International Finance Discussion Papers

Number 156

April 1980

EXPECTED AND UNEXPECTED CHANGES IN EXCHANGE RATES: THE ROLES OF RELATIVE PRICE LEVELS, BALANCE-OF-PAYMENTS FACTORS, INTEREST RATES AND RISK

by

Peter Isard

Expected and unexpected changes in exchange rates: The roles of relative price levels, balance-of-payments factors, interest rates and risk

by

Peter Isard

One of the central unresolved questions about exchange rate determination is how to fit balance-of-payments flows and risk factors into a rational expectations version of the asset equilibrium model. In addressing that question, this paper begins with the view that observed changes in exchange rates predominantly reflect revisions in expectations in response to surprising new information and distinguishes in Section 1 between different types of revisions in the term structure of exchange rate expectations. Wealth variables and exchange risk are recognised to play important rôles in portfolio decisions, and Section 2 describes how this provides a place for current-account flows in asset equilibrium models of exchange rate determination. Section 3 discusses the rôle and limitations of rational expectations assumptions in tying down the level of the term structure of exchange rate expectations.

Section 4 builds further upon Section 1 to develop an accounting identity that relates the exchange rate in a separably additive manner to relative price levels, balance-of-payments factors, interest rates and risk. Section 5 introduces some oversimplified behavioural assumptions about these factors and leads to a reduced-form model in which market participants are viewed to bid exchange rates up and down in response to new information about price levels, interest rates, current-account imbalances, stocks of public debt and the distribution of global private

---

* This paper descends from several joint papers with Michael Dooley, who deserves substantial credit for whatever insights the reader may find valuable. I have also benefited from discussions with a number of my colleagues at the Federal Reserve Board and the Bank for International Settlements. Neither institution should necessarily be assumed to agree with my analysis and opinions.

wealth. Section 6 presents some limited results of testing this model empirically with monthly data on the exchange rate between the US dollar and the Deutsche Mark for the period from April 1973 through September 1979. Section 7 provides a summary and some suggestions for further empirical work.

1. Accounting for exchange rate changes

One of the most striking facts about exchange rate behaviour during the last decade is the extent to which forward exchange rates have failed to predict the future values of spot exchange rates. For example, based on end-of-month data during the period from March 1973 through December 1979, 30-day forward premiums on the Deutsche Mark averaged .12 US cents in absolute value and never exceeded .36 cents, whereas actual month-to-month changes in the spot value of the Mark were ten times as large on average and exceeded 2 cents in absolute value for roughly one month out of every half year. Figure 1 illustrates the tremendous discrepancies between these *ex ante* predictions and *ex post* observations of month-to-month changes in exchange rates. In addition, Figure 2 illustrates that the forward rate consistently underpredicted the level of the spot rate when the spot rate was rising, consistently overpredicted when the spot rate was falling, and failed to predict every one of several dozen turning points in the spot rate during the 82-month period.

The inaccuracy of forward rates as predictors of future spot rates has been interpreted by a number of economists as an indication that short-term movements in exchange rates have predominantly reflected revisions in expectations about future exchange rates in response to surprising new information that has emerged during intervals between the purchase and maturity dates of forward contracts; a very good discussion is provided by Mussa (1979). For purposes of providing *ex post* explanations of movements in observed exchange rates, it is useful to distinguish further between new information that shifts the entire term structure of exchange rate expectations and new information that does not shift expectations about values of exchange rates in the long run but gives rise to revisions in exchange-risk premiums or interest rates and thereby changes the expected path of the exchange rate in the short run.

