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Flexible Exchange Rates, Prices, and the Role of "News": Lessons from the 1970s

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This paper analyzes the key issues and lessons from the experience with flexible exchange rates during the 1970s. It analyzes the efficiency of the foreign-exchange market and the volatility of exchange rates, as well as the relationships between exchange rates and interest rates. A key distinction is made between anticipated and unanticipated events, and it is shown that the key factor affecting exchange rates has been "news." The analysis then proceeds to analyze the relationship between exchange rates and prices. The deviations from purchasing power parities are being interpreted in terms of the modern asset-market approach to the exchange rate.

I. Introduction

Recent experience with flexible exchange-rate systems has led to renewed interest in the operation of foreign-exchange markets as

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reflected in many recent studies of the principal determinants of exchange rates. The 1970s witnessed the dramatic alteration of the international monetary system from a regime of pegged exchange rates which prevailed for about a quarter of a century (since the Bretton Woods Conference) into a regime of flexible (though managed) rates. As a consequence of the emergence of the new legal and economic system, traders, national governments, and international organizations were confronted with new economic problems, choices, and instruments. During the 1970s exchange rates fluctuated widely and inflation rates accelerated. The international monetary system had to accommodate extraordinarily large oil-related shocks which affected trade flows in goods and assets. Huge oil payments had to be recycled. Uncertainties concerning future developments in international politics reached new heights, and the prospects for the world economy got gloomier. These developments placed unprecedented pressures on the markets for foreign exchange as well as on other asset markets. They were associated with a large slide in the value of the U.S. dollar and resulted in speeding up the creation of new institutions like the European Monetary System which provided the formal framework for the management of exchange rates among members. The increased interdependence among countries and the realization that exchange-rate policies by one national government exert influence on other economies have also induced legal responses from international organizations. For example, in late April 1977, the executive board of the International Monetary Fund approved the details of the second amendment to article IV of the amended Articles of Agreement dealing with the principles and procedures for surveillance of exchange-rate policies of member countries.

These developments provide the background for this paper which is intended to sum up the relevant evidence bearing on a set of related questions and to present a brief survey of key issues and lessons from the experience with floating rates during the 1970s. The main orientation of the paper is empirical and the analysis is based on the experience of three exchange rates involving the dollar/pound, the dollar/French franc and the dollar/deutsche mark (DM). Section II provides an analysis of the efficiency of foreign-exchange markets by examining the relationship between spot and forward exchange rates. The extent of exchange-rate volatility is also examined. This analysis of the foreign-exchange markets sheds light on several questions including (i) whether exchange rates fluctuate "excessively"; (ii) whether speculation in the foreign-exchange markets is destabilizing; (iii) whether there is "insufficient" speculation in the foreign-exchange markets; and (iv) whether there is evidence for market failure in the sense that there are unexploited profit opportunities.

These issues are significant in assessing the performance of floating rates as well as in evaluating the need for government intervention in the foreign-exchange markets. The analytical framework that is used for interpreting the volatility of exchange rates and the association between spot and forward rates is the modern theory of exchange-rate determination. Within this framework, exchange rates are viewed as the prices of assets that are traded in organized markets and, like the prices of other assets, are strongly influenced by expectations about future events.

The relationship between exchange rates and interest rates is analyzed in Section III. One of the key issues that is raised in this section is the distinction between anticipated and unanticipated changes in rates of interest. As an analytical matter this distinction is important, because the modern approach to exchange-rate determination implies that exchange rates are strongly influenced by "news," which by definition is unpredictable. Therefore, it is unanticipated rather than anticipated changes in interest rates that should be closely associated with changes in exchange rates. This prediction is tested empirically.

Section IV analyzes the relationship between exchange rates and prices by examining the patterns of deviations from purchasing power parities. The main point that is being emphasized is that there is an important intrinsic difference between exchange rates and national price levels. Exchange rates are more sensitive to expectations concerning future events than national price levels. As a result, in periods which are dominated by "news" which alters expectations, exchange rates are likely to be more volatile, and departures from purchasing power parities are likely to be the rule rather than the exception. The analysis of the relationship between exchange rates and prices is relevant for assessing whether the flexible exchange-rate system was successful in providing national economies with an added degree of insulation from foreign shocks and whether it provided policy makers with an added instrument for the conduct of macroeconomic policy. The evidence regarding deviations from purchasing power parities is also relevant for determining whether there is a case for managed float. Section V contains concluding remarks.

II. The Efficiency of the Foreign-Exchange Market and the Movement of Exchange Rates

In this section I analyze the principal characteristics of the relationship between spot and forward exchange rates which seem to emerge from the experience of the 1970s. Following an analysis of the efficiency of the foreign-exchange market, I discuss the more general issues underlying the relationships between spot and forward rates and their volatility.

The Efficiency of the Foreign-Exchange Market

One of the central insights of the monetary (or the asset-market) approach to the exchange rate is the notion that the exchange rate, being a relative price of two assets, is determined in a manner similar to the determination of other asset prices and that expectations concerning the future course of events play a central role in affecting current exchange rates.[1]

If the foreign-exchange market is efficient and if the exchange rate is determined in a fashion similar to the determination of other asset prices, we should expect current prices to reflect all currently available information. Expectations concerning future exchange rates should be incorporated and reflected in forward exchange rates. To examine the efficiency of the market, I first regress the logarithm of the current spot exchange rate, $\ln S_t$, on the logarithm of the 1-month forward exchange rate prevailing at the previous month, $\ln F_{t-1}$, as in equation (1):[2]

$$\ln S_t = a + b \ln F_{t-1} + u_t. \tag{1}$$

If the market for foreign exchange is efficient, so that prices reflect all relevant available information, then the residuals in equation (1), u_t, should contain no information and therefore should be serially uncorrelated. Further, if the forward exchange rate is an unbiased forecast of the future spot exchange rate (as should be the case under an assumption of risk neutrality), then the constant term in equation (1) should not differ significantly from zero,[3] and the slope coefficient should not differ significantly from unity. I examine three exchange rates: the dollar/pound, the dollar/franc, and the dollar/DM. Equa-

[1] For collections of articles summarizing this approach, see the *Scandinavian Journal of Economics*, no. 2 (1976) and Frenkel and Johnson (1978).

[2] For an application of the same methodology in analyzing the efficiency properties of the foreign-exchange market during the German hyperinflation of 1921–23 see Frenkel (1976, 1977, 1979). For an application to other exchange rates during the 1920s see Frenkel and Clements (1981); for an application to the 1920s and the 1970s see Krugman (1977); for an interesting analysis using time-series and cross-sectional data see Bilson (in press); for an analysis of market efficiency using novel econometric techniques see Hakkio (1979) and Hansen and Hodrick (1980), and for surveys see Levich (1978, 1979).

[3] More precisely, if (assuming risk neutrality) the forward rate measures the expected value of the future spot rate, then the constant term in the logarithmic equation (1) should be $-.5\sigma_u^2$; see Frenkel 1979. The statement that under risk neutrality the forward rate equals the expected future spot rate neglects the effects of the stochastic elements in prices. As an empirical matter this neglect does not seem to be consequential; see Frenkel and Razin 1980.

tion (1) was estimated using monthly data for the period June 1973–July 1979 (data sources are listed in the Appendix). The beginning of the period was set so as to concentrate on the experience of the current exchange-rate regime (following the initial post–Bretton Woods transition period). The resulting ordinary-least-squares (OLS) estimates are reported in table 1. Also reported in table 1 are additional regressions which will be analyzed shortly.

As may be seen for the dollar/DM exchange rate, the hypotheses that (at the 95 percent confidence level) the constant term does not differ significantly from zero and that the slope coefficient does not differ significantly from unity cannot be rejected. These hypotheses are rejected for the dollar/franc exchange rate and are rejected (marginally) for the dollar/pound exchange rate. The joint hypotheses, however, that the constant is zero and that the slope coefficient is unity cannot be rejected at the 95 percent level for the dollar/pound and the dollar/DM exchange rates and at the 99 percent level for the dollar/franc exchange rate. The test statistics for testing the joint hypotheses are reported in the column headed by F in table 1. These results are relevant for assessing whether the forward rate is an unbiased forecast of the future spot rate. We turn next to the question of efficiency.

It was argued above that in an efficient market, expectations concerning future exchange rates are reflected in forward rates and that spot exchange rates reflect all currently available information. If forward exchange rates prevailing at period $t - 1$ summarize all relevant information available at that period, they should also contain the information that is summarized in data corresponding to period $t - 2$. It thus follows that including additional lagged values of the forward rates in equation (1) should not greatly affect the coefficients of determination and should not yield coefficients that differ significantly from zero. The results reported in table 1 are consistent with this hypothesis; in all cases the coefficients of $\ln F_{t-2}$ do not differ significantly from zero, and the inclusion of the additional lagged variables does not improve the fit. Most important, in all cases the Durbin-Watson statistics are consistent with the hypothesis of the absence of first-order autocorrelated residuals, and an examination of higher-order correlations (up to 12 lags) shows that no correlation of any order is significant.[4]

To examine further the relationship between the various exchange rates, we note that one of the assumptions underlying equation (1)

[4] Since $\ln F_{t-1}$ is highly correlated with $\ln S_{t-1}$ the Durbin-Watson statistic may not be appropriate since equation (1) is very similar to a regression of $\ln S_t$ on its own lagged value. Durbin's h-statistic reveals, however, that the residuals are serially uncorrelated at conventional confidence levels.

