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FACTORS DETERMINING EXCHANGE RATES: THE ROLES OF RELATIVE PRICE LEVELS, BALANCES OF PAYMENTS, INTEREST RATES AND RISK

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1. Introduction

This paper focuses on an accounting framework that is useful for distinguishing between the effects on exchange rates of four separate factors: relative price levels, balances of payments, interest rates and risk. The framework rests upon an approximate identity, developed in Section 2, which is transformed into a behavioral model of exchange rates in Sections 3-6. Section 6 reports the results of applying the model in an attempt to explain the month-to-month behaviour of the US dollar versus the Deutsche Mark during the 1975-79 period. Section 7 presents a summary and some conclusions.

In attempting to explain the observed behaviour of exchange rates in terms of "fundamental factors" such as relative price levels, balances of payments, interest rates and risk, the challenge is to understand how changes in these fundamental factors influence market psychology or expectations. As Keynes (1936, Chapter 12) put it: "the energies and skill of the professional investor and speculator are mainly occupied...not with making superior long-term forecasts...but with what the market will value.../the investment/ at, under the influence of mass psychology, three months or a year hence." Moreover, in seeking to understand how changes in fundamental factors are channelled, through their impacts on market expectations, to changes in observed exchange rates, an important piece of information is the fact that market expectations have foreseen only a minor portion of actual changes in exchange rates from the perspective of a month or a quarter in advance. Specifically, insofar as forward exchange rates can be taken to approximate the average of market expectations about future spot rates, it is a striking fact that "over 90 per cent. of month-to-month or quarter-to-quarter changes in exchange rates are...unexpected".[2] Alternatively

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For footnotes please see page 37.

stated, over 90 per cent. of changes in exchange rates reflect revisions in expectations from what had been anticipated a month or a quarter earlier. The implication is that attempts to explain the short run volatility of exchange rates should focus on revisions in expectations caused by changes in fundamental factors that had not been anticipated a month or a quarter earlier.

Although such an implication presents a pessimistic outlook for the accuracy of forecasts, it does not preclude the usefulness of retrospective explanations of exchange rate behaviour, which can be valuable in casting light on how policy stances and the uncertainties surrounding them have contributed both to cyclical swings and to longer term movements in currency values. In this context, one of the conclusions drawn from the accounting framework and empirical findings of this paper is that changes of one or two percentage points in nominal interest differentials or expected inflation differentials, per annum, can be associated with much larger changes in real interest differentials compounded over a longer horizon and appear, consistently, to have explained much of the volatility in the dollar/Mark exchange rate since the mid-1970s.

2. An approximate accounting identity

This section focuses on an approximate accounting identity that relates changes in exchange rates to four separate and additive fundamental factors: (i) different rates of change in national price levels, or purchasing power parity factors; (ii) revisions in expectations about the "long run" real exchange rate, which can be viewed to reflect balance of payments factors; (iii) revisions in expectations about the compounded real interest differentials that would accumulate over the "long run" on assets denominated in different currencies; and (iv) changes in the premium for bearing exchange risk, which is a reflection of portfolio balance factors. Much of the discussion and explanation of the last three of these factors is presented after developing the accounting framework, in Sections 3-5 respectively. By itself, the identity is no more than a conceptual framework. Testable models of exchange rate behaviour require that the identity be supplemented by theories or behavioral assumptions about how expectations are formed and revised, and about how the risk factor should be measured.

The approximate accounting identity can be written in terms of the following notation

(1) $\%\Delta S = (\%\Delta P_A - \%\Delta P_B) + \%\Delta SREAL^e + \Delta(r_B^e - r_A^e) - \%\Delta RISK^e$

purchasing power parity factor	balance of payments factor	real interest rate factor	risk or portfolio balance factor

where

S is the spot exchange rate, in units of currency A per unit currency B

P_A, P_B are the price levels in countries A and B

$SREAL^e$ is the expectation held currently of the real exchange rate that will prevail in the "long run"

r_A^e, r_B^e are the compounded real rates of interest - i.e. nominal rates of interest adjusted for inflation - that investors currently expect they could accumulate over the "long run" on assets denominated in currencies A and B. The units here are per cent. per long run, not per cent. per year