Figure 1

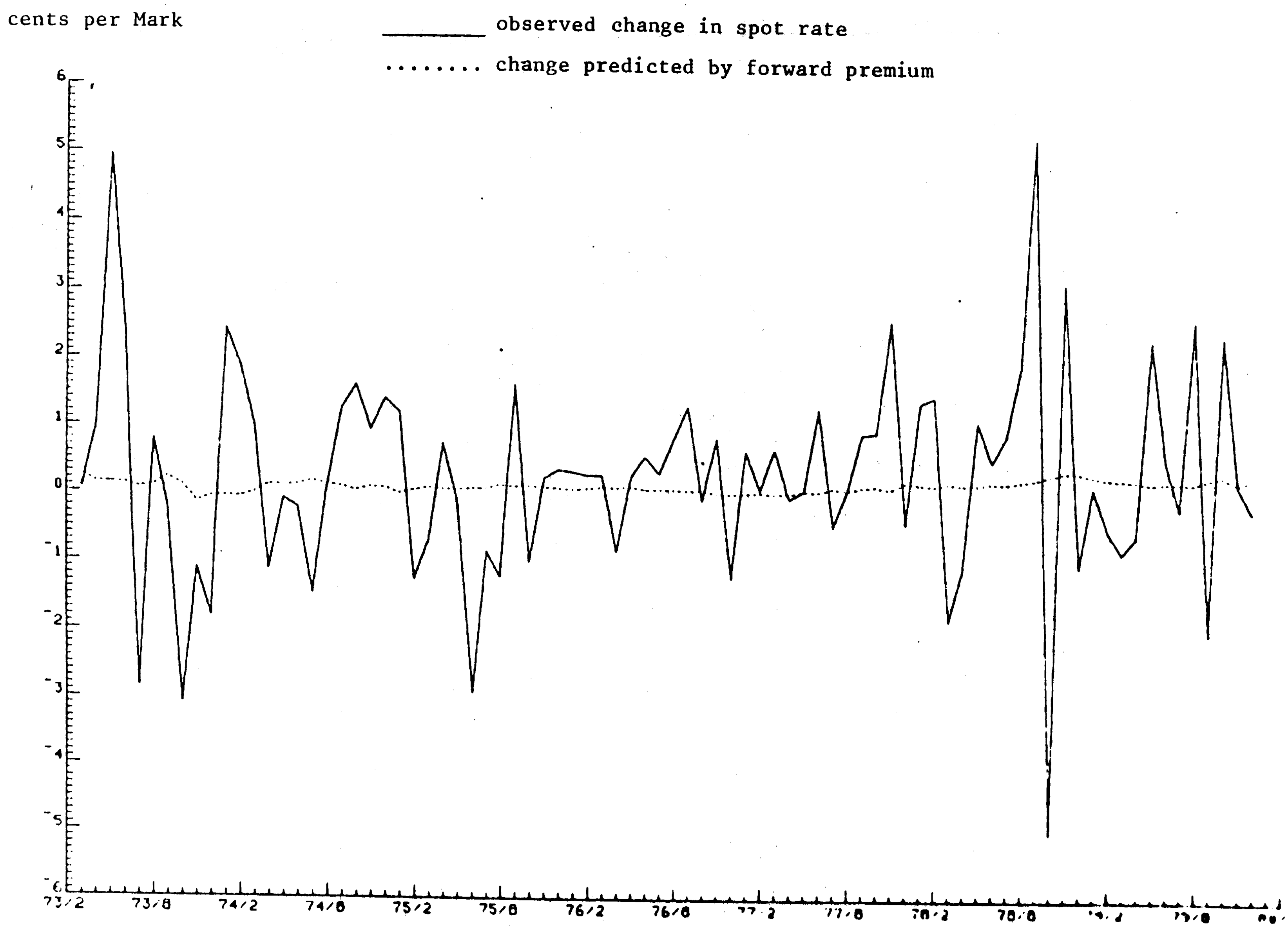
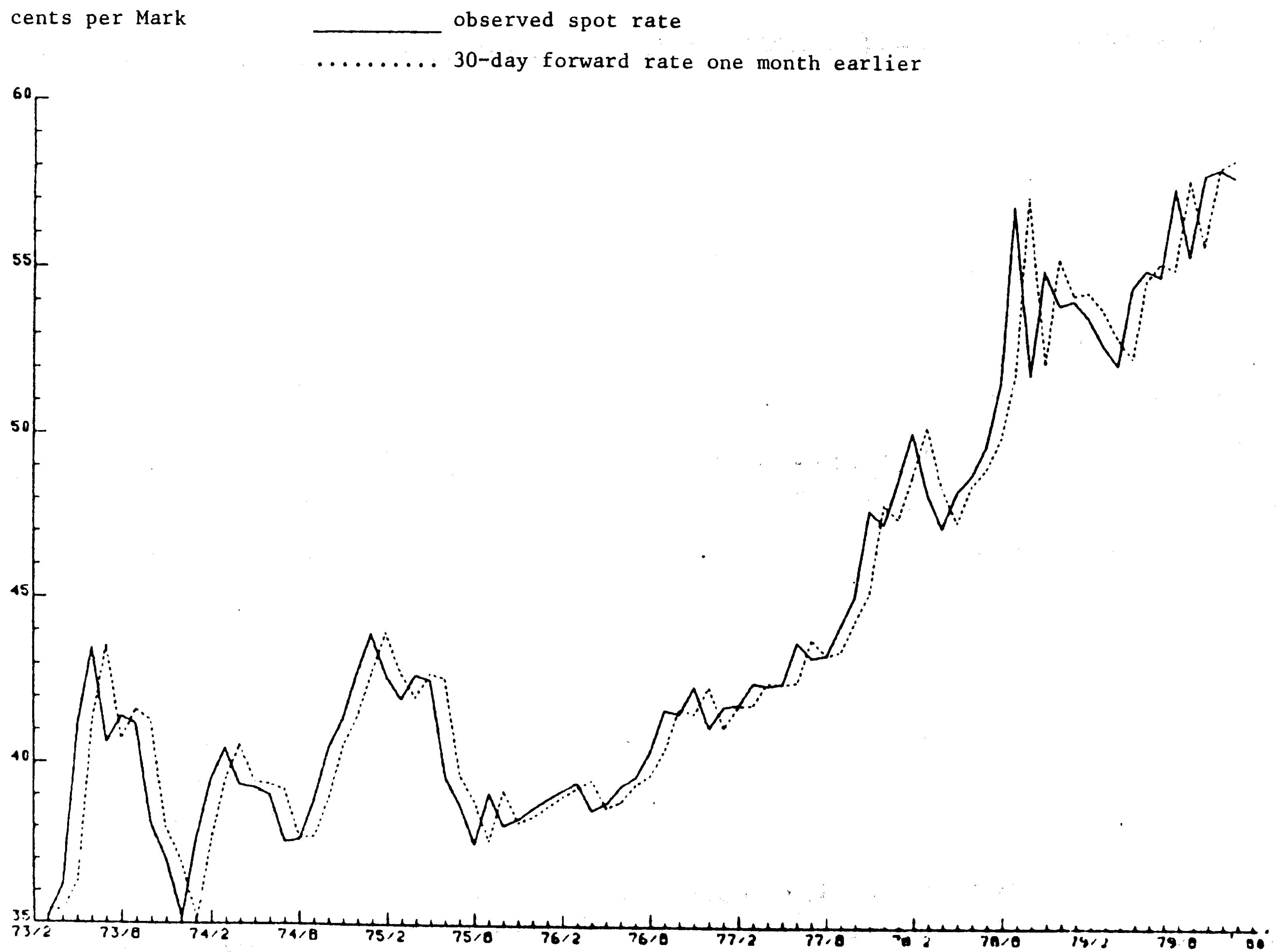

cents per Mark
observed change in spot rate
change predicted by forward premium
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
73/2
73/8
74/2
74/8
75/2
75/8
76/2
76/8
77/8
78/8

Figure 2


cents per Mark
observed spot rate
30-day forward rate one month earlier
60
55
50
45
40
35
73/2
73/8
74/2
74/8
75/2
75/8
76/2
76/8
77/2
77/8
78/8

A framework that accounts for exchange rate changes in terms of the above factors can be developed by expressing the spot rate in terms of the forward rate and relative interest rate factors according to the familiar interest rate parity condition,[1] and by viewing the forward rate to differ from the expected future spot rate by the premium that is required to bear exchange risk. Thus,

$$(1) \quad s_t = f_{t,T} \cdot ((1+r^B_{t,T})/(1+r^A_{t,T}))$$

$$(2) \quad risk_{t,T} = \log(f_{t,T}) - E_t \log(s_T)$$

and hence

$$(3) \quad \log(s_t) = E_t(\log(s_T)) + risk_{t,T} + \log((1+r^B_{t,T})/(1+r^A_{t,T}))$$

where

s_t = the spot exchange rate (currency A per unit currency B) observed at time t

$f_{t,T}$ = the forward exchange rate (currency A per unit currency B) observed at time t on contracts maturing at time T

$r^A_{t,T}$, $r^B_{t,T}$ = the nominal rates of interest prevailing at time t on assets maturing at time T and denominated, respectively, in currencies A and B

E_t = the general notation for expectations held at time t

$risk_{t,T}$ = the exchange-risk premium prevailing at time t on assets maturing at time T, as defined by condition (2).

Condition (3) implies formally that changes in observed exchange rates can reflect either revisions in expectations about the value of the exchange rate that will prevail at some future point in time or changes in the exchange risk and nominal interest rate factors that apply to the intervening time interval. In Figure 3, path 1 represents a plot of the term structure of exchange rate expectations held at time t_1, when the observed spot rate is s_1; more precisely, path 1 is obtained by plotting $E_t(\log(s_T))$, as a function of the horizon T, setting $t = t_1$ and $s = s_1$. Thus, according to condition (3), the curvature of path 1 reflects the term structures of risk premiumsand relative nominal interest rate factors.