TABLE 1

EFFICIENCY OF FOREIGN-EXCHANGE MARKETS
MONTHLY DATA: JUNE 1973–JULY 1979
(Standard Errors in Parentheses)

Dependent Variable $\ln S_t$ and Estimation Method	Constant	$\ln F_{t-1}$	$\ln F_{t-2}$	R^2	SE	D-W	F	m
Dollar/pound:								
OLS	.033	.956	. . .	.96	.027	1.72	1.86	. . .
	(.017)	(.024)						
OLS	.031	1.047	−.088	.96	.027	1.94	. . .	. . .
	(.018)	(.116)	(.113)					
IVAR	.030	.961	. . .	.95	.027	1.74	. . .	2.01
	(.018)	(.025)						
Dollar/franc:								
OLS	−.237	.843	. . .	.79	.029	2.23	4.83	. . .
	(.078)	(.051)						
OLS	−.225	.706	.146	.79	.029	1.90	. . .	. . .
	(.082)	(.117)	(.117)					
IVAR	−.236	.844	. . .	.78	.030	2.24	. . .	2.26
	(.080)	(.053)						
Dollar/DM:								
OLS	−.023	.971	. . .	.93	.032	2.12	.51	. . .
	(.027)	(.032)						
OLS	−.019	.913	.063	.93	.032	1.96	. . .	. . .
	(.028)	(.119)	(.122)					
IVAR	−.021	.973	. . .	.93	.032	2.10	. . .	.91
	(.027)	(.032)						

NOTE.—SE is the standard error of the equation and R^2 is the coefficient of determination; in the case of instrumental variables estimation, the R^2 was computed as $1 - \text{var}(\hat{u}_t)/\text{var}(\ln S_t)$. The F-statistic tests the joint restriction that the constant equals zero, and the slope equals unity. The test statistic is distributed as $F(2,71)$. Critical values for $F(2,71)$ are 3.13 (95%) and 4.92 (99%). The instrumental variable (IVAR) estimation method is used in order to allow for the possibility of errors in variables arising from using $\ln F_{t-1}$ as a proxy for the expected future spot rate; the instruments are a constant, time, time squared, and lagged values of the dependent and the independent variables. The m-statistic which tests for the absence of errors in variables is distributed χ^2 with 2 degrees of freedom. The critical value for $\chi^2(2)$ is 5.99 (95%).

was that the forward exchange rate measures the unobservable value of the expected future spot exchange rate. This assumption provided the justification for using equation (1) instead of the explicit specification of the rational expectations hypothesis that is embodied in equation (2):

$$\ln S_t = E_{t-1} \ln S_t + \epsilon_t, \tag{2}$$

where $E_{t-1} \ln S_t$ denotes the expected (logarithm of the) spot exchange rate for period t based on the information available at period $t - 1$. If, however, the forward exchange rate at $t - 1$ is a "noisy" proxy for the expected future value of the spot rate (i.e., it measures it with a random error), then we would obtain

$$a + b \ln F_{t-1} = E_{t-1} \ln S_t + v_{t-1}; E(v_t) = 0, \tag{3}$$

and substituting equation (3) into equation (2) yields:

$$\ln S_t = a + b \ln F_{t-1} + (\epsilon_t - v_{t-1}). \tag{4}$$

In this case the error term in equation (1) would be $u_t = \epsilon_t - v_{t-1}$; the assumption that the covariance between $\ln F_{t-1}$ and u_t is zero would entail a specification error, and the application of the OLS procedure would yield biased estimates due to the classical errors in variables bias.

In order to examine the possibility that the OLS estimates might be subject to the errors in variables bias, one needs to test the hypothesis that cov $(u_t, \ln F_{t-1}) = 0$. This test follows the specification test outlined by Hausman (1978).[5] To perform the test, equation (1) was estimated by applying the OLS procedure as well as by using an instrumental variables (IVAR) estimation method. Under the null hypothesis of no misspecification the OLS coefficients vector $\hat{b}_0$ is an efficient and unbiased estimate of the true coefficient vector. Under the alternative hypothesis of misspecification, the vector $\hat{b}_0$ is biased and an unbiased coefficient vector $\hat{b}_1$ can be obtained by applying an instrumental variables estimation procedure. The test statistic relevant for testing the null hypothesis can be written as

$$m = (\hat{b}_1 - \hat{b}_0)'(\text{var } \hat{b}_1 - \text{var } \hat{b}_0)^{-1}(\hat{b}_1 - \hat{b}_0), \tag{5}$$

where var $(\hat{b}_1)$ and var $(\hat{b}_0)$ denote the variance-covariance matrices of $\hat{b}_1$ and $\hat{b}_0$, respectively. Under the null hypothesis, m is distributed (in large samples) as χ^2 with 2 degrees of freedom. Table 1 reports the results of estimating equation (1) by applying the instrumental variables estimation method. As may be seen for all exchange rates the

[5] This test was recently applied by Obstfeld (1978) to the analysis of the foreign-exchange market during the 1970s and by Frenkel (1980*a*, 1980*b*) to the analysis of the foreign-exchange markets during the 1920s.

two vectors of coefficients $\hat{b}_1$ and $\hat{b}_0$ are very close to each other. For example, for the dollar/pound exchange rate, the constants are .033 and .030, and the slopes are .956 and .961—consequently, the resulting m-statistic is 2.01, which is well below 5.99—the critical value of $\chi^2(2)$ at the 95 percent confidence level. The m-statistics corresponding to the other exchange rates are also below this critical value. It is concluded, therefore, that the use of the forward exchange rate as a proxy for expectations does not introduce a significant errors in variables bias and, thus, the use of the OLS estimation procedure seems appropriate.[6]

The principal conclusion that may be drawn from the previous discussion is that the behavior of the foreign-exchange market during the 1970s has been broadly consistent with the general implications of the efficient market hypothesis.

Exchange-Rate Movement: Volatility and Predictability

In this section I analyze the volatility of exchange rates and the extent to which this volatility is predictable. As is well known, during the same period exchange rates have been very volatile. The standard errors of the monthly percentage changes of the three exchange rates have been about 3 percent per month. Further, the standard errors of the regressions in table 1 indicate that the forecasts of future spot exchange rates based on the forward rates are very imprecise: The standard errors of the equations are about 3 percent per month.

[6] The efficiency of the foreign-exchange market can also be analyzed from a different angle as in Frenkel (1980*b*). Consider the equation

$$x_t = \alpha_0 + \alpha_1 t + \sum_{i=1}^{n} \beta_i x_{t-i} + \gamma \pi_{t-1} + w_t,$$

where x_t denotes the percentage change of the spot exchange rate ($\ln S_t - \ln S_{t-1}$); π_{t-1} denotes the forward premium on foreign exchange ($\ln F_{t-1} - \ln S_{t-1}$); t denotes time; n denotes the number of lags; and w denotes an error term. If π_{t-1} summarizes all available information concerning the future evolution of the exchange rate, then given the value of the forward premium π_{t-1}, the past history of the percentage change of the exchange rate should not "help" the prediction (i.e., the past history should not be viewed as Granger-causing future changes), and the joint hypotheses that α_0, α_1, and β_i are zero and that γ is unity should not be rejected. The results of applying these tests to the three exchange rates for various numbers of lags as well as to the pooled data base of the three exchange rates show that the null hypothesis cannot be rejected at the 95 percent confidence level, since the values of the various F-statistics fall well below the corresponding critical values. It is noteworthy, however, that the power of this test is low and that the joint hypothesis that α_0, α_1, β_i, and γ are zero could also not be rejected. The difficulties in "explaining" the percentage change of the exchange rate in terms of past values of various variables reflect the fact that like the prices of other assets which are traded in organized markets, changes in exchange rates are dominated by "news" which by definition could not have been incorporated in past changes or in the lagged forward premium. For a further elaboration see the following section.

These characteristics of price changes (volatility and unpredictability) are typical of auction and of organized asset markets. In such markets current prices reflect expectations concerning the future course of events, and new information which induces changes in expectations is immediately reflected in corresponding changes in prices, thus precluding unexploited profit opportunities from arbitrage. The strong dependence of current prices on expectations about the future is unique to the determination of durable asset prices; it is not a characteristic of price determination of nondurable commodities. The strong dependence of asset prices on expectations also implies that periods which are dominated by uncertainties, new information, rumors, announcements, and "news," which induce frequent changes in expectations, are likely to be periods in which changes in expectations are the prime cause of fluctuations in asset prices. Further, since the information which alters expectations must be new, the resulting fluctuations in price cannot be predicted by lagged forward exchange rates which are based on past information.[7] Therefore, during such periods, one should expect exchange rates (and other asset prices) to exhibit large fluctuations. When the prime cause of fluctuations is new information, one may expect that lagged forward exchange rates (which are based on past information) are imprecise (even though possibly the best unbiased) forecasts of future spot rates.

To gain further insights into the implications of this perspective on the relationship between predicted and realized changes in exchange rates, figures 1–3 present plots of predicted and realized percentage changes in exchange rates for the three pairs of currencies where the predicted change is measured by the lagged forward premium. Also presented in these figures are the differentials in national inflation rates which are discussed in Section IV. The key fact which emerges from these figures is that predicted changes in exchange rates account for a very small fraction of actual changes.[8] This phenomenon is also reflected in the comparison between the variances of actual and predicted changes in exchange rates: In all cases the variances of monthly percentage changes in exchange rates exceed the variances of monthly forward premia by a factor that is larger than 20.[9] This fact suggests that the bulk of exchange-rate changes seem to be due to

[7] The analysis of the role of "news" in determining current exchange rates and in explaining forecast errors from the forward rate has been made forcefully by Mussa (1976*a*, 1976*b*, 1977, 1979*a*) and Dornbusch (1978). The large degree of volatility is also analyzed by McKinnon (1976), who attributes it to insufficient speculation.

[8] These and the following empirical regularities are analyzed in detail in Mussa (1979*a*). See also Frenkel and Mussa 1980.

[9] For an analysis of the relationship between the variances of series of predictions and series of realizations see Shiller (1979) and Singleton (1980).

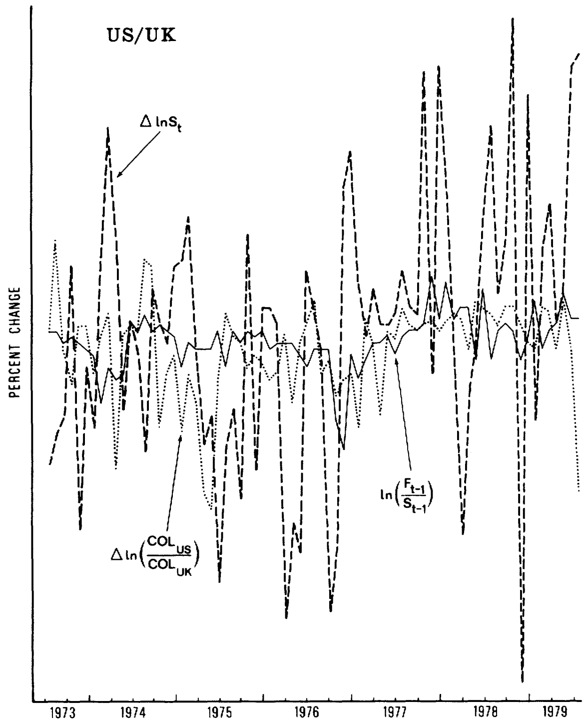

FIG. 1.—Monthly percentage changes of the U.S./U.K. consumer price indices [$\Delta(\ln COL_{US}/COL_{UK})$]; of the \$/£ exchange rate ($\Delta \ln S_t$); and the monthly forward premium [$\ln(F_{t-1}/S_{t-1})$], July 1973–July 1979.

"new information" which, by definition, could not have been anticipated and reflected in the forward premium or discount which prevailed in the previous period.