$RISK^e$ reflects the premium that investors expect to earn by bearing exchange risk

and

Δ, $\%\Delta$ denote changes and percentage changes

The derivation, presented in Appendix A, combines the interest rate parity condition with definitions of the exchange risk factor, the real exchange rate and real rates of interest. 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; thus

(2) $S = F(1+R_B)/(1+R_A)$

where F denotes the forward exchange rate and R_A, R_B denote nominal interest rates. The risk factor, which will be motivated and discussed in Section 5, is defined as the ratio of the expected future spot rate to the forward rate, where the former is denoted by S^e:

(3) $RISK^e = S^e/F$

This factor would be identically one in a risk neutral world in which forward rates were always equal to expected future spot rates, and in such a world the risk term would vanish from accounting identity (1). The real exchange rate, defined in the familiar way, is the nominal exchange rate adjusted for different price levels:

(4) $SREAL = S.P_B/P_A$

Real long-run rates of interest, which are defined precisely in Appendix A, can be viewed as the traditional approximations

(5) $r_A = R_A - \hat{P}_A^e$

(6) $r_B = R_B - \hat{P}_B^e$

where $\hat{P}_A^e$, $\hat{P}_B^e$ represent the percentage changes in price levels that are expected to occur over the long run.

For convenience the accounting identity has been expressed in terms of percentage changes. Alternatively, by using definition (3) to substitute for F in condition (2), we can visualise an underlying multiplicative identity that relates the current level of the exchange rate to an expected future level. This "level" equation reveals a basic conceptual difficulty in explaining exchange rates: the current level of the exchange rate can only be explained by somehow pinning down an expected future level; and consistently, observed changes in the exchange rate can only be explained in terms of revisions in expectations about the exchange rate that will prevail on some date in the future.[3]

In this context, the formulation of accounting identity (1) reflects the choice to confront the problem by attempting to pin down revisions in expectations about the real exchange rate in the "long run". Existing economic theory provides no help in pinning down an expected level of the exchange rate unless we imagine a long-run state in which the balance of payments and/or the real exchange rate are assumed either to be stationary or to move along equilibrium time paths. Unfortunately, however, there is no general consensus on when the long run is reached. Thus, where quantification is required to apply the accounting identity empirically, we assume that it is expected to take up to but no longer than 5 years to reach the long run, partly reflecting the fact that data on Euro-currency interest rates are not readily available for maturities longer than 5 years, and partly reflecting a notion that poor foresight makes stationary or steady-growth "equilibrium" the best prediction for the more distant future. The empirical analysis can be sensitive to this assumption insofar as it may affect the measure of the expected real interest differential, which is expressed as a percentage compounded over a horizon that extends at least until the time at which the long run is reached.[4]

Turning to another conceptual point, it is worth noting again that three of the four components of exchange rate changes, as defined in accounting identity (1), reflect changes or revisions in expectational variables.[5] In this sense, given the particular volatility of the expected real interest differential, observed changes in exchange rates can be predominantly unexpected ex ante - i.e. predominantly the result of new information or events that surprise market participants and lead them to revise their expectations ex post.[6]

Without the last three components, accounting identity (1) would boil down to a theory of continuous purchasing power parity. Conversely, the identity provides three explanations for purchasing power disparities, as will be discussed further in the next three sections. As a general framework, the identity can be collapsed under special assumptions to provide the foundations for different classes of exchange rate models. Monetarist models build primarily on the purchasing power parity component, adding a theory of price levels or inflation rates in terms of money stocks, income levels and interest rates, and generally ruling out risk factors and changes in the expected long-run real exchange rate.[7] Interest rates generally enter through the theory of price levels in the form of short-term yields. Few if any models of exchange rate determination have focussed explicitly on the expected real interest differential compounded over a long-run horizon, as represented by the third component of the basic accounting identity.[8]

As will be elaborated upon in Section 5, the debate between the monetarist and portfolio balance views centres on whether exchange risk can be ignored, or on whether assets denominated in different currencies could be regarded as perfect substitutes if they offered the same expected returns to investors. The portfolio balance view answers no and attaches importance to the risk term in the accounting identity, modelling the risk factor in terms of wealth variables and stocks of bonds as well as money.[9] As is also elaborated upon in Section 5, the risk factor provides an explicit channel through which exchange rates are directly affected (independently of any changes in interest rates or inflation expectations) by official foreign exchange interventions and public budget deficits, and a second channel through which current-account imbalances can be influential.