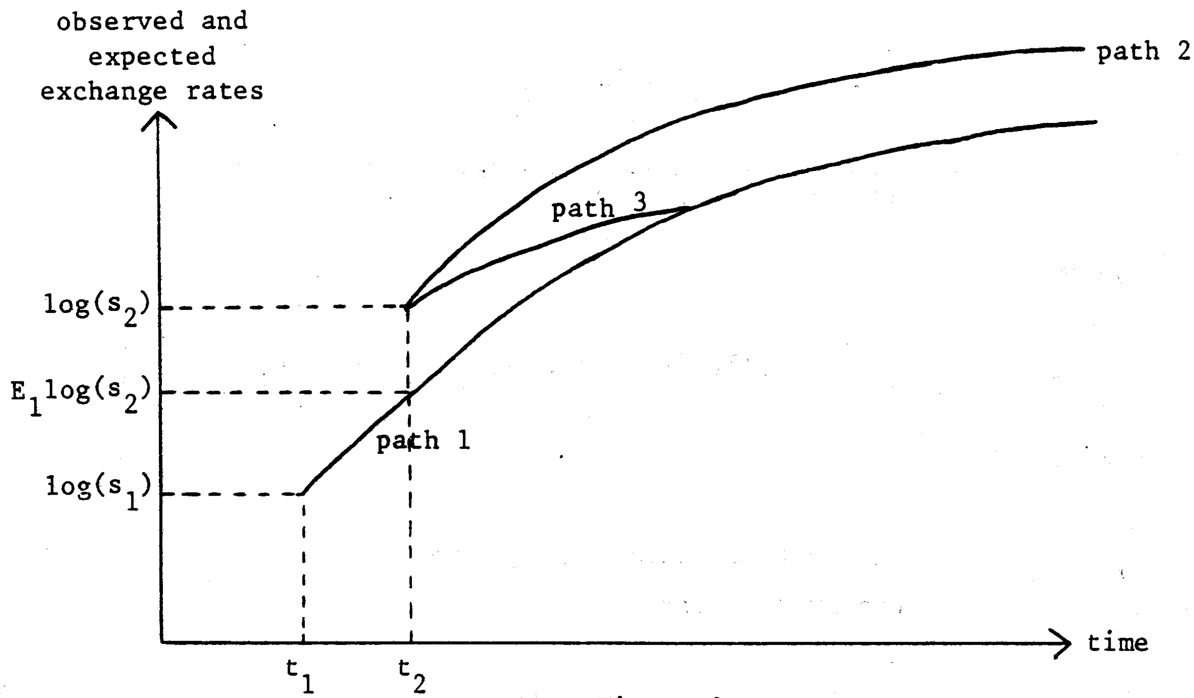


Figure 3

Next consider the economy at some later time t_2. Had the exchange rate moved according to the expectations that were held at t_1, the exchange rate $E_1\log(s_2)$ would have been observed at t_2 - that is, observed exchange rates would have moved along path 1 over time. More generally, however, an observed change in the exchange rate from $\log(s_1)$ to $\log(s_2)$ can be decomposed into an expected change $E_1\log(s_2)-\log(s_1)$ and an unexpected change $\log(s_2)-E_1\log(s_2)$. The unexpected change, in turn, might be the result of a general shift in the entire term structure of exchange rate expectations - such as a shift from path 1 to path 2. Alternatively, the unexpected change might reflect changes in risk or interest rate factors, independently of any revisions in expectations about long-run exchange rates, but implying revisions in expectations about near-term exchange rates. This is illustrated by the shift from path 1 to path 3.

2. The interpretation of risk premiums

Condition (2) defines the exchange-risk premium associated with each maturity of forward contract. In a risk-neutral world, with forward rates equal by definition to expected future spot rates, the risk premiums would be identically zero. Risk premiums could also be diversified away, in theory, in a world with no outside assets, or in a world in which private holdings of public debt were viewed to be matched by future tax liabilities, thereby adding nothing to private wealth; see Frankel (1979). By contrast, in the presence of risk aversion and outside assets that are viewed to add to private wealth, a gap can open up between the forward rate and the expected future spot rate, and it is appropriate to associate this gap with exchange risk.

To appreciate the sense in which the risk premium quantifies the degree of exchange risk, imagine a two-currency world in which governments and central banks create base money and public debt and push these outside assets into private portfolios, allowing interest rates and exchange rates to adjust to a configuration at which private portfolio managers are willing to hold the stocks of outside assets denominated in each currency. Given other factors relevant to private portfolio decisions, an increase in the stock of outside assets denominated in currency A must presumably lead to an increase in the expected relative rate of return on those assets to induce private sectors to absorb the additional assets into their portfolios. Thus, at given interest rates, an increase in the stock of outside assets denominated in currency A will give rise to an increase in the expected rate of appreciation of currency A - presumably associated with an immediate depreciation of currency A that exceeds any downward revision in expectations about future values of currency A. This has the result of raising the forward currency-A price of currency B relative to the expected future price and thus increasing the risk premium as defined in condition (2).

In the same sense that the risk premium may be viewed to increase with an increase in the stock of outside assets denominated in currency A, or with a decline in the stock of outside assets denominated in currency B, risk premiums may also be viewed to increase with exogenous shifts in portfolio preferences away from assets denominated in currency A, or with current-account imbalances that shift the international residence of private wealth towards countries with relatively weak preferences for assets denominated in currency A.

Three aspects of this viewpoint deserve emphasis. First, the riskiness of assets is characterised in terms of fundamental supply and demand factors. Assets are perceived to become more risky with increases in their excess supply - as a function of given expected relative yields; and consistently, assets could be judged to have become more risky, ceteris paribus, if their expected relative yields could be observed to have increased in order to maintain market equilibrium.

A second point is that an increase in excess supply at any given expected relative yield can arise without any increase in global supply or any shift in the asset demand functions of individual behavioural units, but may rather reflect a redistribution of global wealth between countries with different portfolio preferences.

As a third point, accordingly, recognition of the rôles of wealth variables and risk in portfolio decisions provides a place for balance-of-payments flows in asset models of exchange rate determination. Such a framework has been developed by Dooley and Isard (1979b), who relate changes in exchange rates via a formal model of exchange-risk factors to current-account imbalances, budget deficits and official foreign exchange interventions.[2]

3. Tying down the level of exchange rate expectations

Condition (3) is an identity that applies generally to all time horizons T. Thus, given the term structures of interest-rate factors and risk premiums, the presumed rationality of market participants and their opportunities to take positions on the basis of their expectations leads to a consistent term structure of exchange rate expectations.

