that we have been preoccupied with market efficiency as a hypothesis rather than a process. In the short run, we know that the

[19]The estimates of equation (2) with significant D.W. statistics were reestimated using the Cochrane-Orcutt procedure. In all cases this revised procedure eliminated the residual serial correlation. For Switzerland, the R^2 of the revised model ($S_{t+n}/S_t = 1.98 - 1.01\, F_t/S_t + e_t - 0.64\, e_{t-1}$) is 50 percent.

While this in-sample measure of R^2 is significant, we cannot conclude that this revised model will outperform the naive forward premium forecast in post-sample predictions. See Bilson and Levich (1977) for a further discussion of this issue.

[20]We could add to this that at any moment of time, foreign exchange rates vary across the world's many trading rooms.

foreign exchange market does not fully reflect *all* information. Traders invest in information, take positions, time passes, wealth shifts and the exchange market generally moves closer to a full reflection of all information. The test which checks to see if this process is evolving rationally has yet to be devised.

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Discussion

Rimmer de Vries*

Rather than attempting to comment in some detail about the findings reviewed in this research paper, I thought it useful to briefly discuss the foreign exchange-market performance in the period of managed float as seen from the commercial banking side. Specifically, I would like to touch on four sets of issues:

a) Have the foreign exchange markets displayed reasonably good judgment in setting exchange rates in recent months and years, or have exchange rates on balance been unrealistic?

b) How are judgments about foreign exchange-rate movements arrived at by market participants?

c) What factors have contributed to the seemingly large exchange-rate volatility in recent months and should we be overly concerned about it?

d) What is the best course of action to take to restore stability in the foreign exchange market?

As regards the first issue, I believe that, on the whole, the foreign exchange markets have exercised rather good judgments about exchange rates. Countries with very large current-account surpluses, low rates of inflation, and virtually no adjustment policies have seen their exchange rates appreciate substantially; countries with large deficits, relatively high rates of inflation and weak anti-inflationary policies have seen their currencies depreciate, and countries which have a middle position have experienced relative exchange rate stability. Reflecting these factors, the Swiss franc has moved up more than 50 percent against the dollar over the past year, the yen by more than 40 percent, and the mark by more than 20 percent, and most other European currencies by lesser amounts.

However, it is now well recognized that in a system of floating exchange rates whereby many important currencies undergo substantial changes it is far better to measure the changes on a trade-weighted or effective basis. On this basis the yen has appreciated about 35 percent over the past year, the Swiss franc about 30 percent, and the mark about 5 percent. Sterling, the French franc, and the Benelux currencies remained about unchanged on an effective basis over the past year. Even better than discussing exchange-rate changes in effective terms is to discuss them in *real* effective terms whereby the trade-weighted exchange-rate changes are adjusted for past inflation differentials. In real terms, the Swiss franc has moved up 26 percent and the yen 23 percent.

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On the same basis, the German mark has remained just about unchanged over the past year, and so have the Dutch guilder and the Belgian franc, while sterling and the French franc moved up about 2 percent.

I believe that these movements by and large reflect the reality of these countries' balance of payments and domestic economic situations. The major exception is probably that of the German mark, which has lagged behind despite Germany's continued strong current-account performance and very low rate of inflation. However, it looks as if the market is beginning to recognize the apparent undervaluation of the mark and is in the process of correcting it. A sizable appreciation of the mark would tend to reduce somewhat the real appreciation of the Swiss franc and also correct the small real upvaluations of such fragile currencies as sterling and the French franc.

I further believe the market judgment has at times been better than that of monetary authorities. As a result, a large part of past exchange-market intervention ostensibly undertaken to counter temporary disorderly markets in retrospect has proved to have suppressed inevitable exchange-rate changes. Outstanding examples are the extremely heavy intervention during 1976 by the Swiss authorities, which exceeded $10 billion and occurred in the face of the emergence of a very large current-account surplus. The policy of suppressing the appreciation of the Swiss franc during that year has obviously made the adjustment problems for the Swiss economy now much worse. Another example was the extremely heavy intervention by the British authorities in the summer of 1977 when they took in some $10 billion to prevent the rate from going above 174. Japanese officials engaged in heavy intervention in the summer of 1976 to hold the yen to the 290-300 rate range. They insisted at that time that the market was misreading the country's payments performance and argued that export growth would lose momentum and import growth would pick up later in the year, leading to a narrowing of Japan's then modest current-account surplus. In the fall of 1977 the Japanese authorities again intervened heavily in unsuccessful attempts to hold the yen at the 250-260 level. They were projecting a narrowing of the current account surplus and were fearful of the impact of yen appreciation on the viability of their industry. In March of this year they again engaged in heavy intervention which they now have acknowledged was counterproductive in that it induced more yen purchases by market participants. It should be stressed that all this intervention prior to March 1978 occurred when the real effective exchange rate of the yen was below the March 1973 level, entirely inconsistent with economic reality.

This is certainly not to say that the market has always had the correct view regarding exchange rates. An outstanding example of the market's misjudgment was its perception of the effect that the quadrupling of oil prices would have on the dollar. It will be recalled that several market participants incurred huge exchange losses during 1974 mainly as a result of bad judgment about the dollar. However, during the past few years the private sector has devoted sizable resources to improve its information and forecasting capabilities in order to get a better judgment about exchange rates.