3. The expected long-run real exchange rate: how important are balance-of-payments factors?

Balance-of-payments views of exchange rate determination predate Adam Smith by at least a century[10] and occupy a dominant position in most textbooks on international economics. This dominant position has been strongly challenged over the past two decades, as focus has shifted towards viewing exchange rates and interest rates as variables that equilibrate the demands for and supplies of <u>stocks</u> of financial assets, rather than balance-of-payments <u>flows</u>. But recent years have brought a resurgence of sentiment for balance-of-payments factors, particularly after witnessing the behaviour of exchange rates that accompanied the emergence of surprisingly large current-account deficits for the United States during 1977-78.

Among viewpoints that are consistent with the concept of asset stock equilibrium, there are several notions of why unexpected shifts in balance-of-payments flows will lead to revisions in expectations about the long-run real exchange rate, and thereby, according to the accounting identity, to observed changes in nominal exchange rates as well. A first notion follows from the simplified vision of an economy moving over the long run towards a steady state. While such a perception is often adopted merely as a model building convenience, it may also reflect the best image that very poor foresight can provide of the long run, in which distant fluctuations appear blurred. According to this notion, wealth variables in the long run are perceived to change along well-defined equilibrium paths, with current accounts, consistently, either in balance or flowing in well-defined equilibrium patterns.[11] Thus, unexpected shifts in current-account flows in the short run create expectations that the real exchange rate will adjust in the long run by whatever amount is necessary to re-establish the current account on a path that converges to equilibrium.

A second notion focusses on policy reactions in suggesting why the real exchange rate can be altered by unexpected shifts in balance-of-payments flows. Even if balance-of-payments flows are small relative to existing stocks of assets and wealth, the expectation that policy authorities will act to reduce payments imbalances can lead to a systematic response of exchange rates to surprises about the balance of payments. Such expectations of policy reactions were clearly in evidence during the Bretton Woods regime of adjustable pegs, when official international permission or pressure to adjust exchange rates was based on the concept of "fundamental disequilibrium", which in practice became generally viewed as a state of persistent currrent-account imbalances. The validity of the argument is limited, however, to expectations of policy reactions that are likely to have a permanent influence on the exchange rate. The notion is not valid when the expected policy actions are cyclical stabilisation measures, although expectations of such measures may result in revisions in expected real interest rates and affect the exchange rate through the third component of the accounting identity.[12]

Under each of these notions, <u>revisions</u> in expectations about the long-run real exchange rate must be modelled in terms of <u>unexpected</u> components of balance-of-payments flows, and attempting to separate the unexpected from the expected components of balance-of-payments flows is a difficult task. A second difficulty is to further separate the unexpected balance-of-payments flows into those that can be explained by cyclical or other transitory factors and those which are perceived to reflect permanent shifts that, once reported, are expected to be offset by movements in the long run real exchange rate.[13] There would be little cause to revise expectations about the long-run real exchange rate in response to a balance-of-payments shift which reflected an unexpected change in relative activity levels that was viewed as temporary - for example, if it was expected initially that activity growth would slow down worldwide and the surprise merely involved international differences in the timing of slowdowns that did not change the medium-term outlook for relative activity levels and payments balances.

Conceptually, an appealing procedure is to model revisions in expectations about the long-run real exchange rate in terms of errors in forecasts of balance-of-trade flows that cannot be attributed to unforeseen cyclical movements in explanatory variables. Because monthly data on errors from sophisticated balance-of-trade models are not readily available, however, the results reported in this paper rely on an oversimplified measure of the unexpected component of the balance of trade: namely, the reported balance of trade minus the average of the trade balances reported for the previous three months. The cyclical component that is subtracted from the unexpected trade balance is then defined as the component that is explained by regression on both domestic and foreign cyclical indicators, and the residual or non-cyclical component, viewed ex post, is adopted as a measure of the trade imbalance that was "expected to be corrected" via movements in the real exchange rate.[14]