It is important to realise, however, that the assumption of rational expectations by itself does not tie down the general level of the term structure of exchange rate expectations. This point can be established by supposing that condition (3) is translated into the model

$$(4)\quad \log(s_t) = g(Z_t) + E_t\log(s_{t+1})$$

Where $g(Z_t)$ is a behavioural model of the sum of the risk and interest rate factors in terms of a vector of exogenous variables $\mathbf{Z}_t$. The assumption of rational expectations then implies

$$(5)\quad E_t\log(s_{t+1}) = E_t g(Z_{t+1}) + E_t\log(s_{t+2})$$

Hence, by successive substitution

$$(6)\quad E_t\log(s_{t+1}) = \sum_{K=0}^{K} E_t g(Z_{t+1+k}) + E_t\log(s_{t+2+k})$$

and also

$$(7)\quad \log(s_t) = g(Z_t) + \sum_{K=0}^{K} E_t g(Z_{t+1+k}) + E_t\log(s_{t+2+k})$$

for any choice of horizon K. Thus, given a behavioural model of the current exchange rate in terms of an expected future exchange rate and other variables - i.e., given model (4) - the assumption that expectations are formed rationally implies that they are formed - according to condition (6) - in a manner that is consistent both with the behavioural relationship between the current exchange rate and other variables - i.e., the behavioural function $g(Z)$ - and with expectations or subjective probability distributions of the future values of the other variables - i.e., the sequence $Z_{t+1}, \ldots, Z_{t+1+K}$.

This point has been emphasised by Mussa (1976, 1979), Barro (1978) and Dooley and Isard (1979a) - but it is only half of the story told by conditions (6) and (7). The other half of the story is that today's exchange rate - as well as today's expectation about tomorrow's exchange rate - is ultimately linked to today's expectation about the exchange rate on some horizon, however far away. By itself, the assumption of rational expectations cannot get beyond the horizon to explain the level of today's exchange rate. Rational expectations can tell us the shape of the rainbow and direct us towards the horizon, but what we may initially perceive as a point horizon becomes an infinite expanse as we approach it or telescope our sights. Chasing rainbows is a recipe that inevitably evaporates.

The implication is that we need to impose an additional condition to pin down a point at which the exchange is expected to be found at some given distance on the horizon. In this regard most economists find it appealing to choose a long-run horizon that is consistent with reaching a state of equilibrium and to then impose conditions that the exchange rate is expected to satisfy in an equilibrium state. This academic approach, however, has been called into question by the fact that most market participants take positions on the basis of what they expect exchange rates to be in the very short run. An alternative modelling strategy, accordingly, would begin by linking expectations to the classes of new information on which market participants focus in attempting to explain day-to-day movements of exchange rates. New information about external balances and prices would appear to be particularly important, although it might be preferable to focus on new information about actual and prospective underlying shifts in policy variables.

However different the academic and market-oriented approaches may appear, the two alternative starting points for modelling expectations do not necessarily reflect conflicting notions about exchange rate behaviour. More specifically, in revising their exchange rate expectations in response to new information, market participants require frameworks for organising and evaluating the new information, and such frameworks can be presumed to generate expectations that are consistent with the properties of long-run equilibrium. Thus, market participants can be presumed to evaluate new information about price variables under the expectation that exchange rates will exhibit purchasing power parity in the long run, ceteris paribus. In addition, as will be elaborated below, market participants can be presumed to evaluate new information about balance-of-payments factors under the expectation that the timepath of real exchange rates - i.e., nominal exchange rates adjusted by relative price levels - will be consistent with preventing cumulative current-account imbalances from converging towards a point at which any one country becomes infinitely indebted to another.

4. A transformation of the accounting framework

Condition (3) is an accounting identity, not a behavioural model of exchange rates. Two of its right-hand-side elements are unobservable and must be modelled in terms of observable variables before the framework can be applied empirically.

As it stands, however, condition (3) suggests an important point that has been ignored by much of the existing empirical literature on exchange rate determination. To the extent that changes in exchange rates reflect revisions in expectations, it is important to distinguish between the expected and unexpected components of new information about explanatory variables.

The empirical objective of this paper is to test the importance of unexpected balance-of-payments statistics and variables underlying exchange-risk premiums. In order to incorporate the rôle of unexpected payments imbalances it is desirable to decompose the expected future nominal exchange rate into a real factor and a relative price-level term. We thus define the real exchange rate as

$$(8) \qquad sreal_T = s_T P^B_T / P^A_T$$

such that

$$(9) \qquad E_t \log(sreal_T) = E_t \log(s_T) + E_t \log(P^B_T / P^A_T)$$

Letting $\%\Delta_{t,T}P$ denote the percentage change in P between times t and T, we can furthermore write

$$(10) \qquad (P^A_T / P^B_T) = (P^A_t / P^B_t).((1+\%\Delta P^A_{t,T})/(1+\%\Delta P^B_{t,T}))$$

Together, (3), (9) and (10) then imply

$$(11) \qquad \log(s_t) = \log(P^A_t / P^B_t) + E_t \log(sreal_T) + risk_{t,T}$$
$$+ \left\{\log((1+r^B_{t,T})/(1+r^A_{t,T})) - E_t \log((1+\%\Delta_{t,T}P^B)/(1+\%\Delta_{t,T}P^A))\right\}$$

It is important to stress that condition (11) remains an accounting identity that is void of any behavioural assumptions. In providing a general accounting for exchange rates, it has an appealing additive structure and suggests several important points.

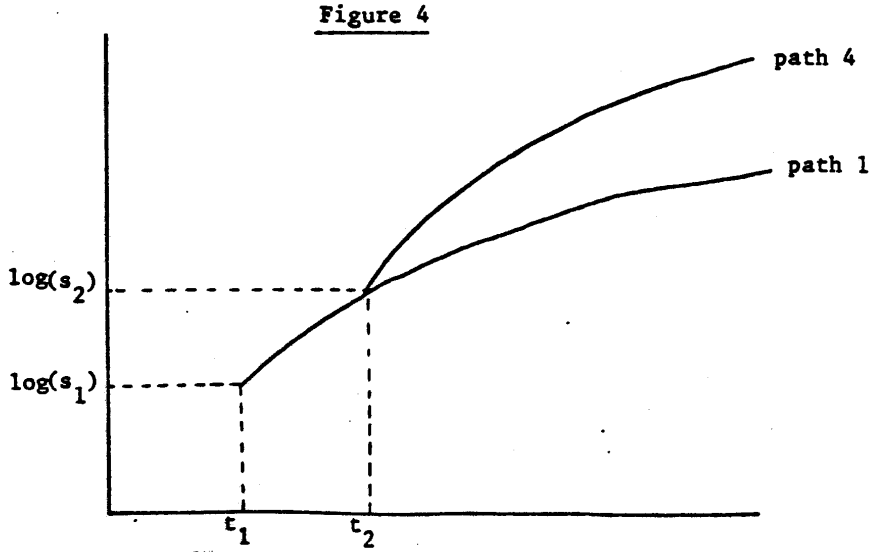
A first point to emphasise is the incompleteness of streamlined versions of the monetary approach to exchange rate determination. This refers to the approach of beginning with the hypothesis that

$$(12) \quad \log(s_t) = \log(P_t^A/P_t^B)$$

and then adding a theory of price levels. In addition to price levels condition (11) suggests that balance-of-payments factors[3], real interest rate factors and risk may have important bearings on exchange rates[4].