This view of the foreign-exchange market can be exposited in terms of the following simple model.[10] Let the logarithm of the spot exchange rate on day t be determined by

$$\ln S_t = z_t + bE_t(\ln S_{t+1} - \ln S_t), \tag{6}$$

where $E_t(\ln S_{t+1} - \ln S_t)$ denotes the expected percentage change in the exchange rate between t and $t + 1$, based on the information available at t, and where z_t represents the ordinary factors of supply and demand that affect the exchange rate on day t. These factors may include domestic and foreign money supplies, incomes, levels of output, etc. Equation (6) represents a sufficiently general relationship which may be viewed as a "reduced form" that can be derived from a variety of models of exchange-rate determination. These models may

[10] The following paragraph draws on Frenkel and Mussa (1980).

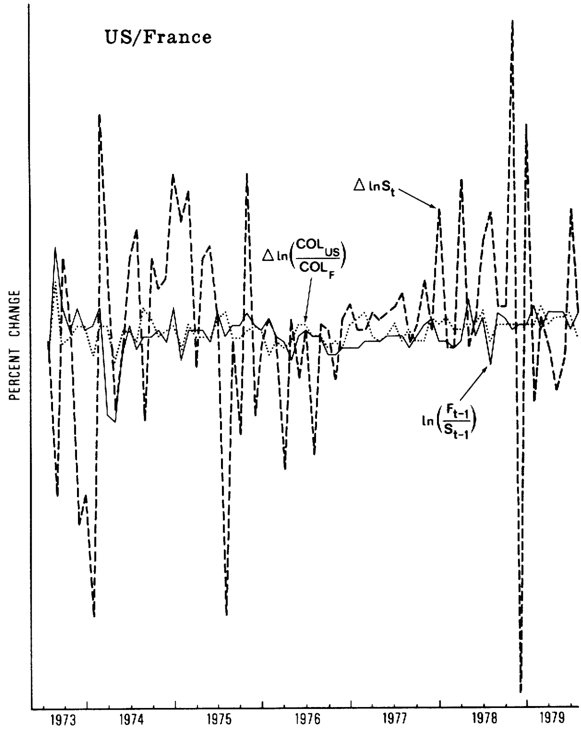

FIG. 2.—Monthly percentage changes of the U.S./French consumer price indices [$\Delta(\ln COL_{US}/COL_F)$]; of the \$/Fr exchange rate ($\Delta \ln S_t$); and the monthly forward premium [$\ln(F_{t-1}/S_{t-1})$], July 1973–July 1979.

differ in their emphasis of the determinants of $z(t)$, but they all are likely to share a similar reduced form.[11] Assuming that expectations are rational in that equation (6) applies to expectations of future exchange rates, it follows, by forward iteration, that

$$E_t \ln S_{t+j} = \frac{1}{1+b} \sum_{k=0}^{\infty} \left(\frac{b}{1+b}\right)^k E_t z_{t+j+k}. \tag{7}$$

Thus, the current exchange rate ($j = 0$) and current expectations of future exchange rates ($j > 0$) are linked, because both depend on expectations concerning the future z's. The strength of the link depends on the magnitude of b which characterizes the dependence of the current exchange rate on the expected percentage change thereof.[12] The presumption is that, due to profit opportunities from

[11] See, e.g., the comprehensive econometric model of Fair (1979).

[12] A result of this general form is derived in Mussa (1976*a*). The unique role of expectations is also emphasized by Black (1973), Dornbusch (1976*c*, 1978), Kouri (1976), and Bilson (1978). In general, the value of b may be viewed as the relevant

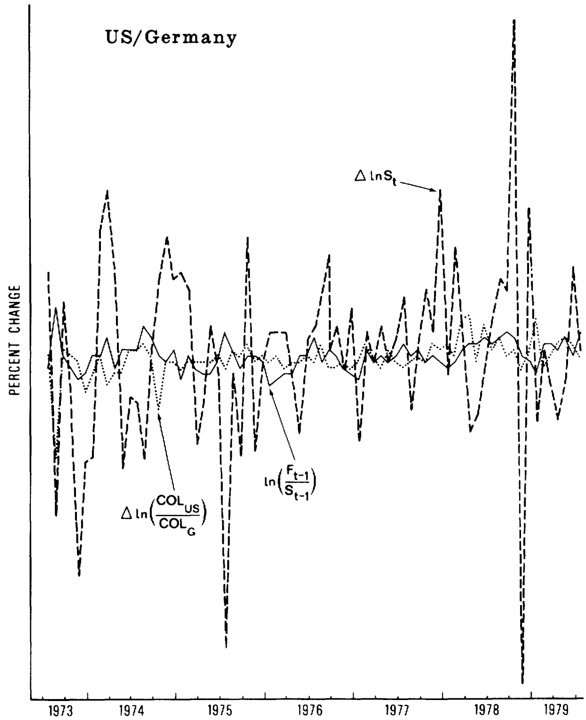

FIG. 3.—Monthly percentage changes of the U.S./German consumer price indices [$\Delta(\ln COL_{US}/COL_G)$]; of the \$/DM exchange rate ($\Delta \ln S_t$); and the monthly forward premium [$\ln(F_{t-1}/S_{t-1})$], July 1973–July 1979.

arbitrage, this link is strong at least for the exchange rates expected in the near future. Hence, the current exchange rate, $\ln S_t = E_t \ln S_t$, should be closely linked to the current expectation of the next period's exchange rate, $E_t \ln S_{t+1}$, which in turn should be closely linked to the exchange rate expected for the following period, $E_t \ln S_{t+2}$, and so on.

In order to examine this hypothesis I present in figures 4–6 plots of the spot and the contemporaneous forward exchange rates for the three pairs of currencies. Also presented are the ratios of national price levels which are discussed in Section IV. If the dominant factor underlying changes in rates is new information which alters views about current and expected future exchange rates by approximately the same amount, then one should expect a high correlation between movements of spot and forward rates. This fact is clearly demon-

parameter for determining whether a specific commodity (whose pricing rule is described in terms of eqq. like [6]–[7]) may be viewed as an asset. The higher the value of b is for a given commodity, the larger is its asset attribute.

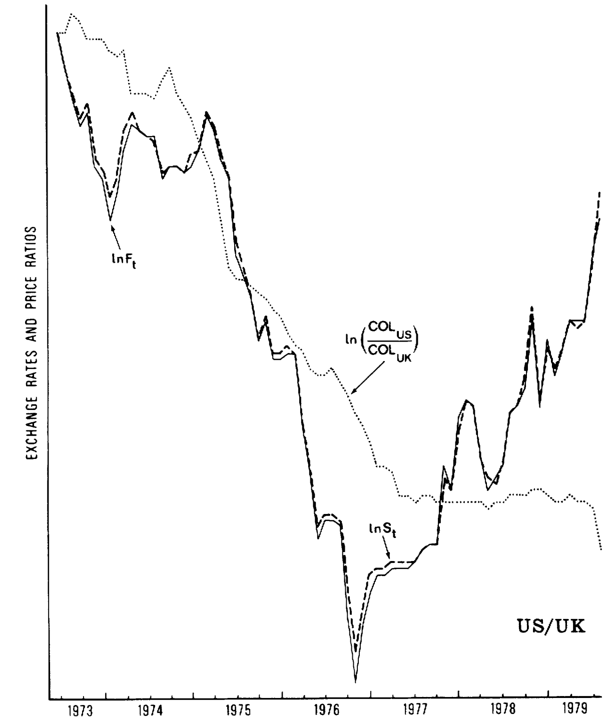

FIG. 4.—Monthly observations of the $/£ spot (ln S_t) and forward (ln F_t) exchange rates and the ratio of the U.S./U.K. cost of living indices [ln(COL_{US}/COL_{UK})] (scaled to equal the spot exchange rate at the initial month): June 1973–July 1979.

strated by figures 4–6 where it is seen that spot and forward exchange rates tend to move together and by approximately the same amount (the vertical difference between the two rates corresponds to the percentage forward premium or discount on foreign exchange). The correlations between the spot and the forward exchange rates for the three pairs of currencies exceed .99, and the correlations between the corresponding percentage changes of the spot and forward rates exceed .96. The high correlation between movements in spot and forward rates is expected, since the two rates respond at the same time to the same flow of new information (which is presumed to affect the rate for more than one period). In general, the details of the relationship between spot and forward exchange rates depend on the time-series properties of the z's in equation (7) and in particular on whether the new information is viewed as permanent or transitory.[13]

[13] New information might be "permanent" when the relevant horizon is 1 month, while it might be transitory when the relevant horizon is a year. In that case, the correlation between the spot exchange rate and the contemporaneous 1-month for-

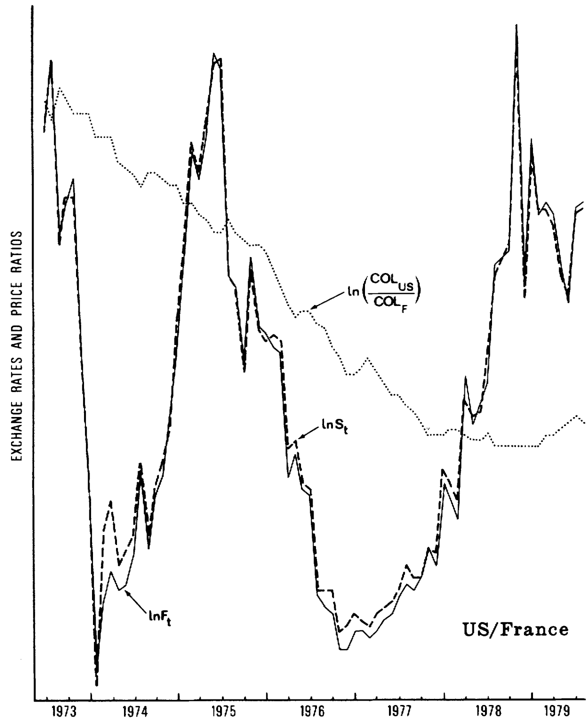

FIG. 5.—Monthly observations of the \$/Fr spot ($\ln S_t$) and forward ($\ln F_t$) exchange rates and the ratio of the U.S./French cost-of-living indices [$\ln(COL_{US}/COL_F)$] (scaled to equal the spot exchange rate at the initial month): June 1973–July 1979.

The comovement of spot and forward rates is evidence of the close link between current and expected future exchange rates which is illustrated by equation (7). This characteristic is typical of the foreign-exchange market and is also shared by prices of many assets and commodities traded in organized markets. The recent pattern of gold prices provides a useful example of this general principle. Table 2 reports the spot and the futures prices of gold as recorded recently in the International Money Market (IMM) at the Chicago Mercantile Exchange on 5 consecutive days. The two key facts which are illustrated by this table are (i) the extent of day-to-day volatility in gold prices and (ii) the general uniformity by which these changes are reflected in the price of gold for immediate delivery as well as in the prices for the eight future delivery dates.

ward rate is likely to be high, while the correlation between the spot rate and the 12-month forward rate is likely to be low. The perceived permanence of the new information can be inferred from the correlation between the spot and the various maturities of the forward rate. As expected, it is generally found that this correlation diminishes with the maturity of the forward contract.