4. Changes in expected real interest differentials: explaining the the short-run volatility of exchange rates

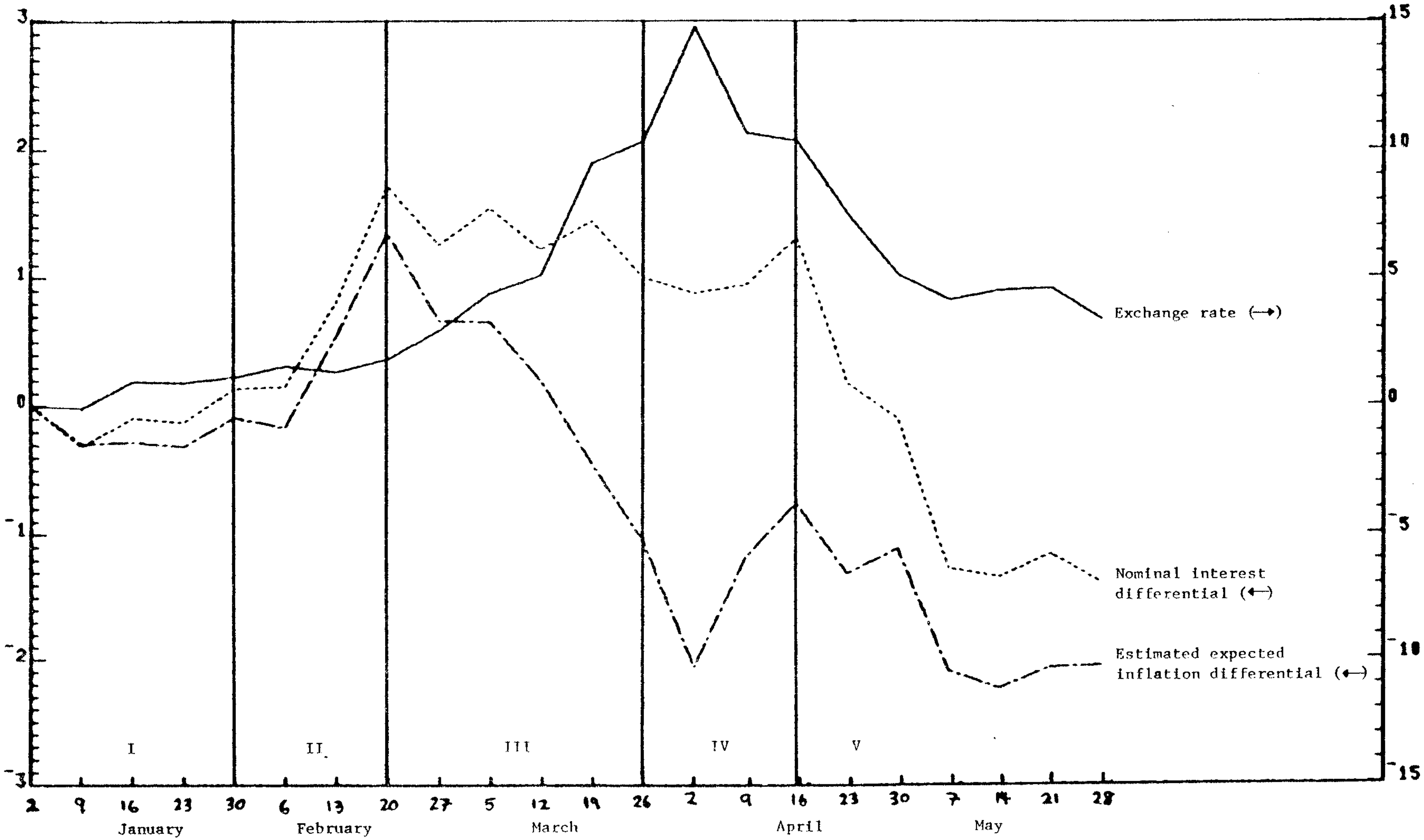
Given expectations about what the real exchange rate will be in the "long run", exchange rates in the short run will be observed to fluctuate in real terms (i.e. relative to purchasing power parity levels) with any revision in expectations about the compounded real interest differentials that can be earned over a period that extends until the "long run" is reached. Moreover, expectations about real interest differentials compounded over periods as long as five years, for example, can be quite volatile and would appear capable of explaining most of the short-run instability of exchange rates. As represented by the third term in accounting identity (1), such expectations are continuously revised in response to updated information on economic statistics, statements by policy authorities and/or market rumours. The revision of expectations is a psychological process in which rational responses to incomplete and gradually emerging information can easily give rise to volatile speculative bandwagons and to overshooting.