A second point revealed by condition (11) is that changes in nominal interest rate factors and changes in expected inflation factors have equal and opposite contemporaneous effects on exchange rates, ceteris paribus. Thus, exchange rates are affected by changes in the ratio of real interest rate factors - defined, in particular, as the last term on the right-hand side of (11) - but not, contemporaneously, by those changes in nominal interest rates that merely reflect shifts in inflation expectations. This is not to deny, however, that shifts in inflation expectations represent shifts in expected future paths of price levels and thus are accompanied by shifts in expectations about future nominal exchange rates. As illustrated by Figure 4, an unexpected change in nominal interest rate factors that reflected a revision in inflation expectations at time t_2 would cause the term structure of exchange rate expectations to shift from path 1 to path 4 at time t_2, but would not lead to an unexpected jump in the spot rate at time t_2.

Figure 4



5. Behavioural assumptions and the reduced-form model

In order to develop an empirically testable hypothesis about exchange rate behaviour we must model the unobservable variables on the right-hand side of condition (11). A prior issue, however, involves the choice of a dependent variable. Both the relative price level and nominal interest rate factors on the right-hand side of condition (11) are observable variables, and accordingly, their coefficients are identifiable and must be constrained to unity. We do this by transposing these terms to the left-hand side and thereby absorbing them into the dependent variable, along with a constructed measure of the expected relative inflation factor. Insofar as relative price levels and interest rates are conceived to be jointly determined with exchange rates, this transposition removes the necessity of modelling them at this stage.

Such a procedure implies, however, that the dependent variable will reflect the measurement error in the variable that we construct as a measure of the expected relative inflation factor. More precisely, the implied error in measuring percentage changes in the dependent variable amounts approximately to the error in measuring the expected difference between the inflation rates for the two countries. Thus, our modelling strategy implicitly presumes that we can proxy the expected inflation differential with errors that are moderately small relative to percentage changes in a "true" measure of the dependent variable, and that are not systematically related to the variables that we adopt to explain the terms remaining on the right-hand side of condition (11). Our specific proxy for expectations held at the end of period t about the relative inflation factor in period t+1 is constructed as a simple average of the actual relative inflation factors for periods t and t+1.

$$(13) \quad E_t(x_{t,t+1}) = (x_{t,t+1} + x_{t-1,t})/2$$

$$\text{where} \quad x_{T,T+1} = \log(1+\%\Delta_{T,T+1}P^B)/(1+\%\Delta_{T,T+1}P^A)$$

Thus, we assume that expectations reflect the simple average of a stationarity assumption and perfect foresight.[5] Needless to say, there is considerable scope to add sophistication here, either by moving towards autoregressive time series models of expected inflation factors or by moving towards behavioural models of inflation expectations.

We turn now to the question of how market participants form their expectations about future real exchange rates. Conveniently, it is sufficient to model how such expectations are revised, and to treat the initial level of these expectations as an unknown constant that is absorbed into the intercept term of the regression equation. We thus restrict our model of expected real exchange rates to the simple hypothesis that expectations about the future real value of the currency unit of any particular country are revised upwards in response to the release of new statistical information that indicates a greater than expected surplus (smaller than expected deficit) in that country's current-account balance. Our focus on the current account as a measure of international payments imbalance reflects a concern to model expectations about real exchange rates in a manner consistent with hypothetical properties of long-run equilibrium; this point will be elaborated below.

In the context of a two-currency model, our specific assumptions are

$$(14)\quad E_t\log(sreal_{t+1}) = E_{t-1}\log(sreal_t) + a^B(CAS^B_{t-1} - E_{t-2}CAS^B_{t-1}) - a^A(CAS^A_{t-1} - E_{t-2}CAS^A_{t-1})$$

and

$$(15)\quad E_{t-2}CAS^k_{t-1} = w^kCAS^k_{t-2} + (1-w^k)CAS^k_{t-1} \qquad \text{for } k=A,B$$

where CAS^A, CAS^B denote current-account surpluses; a^A, a^B are positive constants; and the weights w^k lie between zero and one. The time lags on current-account variables in condition (14) reflect a combination of the fact that balance-of-payments statistics are released with a lag and an assumption that current-account statistics for period t-1 begin to become "reliably predictable" around the end of period t. In condition (15) we again assume that expectations merely reflect a simple weighted average of stationarity and perfect foresight assumptions rather than a more general autoregressive process or a behavioural model. Adding a behavioural model of the current account would allow a distinction between different types of surprises about new current-account statistics - in particular, surprises due to unexpected transitory factors, including transitory deviations from projected price and activity paths, and surprises due to factors that might be perceived as permanent.

The distinction between different types of surprises about the current account is important if we believe that market participants form rational expectations about future exchange rates. In general, surprises about current accounts can be expected rationally to lead to a realignment of real exchange rates that is consistent with whatever revisions in risk premiums result from the associated revisions in expectations about future redistributions of world wealth. Thus, surprises about current accounts that are associated with transitory underlying factors may give rise to relatively minor revisions in expectations about future redistributions of world wealth, to relatively minor implied revisions in the term structure of risk premiums, and thereby to relatively small shifts in the expected future path of exchange rates. Conversely, surprises about current accounts that are associated with permanent underlying factors may give rise to relatively large shifts in the expected future path of exchange rates - and in particular, may give rise to expectations that a permanent shift in real exchange rates is required to prevent a permanent ongoing shift in the rate at which wealth is redistributed between countries with different portfolio preferences. To put the point differently, if real exchange rates did not adjust to prevent a permanent unidirectional shift in the expected path of the current account, the associated expected shift in the cumulative current account would converge towards an infinite shift in wealth from one country to another, which is implausible.[6] Thus it is rational to revise expectations about future real exchange rates in response to new information that would otherwise suggest a permanent unidirectional shift in current-account flows.

Given such considerations, we proceed towards empirical testing with explicit recognition that assumption (14) may be drastically oversimplified in failing to distinguish between permanent and transitory surprises about current-account balances. After substituting (15) into (14) and iteratively using the result to substitute for the expectations term on its right-hand side, we arrive at

$$(16) \quad E_t \log(sreal_{t+1}) = a_o - c_1 CAS^A_t + c_2 CAS^B_t$$

where $c_1 = a^A w^A$ and $c_2 = a^B w^B$ are positive parameters and a_o is a constant term that reflects the values of expectations and current-account balances in some initial period. Note that when (16) is substituted into condition (11), the currency-A value of currency B is positively related to CAS^B and negatively related to CAS^A.