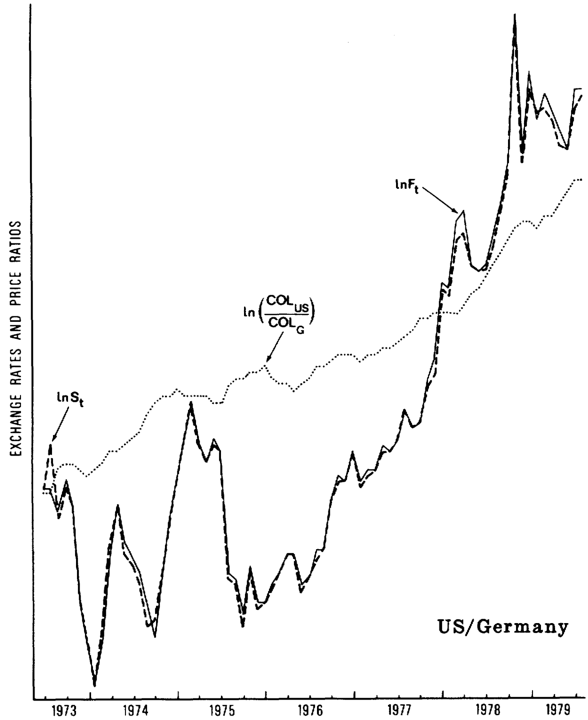

FIG. 6.—Monthly observations of the \$/DM spot (ln S_t) and forward (ln F_t) exchange rates and the ratio of the U.S./German cost-of-living indices [ln(COL_{US}/COL_G)] (scaled to equal the spot exchange rate at the initial month): June 1973–July 1979.

Another feature which is revealed by figures 4–6 is that the contemporaneous spot and forward exchange rates are approximately equal, thus indicating that the market's best forecast of the future spot rate is (approximately) the current spot rate. This phenomenon reflects the fact that, as an empirical matter, exchange rates have followed (approximately) a random-walk process. For such a process, current prices are, indeed, the best forecasts of future prices (and to the extent that the exchange rate had some drift, the statement above should be interpreted in reference to that drift). It is relevant to note, however, that while the random-walk phenomenon seems to correspond to the actual paths of exchange rates, it does not reflect a theoretical necessity.

The final characteristic of the foreign-exchange market is described by figures 7–9, which plot for the three pairs of currencies the spot exchange rate and the forward premium on forward exchange. Since the spot rate and the forward premium are expressed in terms of different units (where the latter is expressed as percentages per

TABLE 2

FUTURES PRICE OF GOLD ON CONSECUTIVE DAYS
DAILY DATA: MAY 1, 1980–MAY 7, 1980

	Price per Ounce and Change from Previous Day									
Delivery Date	May 1	Change	May 2	Change	May 5	Change	May 6	Change	May 7	Change
1980:										
May	516.0	14.4	511.0	−5.0	519.0	8.0	506.5	−12.5	512.0	5.5
June	517.0	10.5	575.5	−1.5	523.7	8.2	510.3	−13.4	516.0	5.7
September	536.0	10.5	533.5	−2.5	540.7	7.2	527.0	−13.7	531.5	4.5
December	554.0	9.5	551.0	−3.0	558.0	7.0	541.5	−16.5	547.0	5.5
1981:										
March	571.5	9.5	568.0	−3.5	574.7	6.7	557.0	−17.7	561.5	4.5
June	588.5	10.5	585.0	−3.5	591.0	6.0	571.5	−19.5	576.0	4.5
September	605.3	10.3	602.0	−3.3	607.0	5.0	585.5	−21.5	590.0	4.5
December	622.0	11.0	619.0	−3.0	623.0	4.0	599.5	−23.5	604.0	4.5
1982:										
March	638.5	11.5	636.0	−2.5	693.0	3.0	613.5	−25.5	618.0	4.5

NOTE.—These prices are settlement prices at the International Money Market (IMM) at the Chicago Mercantile Exchange as reported in the *Wall Street Journal* (May 2–May 8, 1980).

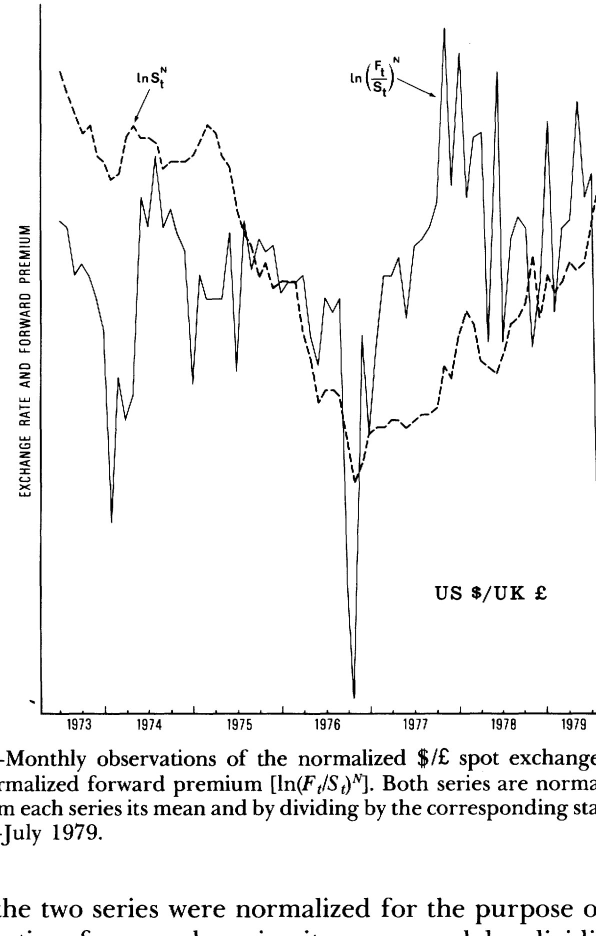

FIG. 7.—Monthly observations of the normalized $/£ spot exchange rate ($\ln S_t^N$) and the normalized forward premium [$\ln(F_t/S_t)^N$]. Both series are normalized by subtracting from each series its mean and by dividing by the corresponding standard error: June 1973–July 1979.

month), the two series were normalized for the purpose of the plots by subtracting from each series its mean and by dividing by the corresponding standard error.[14] The fact which emerges from these figures is that generally (though not always) there is a positive correlation between the expected depreciation of the currency (as measured by the forward premium on foreign exchange) and the spot exchange rate. This positive correlation may be rationalized by noting that currencies which are expected to depreciate are traded at a discount in the forward market and, on average, these currencies also command a lower foreign-exchange value in the spot market.[15] This

[14] The normalized values of the spot rate, $\ln S_t^N$, and of the forward premium, $\ln(F_t/S_t)^N$, which are plotted in figs. 7–9, are defined as $\ln S_t^N \equiv (\ln S_t - \overline{\ln S})/\sigma_{\ln S}$, and $\ln(F_t/S_t)^N \equiv [\ln(F_t/S_t) - \overline{\ln(F/S)}]/\sigma_{\ln(F/S)}$, where a bar over a variable indicates its sample mean, and where σ denotes the sample standard deviation of the subscripted variable.

[15] It is noteworthy that since the forward premium (like the rate of interest) and the exchange rate are dimensionally incommensurate, their association raises questions

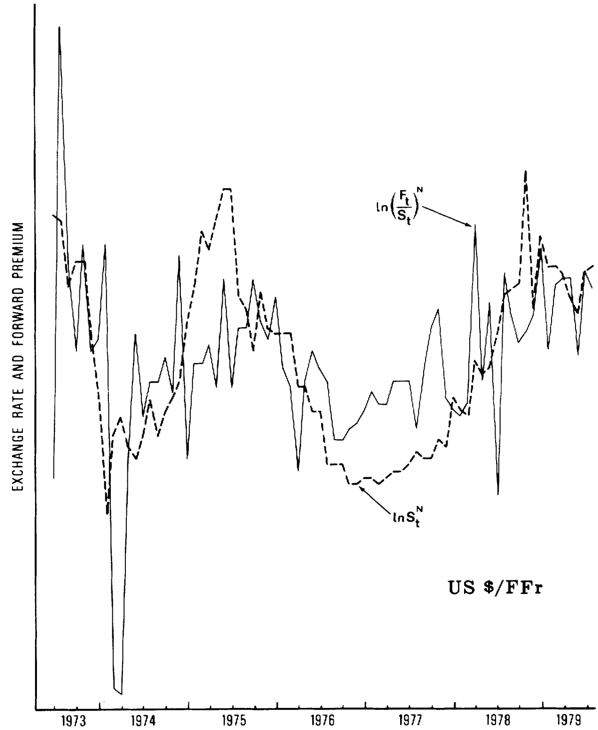

FIG. 8.—Monthly observations of the normalized \$/Fr spot exchange rate (ln S_t^N) and the normalized forward premium [$\ln(F_t/S_t)^N$]. Both series are normalized by subtracting from each series its mean and by dividing by the corresponding standard error: June 1973–July 1979.

relationship is embodied in the specification of equation (6) and is interpreted further in the next section.

III. Exchange Rates, Interest Rates, and Innovations

This section contains an analysis of the relationship between exchange rates and interest rates from the perspective of the monetary (or the asset-market) approach to the exchange rate. Following a discussion of the broad facts, the analysis proceeds with an empirical examination of the role of "news."

Exchange Rates and Interest Rates: The Broad Facts

To set the stage for this section, it is useful to recall the analysis which predicts a negative association between the rate of interest and the

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that are familiar from the discussions of the Gibson paradox. In a separate paper I intend to examine the relationship between exchange rates and the forward premium (or the interest differential) in light of the various explanations of the Gibson paradox.