An illustration is provided by the experience from January through May of 1980, when movements of the US dollar vis-à-vis the Continental European currencies were both volatile and dominated by differential movements in interest rates and expected inflation rates. Figure 1 shows the cumulative week-to-week movements in the Deutsche Mark price of the dollar compared with cumulative changes in the difference between interest rates on 5-year Euro-dollar and Euro-Mark deposits.[15] The associated values of the exchange rate and interest rates are shown in Table 1. Rather than plotting cumulative changes in the interest differential compounded over the 5-year maturity of the Euro-deposits, the graph uses two different vertical scales in order to compare changes in the annual interest differential with one-fifth of the cumulative percentage changes in the exchange rate. Ignoring changes in the expected long-run exchange rate and the risk premium, the residual or discrepancy between the scaled-down percentage change in the exchange rate and the change in the interest differential can be regarded as an estimate of the revision in expectations about the expected differential rate of inflation, measured at an annual rate averaged over a 5-year horizon.

The time path of the estimated expected inflation differential seems quite plausible and, accordingly, it seems quite plausible that the volatility of the exchange rate during the first five months of 1980 predominantly reflected revisions in expectations about the real interest differential. During January there was little movement in the three curves shown in Figure 1. Sub-period II on the graph began right after the US budget proposals and the Economic Report of the President were released on 28th and 30th January respectively. The subsequent three weeks brought an upward revision in the expected pace of US inflation: by 6th February it had been discovered that the US Budget had substantially underestimated the

Figure 1

Changes in the exchange rate, nominal interest differential and estimated expected inflation differential*



* Cumulative changes since the beginning of 1980 based on Wednesday data. The exchange rate curve shows the percentage change in the Deutsche Mark price of the dollar. The interest differential is the Euro-dollar rate minus the Euro-Mark rate on 5-year deposits, in percentage points per annum. The third curve is the difference between the first two, which represents an estimate of the expected difference between US and German inflation rates, in percentage points per annum.

Table 1

Exchange Rates and Interest Rates on 5-year Euro-deposits[1]

		DM/$	Euro-dollar rate	Euro-Mark rate[2]	Differential[2]
January	2	1.7145	11.75	7.85	3.90
	9	1.7127	11.81	8.23	3.58
	16	1.7306	11.88	8.08	3.80
	23	1.7303	12.00	8.23	3.77
	30	1.7340	12.50	8.46	4.04
February	6	1.7414	12.63	8.58	4.05
	13	1.7374	13.25	8.54	4.71
	20	1.7460	14.50	8.89	5.61
	27	1.7649	14.75	9.60	5.15
March	5	1.7897	15.00	9.57	5.43
	12	1.8017	14.88	9.77	5.11
	19	1.8760	15.25	9.92	5.33
	26	1.8902	15.00	10.11	4.89
April	2	1.9664	15.13	10.35	4.78
	9	1.8960	15.00	10.16	4.84
	16	1.8908	14.63	9.43	5.20
	23	1.8420	12.63	8.56	4.07
	30	1.8015	12.13	8.33	3.80
May	7	1.7850	11.38	8.75	2.63
	14	1.7914	11.25	8.69	2.56
	21	1.7926	11.38	8.64	2.74
	28	1.7717	10.88	8.37	2.51

1 Data are taken from various issues of The Money Manager. Interest rates and differentials are expressed in percentage points per annum.

2 Constructed; see footnote 15 of the text.

costs of military outlays for fuel; by 13th February new data showed a strong acceleration in US retail sales during January; by 20th February it had been revealed that US wholesale prices had jumped 1.6 per cent. during January, a sharp acceleration from December; and on 22nd February it was reported that US consumer prices had also accelerated sharply in January. Nevertheless, the exchange rate remained relatively stable throughout those weeks as the Euro-dollar rate increased by 2 percentage points, and by 1½ percentage points more than the Euro-Mark rate.