We next turn to modelling the risk premium. As discussed above, this premium reflects the extent to which currency A must be expected to appreciate in order to equilibrate asset markets. Consequently, for given levels of interest rates, the risk premium is conceived to increase over time with increases in the relative stock of outside assets denominated in currency A, with an exogenous shift in portfolio preferences away from currency A, or with a shift in the international residence of private wealth towards countries with relatively weak preferences for currency A. At the same time that such factors increase the expected rate of appreciation of currency A, however, they are also conceived to generate immediate depreciations of currency A. Thus, the greater expected appreciation of currency A is conceived to reflect a depreciation of the forward price of currency A that exceeds any reduction in the expected future spot price.

Among the factors on which risk premiums depend, acceptable data can be assembled on the stocks of outside assets denominated in different currencies. Data on private financial wealths are more difficult to construct, however, in part because currency diversification makes it difficult to keep track of the capital gains and losses that derive from changing exchange rates. Finally, "exogenous shifts" in portfolio demand parameters cannot be observed directly but might plausibly be modelled in terms of other variables or as responses to major events.

Given these data considerations we have chosen to model the risk premium as a linear function of the stocks of outside assets denominated in currencies A and B (denoted D^A and D^B) along with an estimate of OPEC wealth (WOPEC).

$$(17)\quad \text{risk}_{t,t+1} = b_o + c_3D_t^A - c_4D_t^B + c_5\text{WOPEC}_t$$

The rise in the relative price of oil and the rapid growth of OPEC wealth are widely viewed to have had a significant impact on exchange markets during our sample period (since early 1973), and it seems particularly interesting to try to measure this impact. By the arguments above, we expect c_3 and c_4 to be positive, but c_5 can be either positive or negative depending on whether OPEC countries have relatively weaker preferences for currency A than do non-OPEC countries.[7]

We can now collect assumptions to write our reduced-form model. The dependent variable will be denoted by

$$(18)\quad Y_t = \log(s_t) - \log(P_t^A/P_t^B)$$

$$- \log((1+r^B_{t,t+1})/(1+r^A_{t,t+1})) + E_t(x_{t,t+1})$$

where $E_t(x_{t,t+1})$ is the expected relative inflation factor defined by equation (13). Together with conditions (11), (16) and (17), this leads to the specification hypothesis.

$$(19)\quad Y_t = c_o - c_1\text{CAS}^A_{t-1} + c_2\text{CAS}^B_{t-1} + c_3D_t^A - c_4D^B{}_t$$

$$+ c_5\text{WOPEC}_t$$

where $c_o=a_o+b_o$; c_1,c_2,c_3, and c_4 are positive parameters; and c_5 may be positive or negative.

6. Empirical evidence

To test our model we have examined its ability to explain month-to-month changes in the US dollar (currency A) price of the Deutsche Mark (currency B) during the 78-month period from April 1973 through September 1979. Our data on exchange rates and Euro-currency rates are measured end-of-month; the price variables are a German export price index and US export unit value index; current-account data consist of seasonally-adjusted quarterly observations assigned to mid-quarter months, with linear interpolation in between; the stock of outside dollar-denominated debt is taken to be US Federal Government debt in the hands of the public minus US liabilities to foreign official institutions; the stock of outside Mark-denominated debt is taken to be German Federal debt plus cumulative official German purchases of foreign exchange reserves; and WOPEC is constructed as the cumulative OPEC current-account surplus (based on IMF estimates[8]) based on a summation beginning in March 1973.

The ordinary least-squares fit of specification (19) is

$$
\begin{array}{llllll}
(20)\quad Y = & .983 & -.00538\ CAS^{US}_{-1} & -.00426\ CAS^{G}_{-1} & -.00175\ D^{US} & \\
 & (11.8) & (-2.57) & (-1.41) & (-4.16) & \\
 & +.00423\ D^{G} & -.00053\ WOPEC & & \bar{R}^2 = .62 & \\
 & (8.87) & (-1.68) & & DW = .852 &
\end{array}
$$

where numbers in parentheses are t-values. The estimated coefficients on the German current account and the two stocks of outside debt have signs that conflict with our prior expectations.

A major statistical problem with regression (20) is that D^{US}, D^{G} and WOPEC are highly collinear. Among these variables, D^{G} is the most difficult to defend as independent of the exchange rate and the other right-hand-side variables, given that German authorities reacted continuously to exchange rate pressures during the sample period and, in addition, were subjected to strong international pressures to apply fiscal stimulus in parallel to the United States. Accordingly, this variable is discarded and the consequent ordinary least-squares fit becomes

$$
\begin{array}{lllll}
(21)\quad Y = & .678 & -.00654\ CAS^{US}_{-1} & +.00665\ CAS^{G}_{-1} & +.00106\ D^{US} \\
 & (6.22) & (-2.18) & (1.68) & (2.64) \\
 & -.00098\ WOPEC & & \bar{R}^2 = .22 & \\
 & (-2.21) & & DW = .381 &
\end{array}
$$

In this case the estimated coefficients on both current-account variables and the dollar debt variable have correct signs, and a shift in wealth towards OPEC is estimated to strengthen the dollar again the Mark.

The explanatory power of regression (21) is not impressive by conventional standards,[9] but the purpose of presenting it is merely to suggest that there may be mileage in building further or rebuilding on the basic modelling framework from which it was developed. Goodness-of-fit comparisions with alternative predictors can be appreciated by using Figures 5 and 6 to help interpret the message of conventional statistics.

In Figure 5, the model prediction from regression (21) - when transformed into a prediction of the nominal exchange rate (logrithmic value) -has a low but significant correlation of .26 with the realised exchange rate, whereas the forward-rate prediction has an insignificant correlation of .04 with the future spot rate. On the other hand, the forward rate corrects its prediction errors right away by closely following whatever value of the spot rate is current, whereas prediction errors from equation (21) are more persistant and result in a larger root-mean-squared error (14.7 per cent.) than that associated with the forward-rate prediction (8.4 per cent.). The cynical view of the model prediction is that, like most least-squares fits, it smooths the observed cycles in exchange rate behaviour and its persistent or serially-correlated prediction errors are largely a statistical phenomenon. Alternative views are that the model may have longer foresight than the market, or that the model omits an explanatory variable that has cyclical effects on market exchange rates (relative to model predictions).