Secondly, a few comments about the market's method of making exchange-rate judgments. Most market participants use a judgmental approach rather than any specific theory of exchange-rate determination. Helpful has been the measurement of real effective exchange-rate changes which give a good perspective about exchange-rate movements over the past few weeks, months, a year, and longer periods, using several bases including a long-term base such as 1973-77. It should be stressed that they provide a broad *perspective* of relative movements of exchange rates but are not used in a *normative* sense. Thus, if the real effective exchange rate of the dollar stands at 94, using March 1973 as a base, there is no a priori reason to believe that it should move back to 100 over a particular period of time. Such a mistake was recently made by *Business Week* which indicated that with the real dollar rate at 94, a major upward surge was about due.

It is also useful to look at inflation differentials projected for the next year or so. In a world of widely varying rates of inflation, inflation differentials can be quite sizable. For example at the moment Japan, Germany, and Switzerland all will benefit from a favorable inflation differential of at least 5 percent over the next 12 months, while the United States will suffer an adverse inflation differential of 2 percent or more over the next year. In other words effective exchange rates should also be adjusted for the inflation differential projected for the next year or so.

Other important factors taken into consideration are actual and prospective current-account performance and the economic-policy framework in countries. Many factors influence current accounts but the market probably pays more attention to relative inflation rates and relative growth rates than to other factors. In all this, market psychology, confidence, and expectations are very important. Thus, when private and official sources are currently projecting a substantial narrowing of the U.S. current-account deficit for next year, the market has virtually ignored this information at the moment because the market still has little confidence that policies will bring about a better payment structure that will last. The unfavorable inflation gap will continue into 1979, how much and how soon the growth gap will narrow is still highly unclear, and sizable current-account imbalances will remain.

Thirdly, I have difficulty appreciating the common observation that exchange rates have been excessively volatile during the past year or so. As already indicated, when exchange rates are expressed in real terms, the changes become quite modest and probably still too small in some cases, such as the mark. Secondly, changes should be expected to be swift and sizable in a world where trade and current-account balances, inflation differentials and growth gaps change rapidly and substantially. In the past few years the United States has been affected adversely by one major structural factor after another. First, it was hit seriously by sharply rising oil imports. Then it was hurt by an unusually large adverse growth gap, which was succeeded by a sizable adverse inflation differential. On top of all this there has been the dramatic push of exports and rising market shares by the LDCs. When underlying fundamentals change so rapidly and trade and current-account imbalances move from a record deficit to a record surplus in a short time, we should not be surprised that exchange rates respond equally as fast.

comprehensive, they would completely disrupt the ability of merchants to hedge against exchange risk by forward covering. Indeed, the free and uncontrolled Eurocurrency market is, fortunately, now the principal vehicle or "loophole" by which commercial banks cover forward foreign-exchange obligations to their nonbank customers. More general exchange controls that curbed Eurocurrency transacting would greatly increase the riskiness of foreign trade as seen by merchants and manufacturers — and take away the weakly stabilizing impact of the forward market as it now exists.

More positively, governments should seek an explanation for the wild variations in the relative valuations of national monies at their source: differences in the goals and modes of implementation of national monetary policies. A central bank's basic mandate is to stabilize the purchasing power of the national currency through its unique ability to control the supply of money. Hence private speculators must continually gauge what the central bank is going to do, and much of the instability we observe reflects the difficulties of making this assessment subjectively.

How then can central banks improve the information flow "objectively" available to private traders? I see two principal avenues.

First, for the long run central banks should adhere better to their own announced rates of growth in monetary aggregates. This has the important effect of at least bounding exchange-rate expectations: fears of a really big price inflation in any one country would be allayed.

Secondly, in the short run direct official interventions in the foreign exchanges should be successful and unambiguous in intent. For example, if the Federal Reserve Bank of New York (or its agent the Bank of Japan) intervenes to defend the dollar by selling yen and buying dollars, both central banks should take great care to ensure that the intervention does not fail — that the decline of the dollar is actually halted within the relevant short-run time frame. And, of course, a "successful" intervention is virtually guaranteed as long as central banks adjust their domestic monetary bases to support it.

Since free floating began in 1973, central banks have been in the foreign-exchange market continually but with no clear signal to private traders that the official intervention would be successfully sustained: the supporting domestic monetary adjustments were uncertain. Nothing is more demoralizing for the private market than a failed official intervention that amounts to an unclear signal of official intentions. Far better for a government to intervene many fewer times, and only in those extreme cases where the real purchasing power of the national money is significantly disaligned from those of major trading partners. But then the monetary authorities should use their considerable powers to force the correct realignment. And keying on the currencies of stable trading partners — by putting a floor under — or ceiling over — the rate of exchange with the national currency — may well be a preferred technique of short-run monetary control. For example, there is great uncertainty about how to conduct a stable short-run monetary policy in the United States at the present time. The use of the Federal funds rate of interest as an instrumental variable has fallen into disrepute.[3] Hence, a case can be made for the Federal Reserve to adjust the value of the dollar to the more stable yen or deutsche mark in ways that private traders could easily understand.

[3]In *ibid.*, I argue that the traditional technique of implementing short-run monetary policy — by using short-run money-market rates of interest as indicators of whether money is tight or easy — is no longer valid. Keying on short-term interest rates may lead to a serious loss of monetary control in an open economy where exchange-rage expectations are volatile. In particular, a case is made that the sharp fall in the international value of the dollar in the 1977-78 period was, in part, due to the Federal Reserve Bank keying on the Federal funds interest rate — instead of taking more direct exchange-market measures to prevent the dollar's decline against the yen and some European currencies.