The news of the January rise in US consumer prices ushered in sub-period III on the graph as financial markets, according to Reuters, reacted "perversely". The consumer price data strengthened expectations of further anti-inflationary policy measures by the US authorities - expectations that were confirmed by the new budget proposals and monetary and credit actions of 14th March. According to the estimates shown on the graph, the expected US inflation rate was revised downwards over the course of a month by roughly 2 percentage points relative to the expected German inflation rate, and the dollar appreciated strongly against the Mark even though nominal Euro-Mark rates moved up somewhat faster than Euro-dollar rates.

Sub-period IV on the graph began on 27th March with the decision, announced following the fortnightly meeting of the Bundesbank Central Council, that German credit policies would be left unchanged. The apparent upward revision in expectations about the pace of German inflation, relative to US inflation, was supported on 2nd April by the report of a full half percentage point drop in the German unemployment rate during March. Additional support may have been provided by major new banking legislation, passed by the US Congress on 28th March, which strengthened the Federal Reserve's control over money and credit growth. During the first four trading days of April, spanning the long Easter weekend, the dollar wavered around a level 4 per cent. higher than where it had closed on 26th March. Then it dropped the full 4 per cent. on 9th April. Among the news that may have convinced the market it had overshot was the announcement late on 8th April that the German Government had arranged to borrow one billion Marks from the US Government, the release of data on 9th April indicating no change in German industrial production during February, and the prediction by a respected US banker that dollar interest rates would soon begin to tumble. The first and second items suggested less pressure on the German money supply, given the authorities' reluctance to push interest rates higher, while the third item may have suggested that US money growth would expand. In any case, the residual moved to offset some of the earlier estimated narrowing of the expected difference between US and German inflation rates.

Sub-period V started on 16th April, the day that US prime rates began the rapid descent from their peak. By the end of May the 5-year Euro-dollar rate had fallen by more than 4 percentage points, and by roughly 2½ percentage points relative to the 5-year Euro-Mark rate. Meanwhile the expected pace of US inflation was revised downwards, responding in particular to the 2nd May announcement that US unemployment had skyrocketed from 6.2 per cent. in March to 7.0 per cent. in April.

The story can be complicated by trying to make sense of fluctuations over even shorter sub-periods, drawing on countless secondary news items. The basic test of the story, however, centres on the plausibility of the residual curve as the estimated time path of changes in the expected inflation differential - in particular, on the plausibility of the magnitudes of these estimated changes. Given the focus on 5-year interest differentials, the residuals are estimated changes in the expected inflation differential per annum averaged over a 5-year horizon.[16] Is it plausible that the expected inflation differential over that horizon could have first increased (during sub-period II) by more than 1 percentage point per annum and then declined (through the end of May) to roughly 2 percentage points per annum less than what had been expected during January? The casual answer is yes: changes of such magnitude in the US inflation outlook were widely discussed by the financial press, although without explicitly looking much further into the future than the end of 1981. A more convincing answer seems precluded by the absence of published and frequently revised inflation forecasts that extend as far as 5 years into the future.

Such arguments and evidence relating the short-run volatility of exchange rates to unexpected news can be both helpful and frustrating in efforts to explain exchange rates with formal statistical techniques. Changes in nominal interest differentials can be observed, but changes in the compounded inflation differentials expected over a long horizon can neither be observed nor modelled in a fully satisfactory manner. The stories above are helpful in drawing attention to evidence that unexpected changes in observed inflation rates and unemployment rates (or in other related statistics) can lead to revisions in expectations about future inflation rates. But the stories are frustrating in focussing on the major revisions in long-run inflation expectations that have followed or anticipated such policy measures as the US money and credit actions and revised budget proposals of the 14th March. Such policy measures are difficult to summarise in quantitative terms, and both their magnitude and their timing are difficult to relate systematically to observable economic variables. Thus, the large random element in policy reaction functions forces us to accept some large error terms in formal econometric models of exchange rate behaviour.

5. The portfolio balance effect: is there a premium for bearing exchange risk?

The debate between the monetarist and portfolio balance views of exchange rate determination centres on the significance of the risk premium. By definition, the risk premium is zero if and only if the forward exchange rate corresponds to the expected future spot rate. Under that condition, there would never be any change in the risk factor defined by equation (3) of Section 2, and the risk term would vanish from the accounting identity (1).