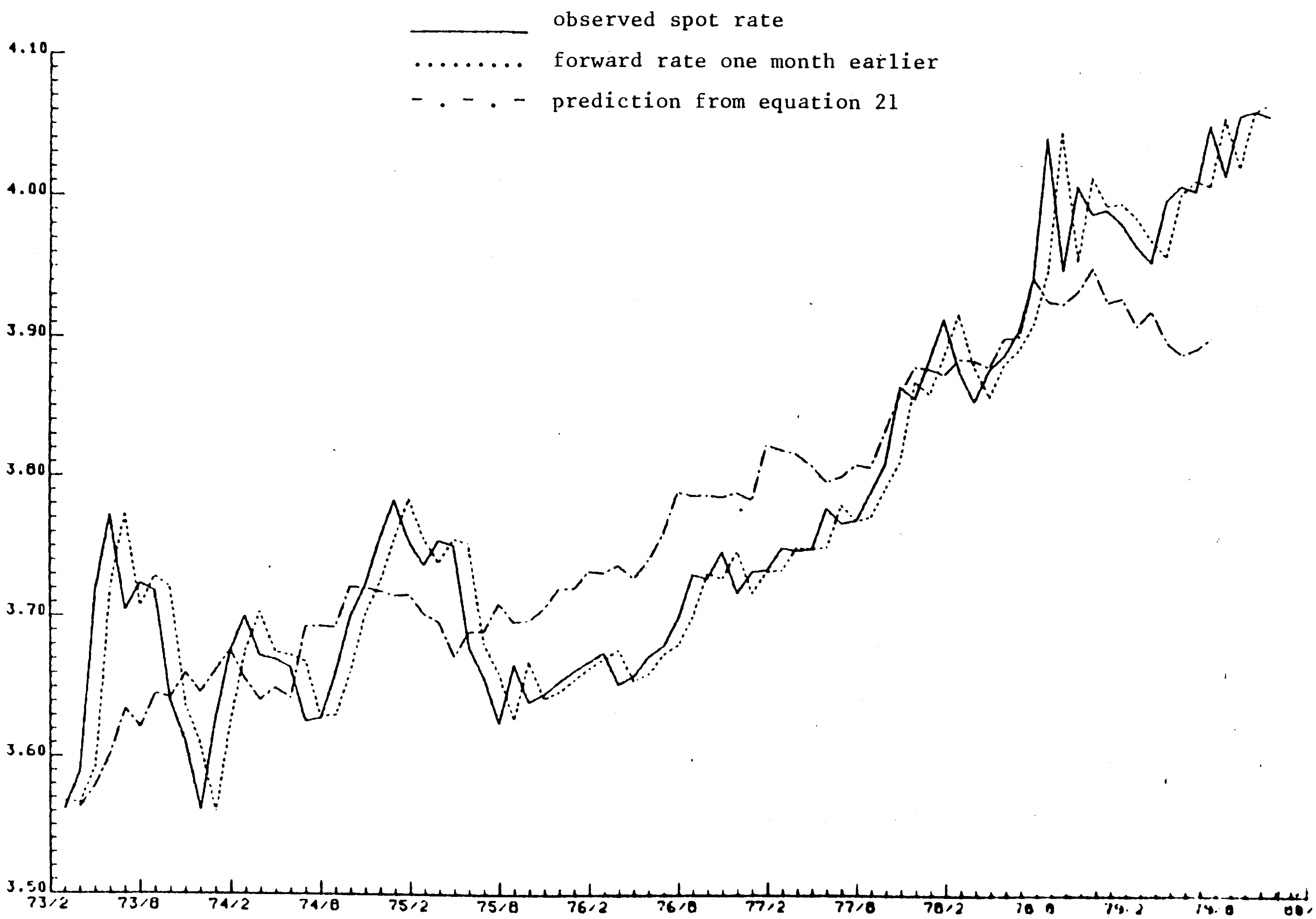
In Figure 6 the dotted curve is the prediction based on relative price levels or purchasing-power parity; the other two curves are the same as in Figure 5. The visual evidence here is in favour of the model prediction, which after mid-1974 stays considerably closer to the realised spot rate than does the purchasing-power parity predictor. The coefficient of correlation between the observed exchange rate and the purchasing-power parity predictor is .13. The root-mean-squared error in the purchasing-power parity prediction is 17.5 per cent. On both statistical measures the model is an improvement over simple purchasing-power parity.

7. Summary and suggestions for further empirical work

This paper has focused primarily on conceptual issues. A minimal statistical analysis has been added to illustrate the empirical validity of

cents per Mark
(logrithmic value)

Figure 5



cents per Mark
(logrithmic value)

Figure 6

the conceptual framework, but the regression hypothesis is based on oversimplified assumptions and leaves considerable scope for improvement.

In focusing on conceptual issues, the paper has built upon existing literature in two directions. Building upon Mussa (1976, 1979), Barro (1978), Bilson (1978), Dornbusch (1978), Dooley and Isard (1979b), Frenkel (1980) and others, the paper begins from the presumption that observed changes in exchange rates are predominantly unexpected ex ante and goes on to distinguish between the different types of surprises that underlie exchange rate changes. This leads to an accounting identity that relates the exchange rate in a separably additive manner to relative price levels, the expected future real terms of trade, relative real interest rate factors and an exchange risk premium. As an identity with a separably addititive structure, such an equation provides an attractive foundation for building empirically upon monetarist models of exchange rate determination.

The empirical usefulness of the exchange rate identity is to test behavioural models of the expected real terms of trade, real interest rates and the exchange-risk premium. The second direction in which this paper has attempted to build conceptually is to use Dooley and Isard's (1979a,b) model of exchange-risk premiums to argue that unexpected information about current-account flows can lead rationally to revisions in expectations about future real terms of trade. This is particularly true when unexpected shifts in current accounts are due to underlying changes that are perceived as permanent, since without a change in the real terms of trade a unidirectional permanent shift in the current account would cumulate to shift an infinite amount of wealth between countries, which is implausible. Accordingly, recognition of the rôles of wealth and exchange risk provides a framework for incorporating balance-of-payments flows into a rational expectations version of the asset-equilibrium model. Empirical work in this direction, such as that by Hooper and Morton (1979), seems required to bridge the apparent gap between the views of market participants and academic economists. This gap reflects the fact that most market participants take positions on the basis of short-run expectations and appear to revise their expectations in response to unexpected information about balance-of-payments statistics, while the majority of academic economists profess that exchange rate expectations must conform to a consistent hypothesis about the properties of equilibrium, even though full equilibrium is no more than a fictional description of the long run.

The econometric analysis of this paper is intended to test the notions that changes in public debts and private wealths have impacts on exchange rates via their influence on risk premiums, and that unexpected information about current-account flows can accordingly lead in a rational way to revisions in expectations about future exchange rates and thereby to unexpected jumps in observed exchange rates. The empirical investigation is limited in the following respects.

One major limitation is that expectations about current-account balances and inflation rates are modelled as simple blends of a stationarity assumption and perfect foresight. It would be more appealing to assume that expectations are based rationally on behavioural models of current accounts and inflation, or possibly to draw expectations from a sophisticated application of autoregressive time-series procedures.