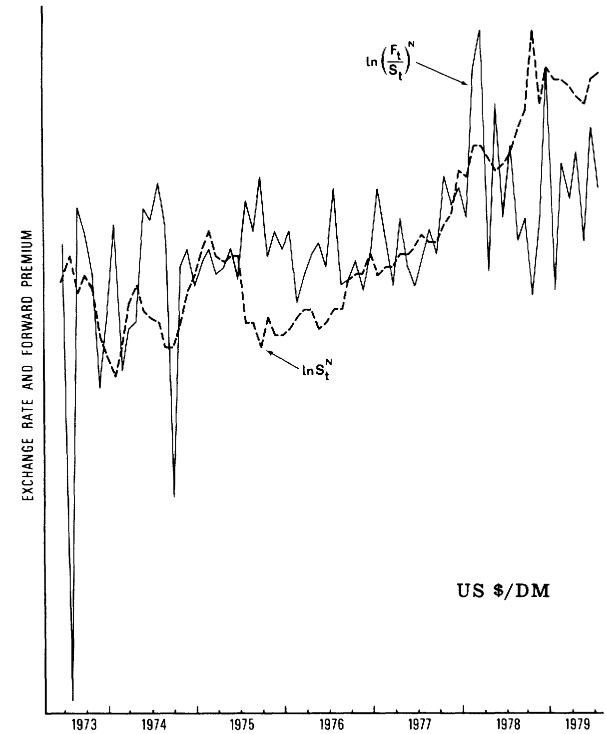

FIG. 9.—Monthly observations of the normalized $/DM spot ($\ln S_t^N$) and the normalized forward premium [$\ln(F_t/S_t)^N$]. Both series are normalized by subtracting from each series its mean and by dividing by the corresponding standard error: June 1973–July 1979.

exchange rate. According to that analysis, a higher rate of interest attracts foreign capital which induces a surplus in the capital account of the balance of payments and thereby induces an appreciation of the domestic currency (i.e., a lower spot exchange rate). Another variant of this approach states that the higher rate of interest lowers spending and thus induces a surplus in the current account of the balance of payments which results in a lower spot exchange rate. A third variant claims that the higher rate of interest implies (via the interest parity theory) a higher forward premium on foreign exchange; and to the extent that at a given point in time the forward exchange rate which represents the expected future spot rate is predetermined by past history—as would be the case under the adaptive expectations hypothesis (which is clearly rejected by the evidence on the comovements of spot and forward rates)—the required rise in the forward premium will be brought about by a lower spot rate (i.e., by an appreciation of the domestic currency). Whatever the route, by ignoring the distinction between nominal and real rates of interest, this approach predicts a *negative* relationship between the rate of interest and the spot exchange rate (or, alternatively, a positive relationship between the rate of interest and the foreign-exchange value of the domestic currency).

While such a prediction might be appropriate for noninflationary environments, it might be entirely inappropriate for inflationary environments (like the one prevailing in the United States in recent years). In such periods variations in rates of interest are most likely to be dominated by variations in inflationary expectations rather than by liquidity effects associated with changes in the ratio of money to bonds. In such an environment, the rate of interest is expected to be *positively* correlated with the exchange rate. The broad facts are consistent with this hypothesis. Over the recent period, the rise in the rate of interest in the United States (relative to the foreign rate of interest) has been associated with a rise in the spot exchange rate (i.e., with a depreciation of the dollar) rather than with a fall in the spot rate. Figure 10 illustrates the point by plotting the foreign-exchange value of the U.S. dollar against the interest rate differential. As is evident, the higher (relative) rate of interest in the United States has been associated with a higher exchange rate (i.e., with a lower foreign-exchange value of the dollar).

The positive association between the rate of interest and the exchange rate in the context of the U.S. dollar and the inflationary environment can be accounted for by the monetary (or the asset-market) approach to the exchange rate which puts a special emphasis on the influence of the expectations on the current values of exchange rates.[16] For example, according to the monetary approach, a rise in the domestic (relative) rate of interest which is primarily dominated by a rise in the expected (relative) rate of inflation induces a decline in the demand for real cash balances; for a given path of the nominal money supply, asset-market equilibrium requires a price level which is higher than the price which would have prevailed otherwise. When the domestic price level is linked to the foreign price through some form of purchasing power parity, and when the path of the foreign price is assumed to be given, the higher domestic price can only be achieved through a rise in the spot exchange rate (i.e., through a depreciation of the currency).[17]

[16] For theoretical developments and applications of the approach see, e.g., Dornbusch (1976*a*, 1976*b*), Frenkel (1976), Kouri (1976), Mussa (1976*a*), Bilson (1978), Frenkel and Johnson (1978), Hodrick (1978), Frankel (1979), Clements and Frenkel (1980), and Frenkel and Clements (1981).

[17] It should be emphasized that this explanation of the positive association between the rate of interest and the exchange rate does not rely on a rigid form of the purchasing power parity theory. It only requires that domestic and foreign price levels, when expressed in terms of the same currency, are positively correlated. The evidence from the 1970s is consistent with this requirement; see Frenkel 1981.

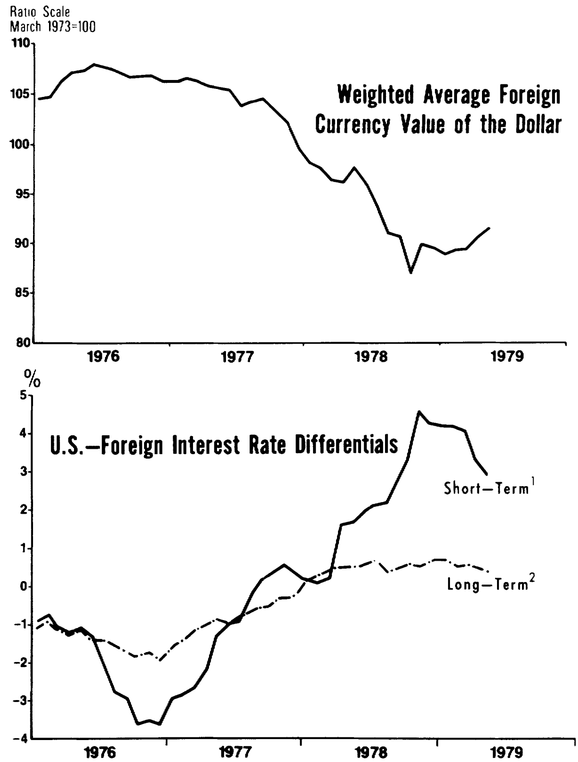

FIG. 10.—Foreign-exchange value of the U.S. dollar and interest rate differentials. Source: Mudd 1979.

This explanation of the positive association between interest rates and exchange rates has an intuitive appeal in that it implies that, in an inflationary environment, a relatively rapid rise in prices is associated with high *nominal* rates of interest as well as with a depreciation of the currency in terms of foreign exchange. This relationship is embodied in equation (6), which states that an expected depreciation of the currency (which in our case is associated with inflationary expectations and high nominal rates of interest) results in an immediate depreciation.[18]

The foregoing analysis also provides the explanation for the obser-

[18] The traditional prediction of a negative relationship between interest rates and the exchange rate could, in principle, be rationalized under the assumption that it concentrates on the short-run liquidity effects of monetary changes. It should be emphasized, however, that in an inflationary environment, like the one prevailing in the United States, the applicability of this rationalization is very limited. The short-run liquidity effect is emphasized in Dornbusch (1976*b*). The role of inflationary expectations in dominating exchange-rate developments is emphasized in Frenkel (1976). Edwards (1979) and Frankel (1979) attempt to integrate these two factors.

vation (which was noted in Sec. II) that, generally, there is a positive correlation between the forward premium on foreign exchange and the level of the spot rate. Since during inflationary periods the spot rate is expected to be positively correlated with the interest rate differential, and since according to the interest parity theory that differential must equal the forward premium on foreign exchange, it follows that the forward premium is also expected to be positively correlated with the level of the spot rate.[19]

Exchange Rates and "News"

One of the central implications of the rational expectations hypothesis is that unanticipated events, "news," play a predominant role in affecting real variables and asset yields. This implication is embodied in many expositions of modern macroeconomics, and its empirical content has been the subject of numerous recent studies.[20] In the context of exchange-rate determination the discussion in Section II and in particular the contributions by Mussa (1977, 1979*a*) and Dornbusch (1978) emphasized that the predominant cause of exchange-rate movements is "news" which could not have been anticipated.[21] Expressing the spot exchange rate at period t as the sum of factors which were anticipated from the past, as well as factors which represent "news," Dornbusch (1978) decomposes the effects of "news" into those which alter the expected future spot rate between the last period and the present and those which lead to a reassessment of the 1-period interest rate differential starting at the present, that is, "news" about the term structure. Both of these white-noise, serially uncorrelated components play a role in determining the spot exchange rate in Dornbusch's analysis.

The evidence presented in Section II suggests that the forward rate summarizes the information that is available to the market when the forward rate is being set, and in equation (3) it was assumed that the expected exchange rate can be written as $a + b \ln F_{t-1}$ plus a serially uncorrelated error. We may, therefore, express the spot rate at period t as a function of factors which have been known in advance and are summarized by the lagged forward rate, as well as a function of the "news":

$$\ln S_t = a + b \ln F_{t-1} + \text{“news”} + w_t. \tag{8}$$

In what follows this notion is applied to an empirical analysis of the

[19] For evidence on the robustness of the interest parity relationship see Frenkel and Levich (1977).

[20] See, e.g., Barro 1977 and Fischer 1980.

[21] See also Bilson 1978; Frenkel and Mussa 1980; Isard 1980; and Longworth 1980.

role of "news" as a determinant of the exchange rate. The key difficulty lies in identifying the variable which measures the "news." Since, quite frequently, it is difficult to observe and quantify the "news," it is convenient to examine the relationship between the exchange rate and a variable whose time series is likely to manifest the "news" promptly. Assuming that asset markets clear fast and that the "news" is immediately reflected in (unexpected) changes in the rates of interest, equation (8) may be written as

$$\ln S_t = \underbrace{a + b \ln F_{t-1}}_{\text{expected exchange rate}} + \alpha\underbrace{[(i - i^*)_t - E_{t-1}(i - i^*)_t]}_{\text{“news”}} + w_t, \tag{9}$$

where the bracketed term denotes the innovation in the (1-month) interest differential and where $E_{t-1}(i - i^*)_t$ denotes the interest differential which was expected to prevail in period t based on the information available at $t - 1$. The expected interest rate differential was computed from a regression of the interest differential on a constant, on two lagged values of the differential, and on the lagged forward exchange rate $\ln F_{t-1}$.

As was argued above, the association between exchange rates and interest rates is likely to be positive during periods in which most of the variations in nominal rates of interest are dominated by variations in inflationary expectations—a characteristic which seems to fit the inflationary environment of the 1970s. Under such circumstances, when the unexpected interest differential reflects "news" concerning inflationary expectations, the coefficient α in equation (9) is likely to be positive.[22] Table 3 reports the two-stage least-squares estimates of equation (9) for the three exchange rates over the period June 1973–July 1979.[23] As may be seen in all cases, the coefficients of the unexpected interest differential are positive and, in the case of the dollar/pound exchange rate, the coefficient is statistically significant. In

[22] In general, of course, the sign of the coefficient α depends on the source of the variation in the interest rate.