Monetarist models assume, explicitly or implicitly, that the risk premium is negligible. Under the interest rate parity condition, interest-bearing bonds denominated in different currencies are then always expected to offer identical returns to investors: by neglecting risk, bonds can thus be treated as perfect substitutes, regardless of currency denomination. Accordingly, in viewing exchange rates to be completely determined by the conditions necessary to maintain equilibrium in money markets, monetarist models are consistent with Walras' Law, under which it is valid to ignore what is essentially assumed to be a single market for bonds.

Portfolio balance models, in contrast, treat risk factors as important and variable, although in some cases the focus on risk is only implicit in the assumption that exchange rates depend on the supplies of and demands for bonds denominated in different currencies, as well as on the supplies of and demands for money. Since bonds, unlike money, cannot be assumed to be demanded for transactions purposes alone, a further implication is that exchange rates are sensitive to changes in wealth variables. Thus, the presumption of a risk premium provides or expands the rôles in the process of exchange rate determination (i) for sterilised foreign exchange interventions, which do not affect money stocks but do change the privately-held stocks of bonds denominated in different currencies, (ii) for public budget deficits, which affect both stocks of bonds and private wealth variables, and (iii) for current-account balances, which shift the international residence of wealth between countries that may have different portfolio preferences.

At the microeconomic level, there is clear evidence that risk premiums are not always zero. Market participants have different expectations that cannot all be simultaneously equal to the same market-clearing forward rate. Moreover, considerable resources are spent on forecasting or formulating expectations about future exchange rates, which is prima facie evidence that expectations are not simply equated to forward rates.

At the macroeconomic level, however, there is still the possibility that risk premiums average out to zero - or that they are sufficiently small to justify neglecting them as a convenient simplification. Dooley and Isard (1978, 1979) present statistically weak evidence that risk premiums do not vanish at the macroeconomic level, whereas Frankel (1979c) presents regression evidence that fails to reject the hypothesis of a zero risk premium.

In theory, there are two cases in which the risk premium would always be zero. The first, by definition, is the case of the risk neutral world in which infinitely-elastic speculation bids forward rates into equality with expected future spot rates. The second is the case of a risk averse (or risk loving) world in which private holdings of public debt are viewed to be matched by future tax liabilities, thereby adding nothing to private wealth; see Frankel (1979a). By contrast, in the presence of risk aversion and public debts that are viewed to add to private wealth, a gap can open up between the forward rate and the expected future spot rate.

To develop a better sense for the factors that influence the risk premium, as well as a sense for how the risk premium serves to quantify the degree of exchange risk, imagine a two-currency world in which governments and central banks create non-interest-bearing base money and interest-bearing public debt, pushing these "outside" assets into private portfolios and 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 B 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 B will require an increase in the expected rate of appreciation of currency B - presumably associated with an immediate depreciation of currency B that exceeds any downward revision in expectations about future values of currency B. This has the result of reducing the forward currency-A price of currency B relative to the expected future spot price and can thus be viewed to increase the risk premium (which condition (3) has implicitly defined as the risk premium for holding assets denominated in currency B).

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

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, other things equal, 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 and without any shift in the asset demand functions of individual behavioural units. Rather, changes in risk premiums may reflect a redistribution of global wealth, through current-account imbalances, between countries with different portfolio preferences.

As a third point, accordingly, recognition of the rôles of wealth variables and risk in portfolio decisions provides an additional place for balance-of-payments flows in asset-equilibrium models of exchange rate determination.

The remainder of this section develops a simple model of the risk premium that will be used in transforming the basic accounting identity into an empirically testable model of exchange rate determination. As suggested by the discussion above and shown formally by Dooley and Isard (1979) and Dornbusch (1980b), among others, the risk premium depends on three classes of variables: the stocks of public debts (or outside moneys and bonds) denominated in different currencies; the global distribution of private financial wealth; and certain parameters that describe the proportions in which private investors desire to divide their financial wealth holdings between assets denominated in different currencies. For these three classes of underlying variables, acceptable data can be assembled on stocks of public debts denominated in different currencies. It is more difficult, however, to construct data on private financial wealths broken down by countries or other groupings within which wealth holders might be assumed to have similar portfolio preferences. As first approximations, the private financial wealths of different countries can be constructed from cumulative data on public budget deficits, current-account imbalances, changes in money stocks and official foreign exchange interventions; but the first approximations may be poor ones in the absence of data on the currency compositions of wealth portfolios, without which it is difficult to assess the capital gains and losses that have resulted from exchange rate movements. For this reason, the attention given to wealth variables in this paper is limited to an attempt to estimate the influence of the substantial shift in the distribution of world financial wealth towards the OPEC countries.