A second major limitation is that the behavioural model does not distinguish between surprises about balance-of-payments statistics that are attributable to transitory factors and surprises that are viewed as the result of permanent changes in underlying factors. This distinction seems very important in modelling the impact of current-account surprises on expectations about future real terms of trade.

A third major limitation is the treatment of outside asset stocks as exogenous, which ignores the policy reaction functions that underlie official foreign exchange interventions, fiscal budget deficits and interventions in domestic money markets. These considerations support the extension of exchange rate modelling, following Artus (1976), to incorporate policy reaction functions in small simultaneous equation systems.

A fourth limitation is due to the inadequacy of data on the currency compositions of private wealths and public debts. Available data are very incomplete but can nevertheless be used more extensively than this paper has used them.

In view of these limitations, it is encouraging to find weak evidence that current-account imbalances, asset stocks and wealth variables have affected the dollar/Mark exchange rate in a manner that is consistent with a rational expectations version of the asset-equilibrium model.

References

Aliber, Robert Z. "The Interest Rate Parity Theorem: A Reinterpretation." Journal of Political Economy 81, November 1973.

Artus, Jacques R. "Exchange Rate Stability and Managed Floating: The Experience of the Federal Republic of Germany." IMF Staff Papers, 23, July 1976.

Barro, Robert J. "A Stochastic Equilibrium Model of an Open Economy Under Flexible Exchange Rates." Quarterly Journal of Economics XVll (no. 1), February 1978.

Bilson, John F.O. "Rational Expectations and the Exchange Rate." In Frenkel, J.A. and Johnson H.G. (eds.), The Economics of Exchange Rates: Selected Studies. Reading, Mass: Addison-Wesley, 1978.

Dooley, Michael P. and Isard, Peter. "A Portfolio-Balance Rational-Expectations Model of the Dollar-Mark Rate: May 1973-June 1977." Federal Reserve Board, International Finance Discussion Paper No. 123, revised May 1979a.

________ "The Portfolio-Balance Model of Exchange Rates." Federal Reserve Board, International Finance Discussion Paper No. 141, May 1979b.

________ "Capital Controls, Political Risk and Deviations from Interest-Rate Parity", Journal of Political Economy, forthcoming 1980.

Dornbusch, Rudiger. "Monetary Policy Under Exchange Rate Flexibility". In Managed Exchange Rate Flexibility: The Recent Experience.

Federal Reserve Bank of Boston Conference Series, No. 20, 1978.

Frankel, Jeffrey A. "The Diversifiability of Exchange Risk." Journal of International Economics, August 1979.

Frenkel, Jacob A. "Flexible Exchange Rates in the 1970's." In Stabilisation Policy: Lessons from the 1970's and Implications for the 1980's, Center for the Study of American Business at Washington University, St. Louis, Missouri, forthcoming 1980.

Hooper, Peter and Morton, John. "Fluctuations in the Dollar: A Model of Nominal and Real Exchange Rates." Federal Reserve Board, processed draft, July 1979.

Mussa, Michael. "The Exchange Rate, the Balance of Payments, and Monetary and Fiscal Policy Under a Regime of Controlled Floating." Scandinavian Journal of Economics 2, 1976.

_______ "Empirical Regularities in the Behaviour of Exchange Rates and Theories of the Foreign Exchange Market." Vol. 11 of the Carnegie-Rochester Conference Series on Public Policy, a supplementary series to the Journal of Monetary Economics, 1979.

Footnotes

1 Throughout this paper, interest rates refer to yields on Euro-currency deposits or other assets that are known to satisfy the interest rate parity condition.

2 Aliber (1973) has emphasised that risk in asset markets can be associated with uncertainty about factors other than exchange rates. Dooley and Isard (1980) provide a model of political-risk premiums in terms of asset stocks and wealth variables, with assets distinguished by the residence of the issuer rather than by currency of denomination. Such a model illustrates that political-risk premiums and exchange-risk premiums are interrelated.

3 We take the view here that balance-of-payments factors underlie expectations about future real exchange rates.

4 This language should not be taken to suggest that causation necessarily begins with price levels, balance-of-payments factors, real interest rate factors or risk premiums. In most cases it is preferable to view such variables as endogenously determined by other underlying exogenous factors.

5 Because data as originally released are not conveniently available, variables are measured to include the revisions that had been incorporated into published statistics as of March 1980.

6 This argument is not invalidated by ignoring asymptotic cases in which the shift in the current account path becomes infinitesimal at its long-run limit.

7 In this connection it is instructive to consider the general belief that the energy endowments of Germany-Switzerland, the United Kingdom and the United States are, respectively, inadequate for home consumption needs, roughly equal to home consumption needs, and in excess of home consumption needs in the long run. Accordingly, a rise in the relative price of energy reduces the real wealth of Germany-Switzerland, has little effect on the real wealth of the United Kingdom and raises the real wealth of the United States. Such wealth effects, however, are not inconsistent with appreciations of the Mark and the Swiss franc relative to the pound, and the pound relative to the dollar. This can be seen by aggregating Germany, Switzerland, the

United Kingdom and the United States with the rest of the non-OPEC world, and by considering the effects of a transfer of real wealth from non-OPEC to OPEC. Let q^o_{GS}, q^o_{UK}, q^o_{US} and q^o_{OC} denote the shares of OPEC wealth that are denominated in Marks or Swiss francs, in pounds, in dollars and in other currencies; and let q^n_{GS}, q^n_{UK}, q^n_{US} and q^n_{OC} denote the corresponding shares of the combined wealth of the non-OPEC world. Then a shift in real wealth towards OPEC will lead to an appreciation of the Mark and the franc relative to the pound, and the pound relative to the dollar, <u>ceteris paribus</u>, if OPEC has relatively very strong preferences for Marks and francs and relatively strong preferences for pounds (i.e., if $q^o_{GS} - q^n_{GS} > q^o_{UK} - q^n_{UK} > 0$) along with little or no desire to hold other non-dollar currencies ($q^o_{OC} \approx 0$), and if non-OPEC preferences for other non-dollar currencies are sufficiently weak that $q^o_{US} - q^n_{US} \approx q^n_{OC} - (q^o_{GS} - q^n_{GS}) - (q^o_{UK} - q^n_{UK}) < 0$. Needless to say, these "ifs" are hypothetical and may well conflict with the facts.

8 Annual current-account estimates are distributed uniformly over months in each year except 1974. In 1974 the assumed shares were 1/18th of the annual total for months in the first quarter, 1/9th for months in the second quarter and 1/12th for months in the second half of the year.

9 Correction of first-order serial correlation substantially increases the R^2 statistic and reduces the t-values on all coefficients without changing the signs of any coefficients. However, the validity of using purely statistical techniques to correct for serial correlation is questionable. There is a strong presumption that the serial correlation may largely reflect the over-simplified assumptions that underlie our specification hypothesis and, accordingly, initial efforts to eliminate serial correlation should focus on improving the model specification.