[23] In all cases, the lagged forward exchange rate was included as an instrument in order to obtain consistent estimates; see Nelson 1975. Adding lagged values of the percentage changes of the domestic and the foreign money supplies as determinants of the expected interest differential and adding the current values of the percentage change of the money supplies as instruments for the unexpected interest differential did not affect the results in any material way. In order to obtain consistent estimates, the assumption made in the regressions reported in tables 3–6 is that, in forming expectations concerning the interest differential, individuals look only at the lagged forward premium and at past values of the differential. An alternative way to compute the expected differential would use data on the term structure of interest rates. Since data on the differential of 2-month rates are not readily available, this computation would require interpolations.

order to verify the importance of using the series of innovations in the interest differential, table 3 also reports estimates of regressions which replace the innovations by the actual series of the interest differential. In all cases the coefficients of the actual interest differential do not differ significantly from zero. Table 4 describes analogous two-stage least-squares estimates of regressions which include both the actual interest rate differential and the innovation in the differential.[24] Again, in all cases the coefficients on the actual differential do not differ significantly from zero, while the coefficients on the innovations are all positive and are significant for the dollar/pound and the dollar/franc exchange rates.

One possible interpretation of the positive coefficient on the (unexpected) interest differential may be given in terms of the prediction of the monetary approach to the exchange rate, in which case the estimate of the coefficient α in equation (9) might be interpreted as an estimate of a structural parameter. Under an alternative interpretation the innovations in the interest differential belong in equation (9) only as far as they manifest "news" which is relevant for exchange-rate determination. If, for example, the dominant element of "news" was variation in inflationary expectations, then one could also use the innovations in other time series as long as they reflect the relevant "news." To examine this possibility the same regressions as in tables 3–4 were estimated using the 12-month interest differential, and the results are reported in tables 5–6. As before, in all cases the coefficients on the actual differential do not differ significantly from zero, while in all cases the coefficients on the innovations in the differential are positive and significant for the dollar/pound and the dollar/franc exchange rates.[25]

On the whole the record shows that during the 1970s exchange

[24] The difficulties in obtaining instruments for data that are innovations are obvious since, by virtue of being "news," it is unlikely that variables which characterize the history can serve as good instruments. The difficulties are acute in cases where a variable and its expected value appear in the same regression, in which case consistent estimates require the use of an instrument that is contemporaneous with the innovation and is exogenous (see McCallum 1979). Thus, in addition to a constant and the lagged forward exchange rate, Durbin's rank variable was used as an instrument for estimating the innovations in the interest rate differential.

[25] To allow for the possibility that the exchange-rate equation includes both the short- and the long-term interest rates where, as suggested by Frankel (1979), the former captures liquidity effects and the latter captures expectations effects, eq. (9) was also estimated using the innovations in both the 1-month and the 12-month interest differential on the right-hand side. Since the two sets of innovations are highly collinear, none of the coefficients differed significantly from zero. In this context it is also noteworthy that the 12-month interest rate contains elements of the 1-month rates, due to the characteristics of the term structure of interest rates. As a result, coefficient estimates from regressions which use both rates, like those in Frankel (1979), must be interpreted with great care.

TABLE 3

One-Month Interest Rate Differentials and Exchange Rates; Instrumental Variables
Monthly Data: June 1973–June 1979
(Standard Errors in Parentheses)

Dependent Variable $\ln S_t$	Constant	$\ln F_{t-1}$	$(i - i^*)_t$	$[(i - i^*)_t - E_{t-1}(i - i^*)_t]$	SE	R^2	D-W
Dollar/pound	.021	.965	−.152	...	.028	.95	1.69
	(.020)	(.026)	(.118)				
	.031	.959	...	.432	.026	.96	1.78
	(.017)	(.024)		(.181)			
Dollar/franc	−.024	.992	−.462	...	.034	.71	2.21
	(.181)	(.124)	(.324)				
	−.246	.837	...	.245	.029	.80	2.17
	(.077)	(.051)		(.167)			
Dollar/DM	.004	.997	−.180	...	.033	.93	2.12
	(.064)	(.064)	(.394)				
	−.022	.972	...	.413	.031	.93	2.05
	(.026)	(.031)		(.347)			

Note.—Interest rates are the 1-month (annualized) Euromarket rates. The expected interest rate differential $E_{t-1}(i - i^*)_t$ was computed from a regression of the interest differential on a constant, two lagged values of the differential, and the logarithm of the lagged forward exchange rate. A two-stage least-squares estimation method was used. The instruments for the interest differential were a constant, two lagged values of the differential, and the logarithm of the lagged forward exchange rate; the instruments for the unexpected differential were a constant, Durbin's rank variable, and the logarithm of the lagged forward exchange rate. The actual interest rate differential is denoted by $(i - i^*)_t$, where i denotes the rate of interest on securities denominated in U.S. dollars, and i^* denotes the rate of interest on securities denominated in foreign currency. The unexpected interest rate differential is denoted by $[(i - i^*)_t - E_{t-1}(i - i^*)_t]$. SE is the standard error of the equation. A quasi-R^2 was computed as $1 - \text{var}(\hat{u}_t)/\text{var}(\ln S_t)$.

TABLE 4

ONE-MONTH INTEREST RATE DIFFERENTIALS AND FORECAST ERRORS OF EXCHANGE RATES; INSTRUMENTAL VARIABLES
MONTHLY DATA: JUNE 1973–JULY 1979
(Standard Errors in Parentheses)

Dependent Variable $\ln S_t$	Constant	$\ln F_{t-1}$	$(i - i^*)_t$	$[(i - i^*)_t - E_{t-1}(i - i^*)_t]$	SE	R^2	D-W
Dollar/pound	.018	.969	−.156	.562	.023	.97	1.81
	(.017)	(.022)	(.100)	(.191)			
Dollar/franc	−.136	.915	−.312	.547	.031	.75	2.19
	(.112)	(.076)	(.209)	(.282)			
Dollar/DM	.002	.996	−.173	.599	.032	.93	2.07
	(.044)	(.045)	(.286)	(.457)			

NOTE.—Interest rates are the 1-month (annualized) Euromarket rates. The expected interest rate differential $E_{t-1}(i - i^*)_t$ was computed from a regression of the interest differential on a constant, two lagged values of the differential, and the logarithm of the lagged forward exchange rate. A two-stage least-squares estimation method was used. The instruments were a constant, two lagged values of the interest differential, Durbin's rank variable of the unexpected differential, and the logarithm of the lagged forward exchange rate. The actual interest rate differential is denoted by $(i - i^*)_t$, where i denotes the rate of interest on securities denominated in U.S. dollars, and i^* denotes the rate of interest on securities denominated in foreign currency. The unexpected interest rate differential is denoted by $[(i - i^*)_t - E_{t-1}(i - i^*)_t]$. SE is the standard error of the equation. A quasi-R^2 was computed as $1 - \text{var}(\hat{u}_t)/\text{var}(\ln S_t)$.

TABLE 5

TWELVE-MONTH INTEREST RATE DIFFERENTIALS AND EXCHANGE RATES; INSTRUMENTAL VARIABLES
MONTHLY DATA: JUNE 1973–JULY 1979
(Standard Errors in Parentheses)

Dependent Variable $\ln S_t$	Constant	$\ln F_{t-1}$	$(i - i^*)_t$	$[(i - i^*)_t - E_{t-1}(i - i^*)_t]$	SE	R^2	D-W
Dollar/pound	.027	.960	−.083	...	.027	.95	1.71
	(.019)	(.025)	(.147)				
	.031	.959	...	.887	.025	.96	1.81
	(.017)	(.024)	...	(.291)			
Dollar/franc	−.152	.904	−.230	...	.030	.77	2.32
	(.155)	(.107)	(.320)				
	−.246	.837	...	.729	.029	.80	2.10
	(.077)	(.051)		(.342)			
Dollar/DM	−.012	.982	−.074	...	.032	.93	2.11
	(.063)	(.063)	(.395)				
	−.022	.972	...	.979	.031	.94	2.07
	(.026)	(.031)		(.663)			

NOTE.—Interest rates are the 12-month Euromarket rates. The expected interest rate differential $E_{t-1}(i - i^*)_t$ was computed from a regression of the interest differential on a constant, two lagged values of the differential, and the logarithm of the lagged forward exchange rate. A two-stage least-squares estimation method was used. The instruments for the interest differential were a constant, two lagged values of the differential, and the logarithm of the lagged forward exchange rate; the instruments for the unexpected differential were a constant, Durbin's rank variable, and the logarithm of the lagged forward exchange rate. The actual interest rate differential is denoted by $(i - i^*)_t$, where i denotes the rate of interest on securities denominated in U.S. dollars, and i^* denotes the rate of interest on securities denominated in foreign currency. The unexpected interest rate differential is denoted by $[(i - i^*)_t - E_{t-1}(i - i^*)_t]$. SE is the standard error of the equation. A quasi-R^2 was computed as $1 - \text{var}(\hat{u}_t)/\text{var}(\ln S_t)$.

TABLE 6

TWELVE-MONTH INTEREST RATE DIFFERENTIALS AND EXCHANGE RATES; INSTRUMENTAL VARIABLES
MONTHLY DATA: JUNE 1973–JULY 1979
(Standard Errors in Parentheses)

Dependent Variable $\ln S_t$	Constant	$\ln F_{t-1}$	$(i - i^*)_t$	$[(i - i^*)_t - E_{t-1}(i - i^*)_t]$	SE	R^2	D-W
Dollar/pound	.024	.965	−.087	.978	.022	.97	1.82
	(.016)	(.021)	(.121)	(.286)			
Dollar/franc	−.180	.884	−.184	.915	.029	.79	2.16
	(.118)	(.181)	(.245)	(.432)			
Dollar/DM	−.013	.981	−.063	1.031	.031	.93	2.08
	(.053)	(.054)	(.338)	(.752)			

NOTE.—Interest rates are the 12-month Euromarket rates. The expected interest rate differential $E_{t-1}(i - i^*)_t$ was computed from a regression of the interest differential on a constant, two lagged values of the differential, and the logarithm of the lagged forward exchange rate. A two-stage least-squares estimation method was used. The instruments were a constant, two lagged values of the interest differential, Durbin's rank variable of the unexpected differential, and the logarithm of the lagged forward exchange rate. The actual interest rate differential is denoted by $(i - i^*)_t$, where i denotes the rate of interest on securities denominated in U.S. dollars, and i^* denotes the rate of interest on securities denominated in foreign currency. The unexpected interest rate differential is denoted by $[(i - i^*)_t - E_{t-1}(i - i^*)_t]$. SE is the standard error of the equation. A quasi-R^2 was computed as $1 - \text{var}(\hat{u}_t)/\text{var}(\ln S_t)$.

rates and the interest rate differential have been associated positively, thus indicating that during that inflationary period the same factors which induced a rise in the interest differential also induced a rise in the spot exchange rates. Furthermore, consistent with the hypothesis that current changes in exchange rates are primarily a response to new information, the evidence shows the importance of the innovations in the interest differential.

The principle that current exchange rates already reflect expectations concerning the future course of events implies that unanticipated changes in exchange rates are primarily due to innovations. Since the empirical work suggests that most of the actual changes in exchange rates are unanticipated, it follows that most of the actual changes in exchange rates are due to "news." In the present section this principle was applied to the analysis of the relationship between exchange rates and interest rate differentials. The principle, however, is general. For example, it implies that the relationship between a deficit in the balance of trade and the exchange rate depends crucially on whether the deficit was expected or not. A deficit that was expected may have no effect on the exchange rate, since the latter already reflected these expectations. In contrast, an unexpected deficit in the balance of trade may contain significant new information that is likely to be accompanied by large changes in the exchange rate.[26] This distinction might be useful in interpreting the weak and unstable relationship between the balance of trade and the exchange rate without having to rely on explanations like the *J* curve or on variable import and export elasticities.

IV. Exchange Rates and Prices

One of the striking facts concerning the relationship between prices and exchange rates during the 1970s has been the poor performance of the predictions of the simple versions of the purchasing power parity doctrine. The originators and proponents of the purchasing

[26] For a further elaboration on the relationship between exchange rates and the current account see Kouri (1976); Branson (1977); Branson, Halttunen, and Masson (1977); Dornbusch and Fischer (1980); and Rodríguez (1980). For a special emphasis on the role of innovations in the trade balance see Mussa (1979*c*), and for empirical evidence see Dornbusch (1980) and Hakkio (1980). It should be noted that the empirical work on the association between exchange rates and current account innovations faces some difficulties since, in contrast with data on financial variables like interest rates, data on the current account are not available at short intervals. Furthermore, findings on the association between exchange rates and current account innovations should be interpreted with care since, rather than reflecting the sensitivity of exchange rates to "news," they might just reflect invoicing practices according to which U.S. exports are invoiced in terms of U.S. dollars, while imports are invoiced in terms of foreign currencies.

power parity doctrine (Wheatley and Ricardo during the first part of the nineteenth century and Cassel during the 1920s) have viewed the doctrine as an extension of the quantity theory of money to the open economy. By now the consensus seems to be that, when applied to aggregate national price levels, purchasing power parities can be expected to hold in the long run if most of the shocks to the system are of a monetary origin which do not require changes in relative prices. To the extent that most of the shocks reflect "real" changes (like differential growth rates among sectors), the required changes in sectoral relative prices may result in a relatively loose connection between exchange rates and aggregate price levels. The experience during the 1970s illustrates the extent to which real shocks (oil embargo, supply shocks, commodity booms and shortages, shifts in the demand for money, differential productivity growth) result in systematic deviations from purchasing power parities. As illustrated in figures 1–3, short-run changes in exchange rates have not been closely linked to short-run differentials in the corresponding national inflation rates as measured by consumer price indices. Furthermore, this loose link seems to be cumulative. As illustrated in figures 4–6 divergences from purchasing power parities, measured in terms of the relationship between exchange rates and the ratio of consumer price indices, seem to persist.

The link between prices and exchange rates is illustrated in table 7, which reports the results of regressions of the various exchange rates on the corresponding ratios of wholesale and of cost-of-living price indices. As may be seen, the results of the regressions which involve the U.S. dollar are extremely poor. For the dollar/pound and the dollar/franc exchange rates, the estimates of the coefficients of the price ratios are insignificant and, for the dollar/DM exchange rate, the estimates differ significantly from unity. In contrast the results of the regressions of exchange rates that do not involve the U.S dollar or the U.S. price level (the pound/DM and the franc/DM exchange rates) are superior: Except for the wholesale price indices in the franc/DM regression all the coefficients are highly significant and the elasticities of the exchange rates with respect to the various price indices do not differ significantly from unity.

The vast difference in the performance of the regressions for the various currencies can be explained by noting that first, due to transport cost, purchasing power parities are expected to hold better among the neighboring European countries than among each of these countries and the United States; second, changes in commercial policies and nontariff barriers to trade seem to have been more stable within Europe than between Europe and the United States; third, within Europe the snake agreement and later on the European Mon-

TABLE 7

PURCHASING POWER PARITIES: INSTRUMENTAL VARIABLES MONTHLY DATA: JUNE 1973–JULY 1979
(Standard Errors in Parentheses)

Dependent Variable $\ln S_t$	Constant	$\ln(P_w/P_w^*)$	$\ln(P_c/P_c^*)$	SE	D-W	ρ
Dollar/pound	.712	.165	...	.027	1.63	.963
	(.149)	(.507)				
	2.982	...	1.070	.029	1.66	.998
	(2.978)		(.897)			
Dollar/franc	−1.521	.184	...	.029	2.26	.863
	(.027)	(.374)				
	−1.570	...	−1.070	.029	2.30	.901
	(.047)		(.817)			
Dollar/DM	−.900	1.786	...	.034	1.69	.739
	(.018)	(.230)				
	−.908	...	2.217	.031	1.96	.759
	(.175)		(.263)			
Pound/DM	−1.668	.821	...	.027	1.60	.895
	(.041)	(.144)				
	−1.666	...	.965	.027	1.57	.909
	(.048)		(.197)			
Franc/DM	.863	−.026	...	.020	1.61	.981
	(.143)	(.487)				
	.602	...	1.180	.019	1.48	.929
	(.048)		(.327)			

NOTE.—The logarithm of the spot exchange rate is denoted by $\ln S_t$; $\ln(P_w/P_w^*)$ and $\ln(P_c/P_c^*)$ denote, respectively, the logarithms of the ratios of the wholesale price indices and the cost of living indices. Cochrane-Orcutt iterative technique with a two-stage least-squares estimation method was used; the instruments are a constant, time, time squared, and lagged values of the dependent and independent variables. SE is the standard error of the equation, and ρ denotes the first-order autocorrelation coefficient.

etary System have resulted in a reduced degree of intra-European flexibility of exchange rates; and fourth, there seem to have been large changes in the equilibrium real exchange rate between the U.S. dollar and the European currencies.[27] It should be noted, however, that to some extent the overall poor performance of the purchasing power parities doctrine is specific to the 1970s. During the floating rates period of the 1920s, the doctrine seems to have been much more reliable.[28]

The preceding discussion accounted for the persisting deviations from purchasing power parities in terms of changes in real factors which affect equilibrium relative price structure. It should be noted, however, that even in the absence of such changes there is a presumption that, at least in the short run, exchange-rate fluctuations

[27] The failure of the regression of the franc/DM exchange rate on the ratio of the wholesale price indices is explained in terms of the large changes in the French intersectoral relative prices; for an elaboration see Frenkel (1981).

[28] For evidence see Frenkel (1976, 1978, 1980*a*) and Krugman (1978).

would not be matched by corresponding fluctuations of aggregate price levels. The discussion in Section II emphasized that in periods which are dominated by "news" which alters expectations, exchange rates (and other asset prices which are traded in organized markets) are expected to be highly volatile. Aggregate price indices, on the other hand, are not expected to reveal such a degree of volatility, since they reflect the prices of goods and services which are less durable and, therefore, are likely to be less sensitive to the "news" which alters expectations concerning the future course of events. It follows, therefore, that in periods during which there is ample "news" which causes large fluctuations in exchange rates, there will also be large deviations from purchasing power parities.[29]

The difference between the characteristics of exchange rates and national price levels is also reflected in their time-series properties and is fundamental for interpreting the deviations from purchasing power parities. The monthly changes in exchange rates exhibit little or no serial correlation, while national price levels do exhibit a degree of serial correlation. The "stickiness" exhibited by national price levels need not reflect any market imperfection but rather it may reflect the costs of price adjustment which result in the existence of nominal contracts of finite length. Likewise, it may reflect the results of confusion between relative and absolute prices and confusion between permanent and transitory changes. This difference between the time-series properties of exchange rates and prices is reflected in the low correlation between the practically random month-to-month exchange-rate changes and the serially correlated differences between national rates of inflation.

The different degrees of volatility of prices and exchange rates are illustrated in table 8, which reports the average absolute monthly percentage changes in the various exchange rates and prices. As is evident, the mean absolute change in the various spot exchange rates has been about 2 percent per month (and even slightly higher for the changes in the forward rate). The magnitudes of these changes have been more than double the magnitudes of the changes in most of the various price indices, as well as in the ratios of national price levels. For example, the mean monthly change in the cost-of-living price index was 0.4 percent in Germany, 0.7 percent in the United States,

[29] On this see Mussa (1979*a*). It is noteworthy that the emphasis in the text has been on the words "large fluctuations"; this should be contrasted with periods during which there are large secular changes in the exchange rate (like the changes which occurred during the German hyperinflation). During such periods the secular changes do not stem necessarily from "news" and need not be associated with deviations from purchasing power parities.

0.9 percent in France, and 1.2 percent in the United Kingdom. These differences are even more striking for the detrended series.

The notion that exchange rates have been volatile is clearly illustrated by figures 1–3 and by table 8. The comparison of the magnitudes of the changes in the exchange rates with the magnitudes of the changes in the price indices and in the ratios of national price levels may suggest, according to a narrow interpretation of the purchasing power parity doctrine, that exchange-rate fluctuations have been "excessive." The previous discussion, however, has emphasized that exchange rates, being the relative prices of assets, are fundamentally different from the price indices of goods and services and, therefore, are expected to exhibit a different degree of volatility in particular during periods that are dominated by "news." An alternative yardstick for measuring the degree of exchange-rate fluctuations would be a comparison with prices of other assets. Indeed, while exchange-rate changes have been large relative to changes in national price levels, they have been considerably smaller than changes in the prices of other assets like gold, silver, many other commodities that are traded in organized markets, and common stocks. For example, table 8 also reports the mean absolute monthly percentage change in stock-market indices. As may be seen, the mean monthly change in these indices ranged from over 3 percent in Germany to over 6 percent in the United Kingdom. By these standards it is difficult to argue that exchange rates have been excessively volatile.

Given the short-run deviations from purchasing power parities, it is relevant to explore whether these deviations tend to diminish with time or tend to persist or even grow in size. In order to examine the patterns of the deviations, the autocorrelation functions and the par-

TABLE 8

MEAN ABSOLUTE PERCENTAGE CHANGES IN PRICES AND EXCHANGE RATES
MONTHLY DATA: JUNE 1973–JULY 1979

	Variable					
				Exchange Rates against the Dollar		
Country	WPI	COL	Stock Market	Spot	Forward	COL/COL_{US}
U.S.	.009	.007	.037	...	...	...
U.K.	.014	.012	.066	.021	.021	.007
France	.011	.009	.054	.020	.021	.003
Germany	.004	.004	.030	.024	.024	.004

NOTE.—All variables represent the absolute values of monthly percentage changes in the data. WPI denotes the wholesale price index and COL denotes the cost-of-living index. Data on prices and exchange rates are from the IMF tape (May 1979 version). The stock market indices are from *Capital International Perspective* (monthly issues).

tial autocorrelation functions of these deviations for the wholesale and the cost-of-living price indices have been computed. The deviation from purchasing power parities during month t is denoted by Δ_t and is defined as:

$$\Delta_t = \ln S_t - \ln(P/P^*)_t. \quad (10)$$

Figures 11–13 illustrate the patterns of the deviations for the three exchange rates. As may be seen, the general pattern is very similar for the three exchange rates and for the two price indices. In all cases the autocorrelation function tails off at what seems to be an exponential rate, and in all cases the partial autocorrelation function shows a spike at the first lag. This pattern seems to indicate (as might have been expected on the basis of the time-series properties of exchange rates and price indices) that the deviations from purchasing power parities follow a first-order autoregressive process. It is noteworthy, however,

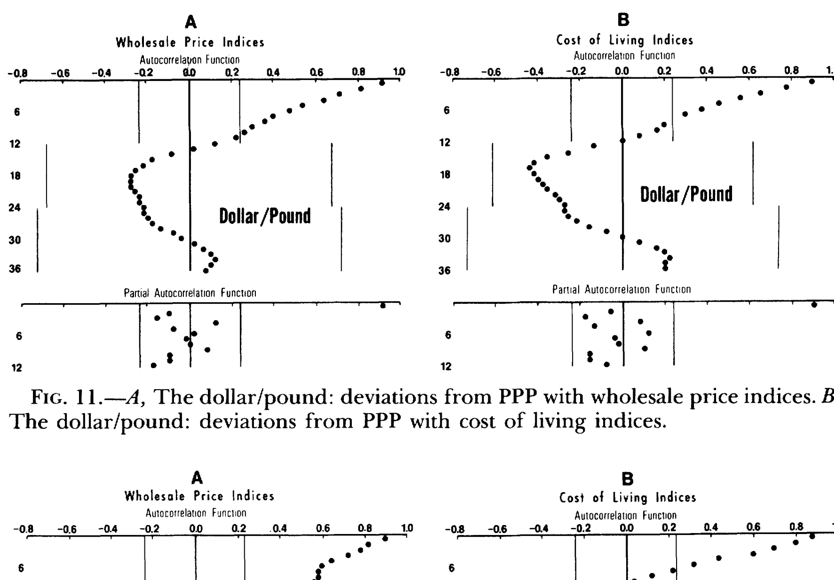

FIG. 11.—*A*, The dollar/pound: deviations from PPP with wholesale price indices. *B*, The dollar/pound: deviations from PPP with cost of living indices.

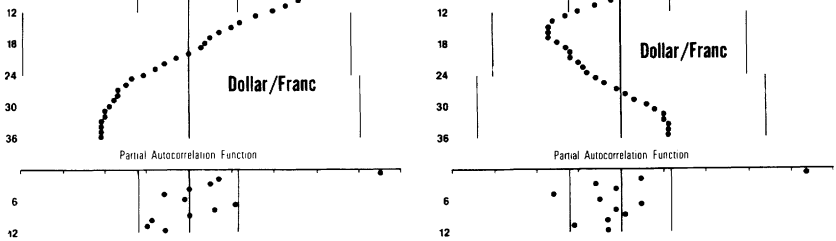

FIG. 12.—*A*, The dollar/franc: deviations from PPP with wholesale price indices. *B*, The dollar/franc: deviations from PPP with cost-of-living indices.

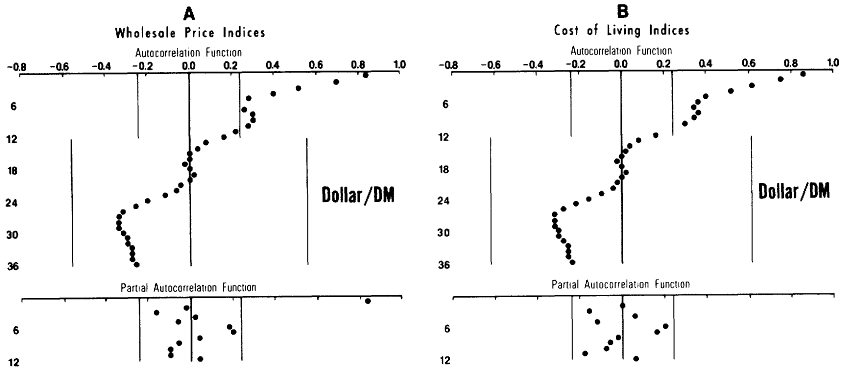

FIG. 13.—*A*, The dollar/DM: deviations from PPP with wholesale price indices. *B*, The dollar/DM: deviations from PPP with cost-of-living indices.

that in all cases the value of the autoregression term is about .9, indicating the possibility that the series may not satisfy the stationarity requirement. To allow for this possibility, the autocorrelation functions and the partial autocorrelation functions of $\Delta_t - \Delta_{t-1}$, that is, of the first difference of the deviations from purchasing power parities, have also been examined. The results indicate that these differences are serially uncorrelated and thus imply that the deviations Δ_t follow a random-walk process. In view of this possibility it is concluded that the deviations from purchasing power parities seem to follow a first-order, autoregressive process, but that the data do not provide sufficient evidence to reject the alternative hypothesis of a random walk.[30]

V. Concluding Remarks

This paper examined some aspects of the operation of flexible exchange rates. The analysis was based on the experience of the 1970s. The principal conclusions which may be drawn from the empirical work are:

[30] If the deviations follow a random-walk process, then they do not entail (ex ante) unexploited profit opportunities. For a study of the deviations from purchasing power parities see Roll (1979). For an analysis of equilibrium deviations from purchasing power parities see Saidi (1977). It may be noted that the main difference between accepting the AR(1) rather than the random-walk hypothesis relates to the economic interpretation of the two alternative processes. The random-walk process implies that deviations from purchasing power parities do not tend to diminish with the passage of time, while the stable AR(1) process implies that there are mechanisms which operate to ensure that, in the long run, purchasing power parities are satisfied. For the purpose of forecasting the near future, however, there is very little difference between using the AR(1) process with an autoregressive coefficient of 0.9 and using the random-walk process.

i) In spite of the extraordinary turbulence in the markets for foreign exchange, it seems that, to a large extent, the markets have operated efficiently. It should be emphasized, however, that the concept of "efficiency" used in this context is somewhat narrow in that it only refers to the notion that the markets do not seem to entail unexploited profit opportunities. A broader perspective should deal with the social cost of volatility in terms of the interference with the efficiency of the price system in guiding resource allocation as well as with the cost of alternative outlets for the disturbances that are currently reflected in the volatility of exchange rates. As for the choice among alternative outlets for the disturbances, one may argue that since the foreign-exchange market is a market in which risk can be bought and sold relatively easily, it may be reasonable to concentrate the disturbances in this market rather than transfer them to other markets, such as labor markets, where they cannot be dealt with in as efficient a manner.

ii) The high volatility of exchange rates (spot and forward) reflects an intrinsic characteristic of the relative price of monies and other assets that are traded in organized exchange. The price of gold, the price of stocks, as well as exchange rates between national monies depend critically on expectations concerning the future course of events and adjust rapidly in response to new information. In this perspective, the exchange rate (in contrast with the relative price of national outputs) is being viewed as a financial variable which is determined in a macroeconomic setting.

iii) During inflationary periods, variations in nominal rates of interest are dominated by changes in inflationary expectations; as a result, high nominal rates of interest are associated with high exchange rates (a depreciated currency). This relationship was supported by the empirical work.

iv) The asset view of exchange-rate determination implies that "news" is among the major factors which influence changes in exchange rates. In this context the key finding was the dependence of exchange-rate changes on the unexpected changes in the rates of interest. This finding is in accord with the analytical prediction that current exchange rates already reflect current expectations about the future, while changes in the current exchange rates reflect primarily changes in these expectations which, by definition, arise from new information.

v) The experience of the 1970s does not support the predictions of the simple version of the purchasing power parity doctrine which relates the values of current measured prices to current exchange rates. The empirical work showed that deviations from purchasing power parities can be characterized by a first-order autoregressive process.

vi) One of the key analytical insights that is provided by the monetary (or the asset-market) approach to the exchange rate is that exchange rates do not reflect only current circumstances but also reflect those circumstances which are expected to prevail in the future. This anticipatory feature of the exchange rate (which is emphasized by Mussa [1979*b*]) does not characterize (at least to such a degree) the prices of national outputs, which reflect to a large extent present and past circumstances as they are embedded in existing contracts. Consequently, periods which are dominated by large and frequent changes in expectations are likely to be periods in which the future is expected to differ greatly from the present and the past. Under such circumstances one may expect to find frequent deviations from purchasing power parities when the latter are computed using current prices. These deviations reflect the intrinsic difference between asset prices and national price indices.[31]

vii) Since commodity prices do not adjust fully in response to exogenous shocks, it seems that intervention in the foreign-exchange market, which ensures that exchange rates conform with purchasing power parities, would be a mistaken course of policy. When commodity prices are slow to adjust to current and expected economic conditions, it may be desirable to allow excessive adjustment in some other prices. Further, changes in real economic conditions requiring adjustment in the equilibrium relative prices of different national outputs occur continuously. An intervention rule which links changes in exchange rates rigidly to changes in

[31] It is interesting to note that this phenomenon was recognized by Gustav Cassel—the most recognized proponent of the purchasing power parity doctrine—according to whom: "The international valuation of the currency will, then generally show a tendency to anticipate events, so to speak, and become more an expression of the internal value that the currency is expected to possess in a few months, or perhaps in a year's time" (Cassel 1930, pp. 149–50).

domestic and foreign prices in accord with purchasing power parity ignores the occasional need for equilibrating changes in relative prices.

Appendix

1. *Exchange Rates*

The spot exchange rates are end-of-month rates obtained from the IMF tape (May 1979 version, updated to July 1979 using the November 1979 issue of the *International Financial Statistics*) obtained from the International Monetary Fund.

The forward exchange rates are end-of-month rates for 1-month maturity. The forward rates for the U.K. pound and the DM for the period June 1973–June 1978 are bid prices obtained from the International Money Market (IMM). For the period July 1978–July 1979 they are sell prices obtained from the *Wall Street Journal.* The forward rates for the French franc for the period June 1973–July 1974 are bid prices calculated from the *Weekly Review* publication of the Harris Bank which reports the spot rate and the forward premium; in each case the closest Friday to the end of the month was chosen. For the period August 1974–June 1978 the rates are bid rates obtained from the IMM, and for the period July 1978–July 1979 they are sell prices obtained from the *Wall Street Journal.*

2. *Prices*

The wholesale and cost-of-living price indices are period averages obtained from the IMF tape, lines 63 and 64, respectively.

3. *Rates of Interest*

All interest rates are 1-month Eurocurrency rates obtained from the *Weekly Review* of the Harris Bank. In all cases the figures used correspond to the last Friday of each month.

4. *Stock Markets*

The stock market indices correspond to the last trading day of the month. The sources are *Capital International Perspective* (Geneva, Switzerland, monthly issues).

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