The third class of variables on which risk premiums depend are the parameters that describe the proportions in which investors desire to divide their financial wealth holdings between assets denominated in different currencies. Intuition suggests that two types of parameters are relevant here: parameters that express the degree to which investors are risk averse and parameters that describe the magnitude of the risk that investors perceive.

Appendix B follows Dornbusch (1980b) in applying the theory of portfolio selection to suggest formally that the risk factor can be viewed to depend on the types of variables and parameters just discussed in the following multiplicative form:

$$(7) \quad \text{RISK}^e = 1 + \frac{u_N.v.\text{ASSETRATIO}}{1 + \frac{(u_N - u_O)}{u_O}.\text{WEALTHRATIO}}$$

where

u_N, u_O	are the coefficients of risk aversion that characterise non-OPEC and OPEC portfolio preferences
v	is the subjectively perceived variance of the ratio of the future spot rate to the forward rate
ASSETRATIO	is the share of assets denominated in currency B in the global private portfolio of outside assets denominated in either currencies A or B

and

WEALTHRATIO	is the share of global private financial wealth that is owned by the OPEC countries (treated as part of the global private sector)

Several points can be noted about equation (7). In the limiting risk-neutral case in which bonds offering the same expected yields are regarded as perfect substitutes independent of currency denomination,

u_N is zero and $\%\Delta RISK^e$ vanishes from the accounting identity (1). In the general case, the risk premium (defined as $(S^e-F)/F = RISK^e-1$) is proportionate to both the degree of risk aversion (u_N) and the perceived degree of exchange rate variability (v). The distribution of world wealth affects the exchange rate via the risk premium only if different countries have different preferences for assets denominated in different currencies - or equivalently, only if different countries have different coefficients of risk aversion. As shown in Appendix B, the proportionate difference between the OPEC and non-OPEC coefficients of risk aversion ($(u_N-u_O)/u_O$) is equal to the proportionate difference between the shares of OPEC and non-OPEC portfolios that are held in assets denominated in currency B.

Under the assumption that $RISK^e$ does not differ greatly from one, the transformation of equation (7) into percentage changes can be approximated as

$$(8) \quad \%\Delta RISK^e = \Delta \frac{u_N . v . ASSETRATIO}{1 + \frac{(u_N-u_O)}{u_O} WEALTHRATIO}$$

Substitution of (8) into the accounting identity (1) then suggests a non-linear exchange rate equation, however, which would greatly complicate the estimation problem. In order to avoid this complication, u_N and v are treated as constant time-invariant parameters in the estimation below,[17] and a prior value is assigned to $(u_N-u_O)/u_O$ based on ordinary least squares estimates of the currency compositions of non-OPEC and OPEC wealth holdings that satisfy the market-clearing condition for assets denominated in currency B (i.e. that satisfy condition A17 of Appendix B). This leads to the construction of a composite variable

$$(9) \quad AW = \frac{ASSETRATIO}{1 + \frac{(u_N-u_O)}{u_O} . WEALTHRATIO}$$

and to the simplified expression

$$(10) \quad \%\Delta RISK^e = u_N . v\Delta AW$$

6. Empirical application of the accounting framework

This section reports on attempts to explain monthly data on the exchange rate between the US dollar and the Deutsche Mark from 1975 through 1979, using an equation derived by substituting behavioural assumptions into the accounting identity (1). Equation (10) of the previous section describes our behavioural model of the risk term that appears in the accounting identity, and by substituting that equation along with the definitions of real interest rates (equations (5) and (6) of Section 2) we can transform (1) into

$$(11) \quad \%\Delta S = (\%\Delta P_A - \%\Delta P_B) + \Delta(R_B - R_A) + \Delta(\hat{P}^e_A - \hat{P}^e_B) + \%\Delta SREAL^e - u_N v\Delta AW$$

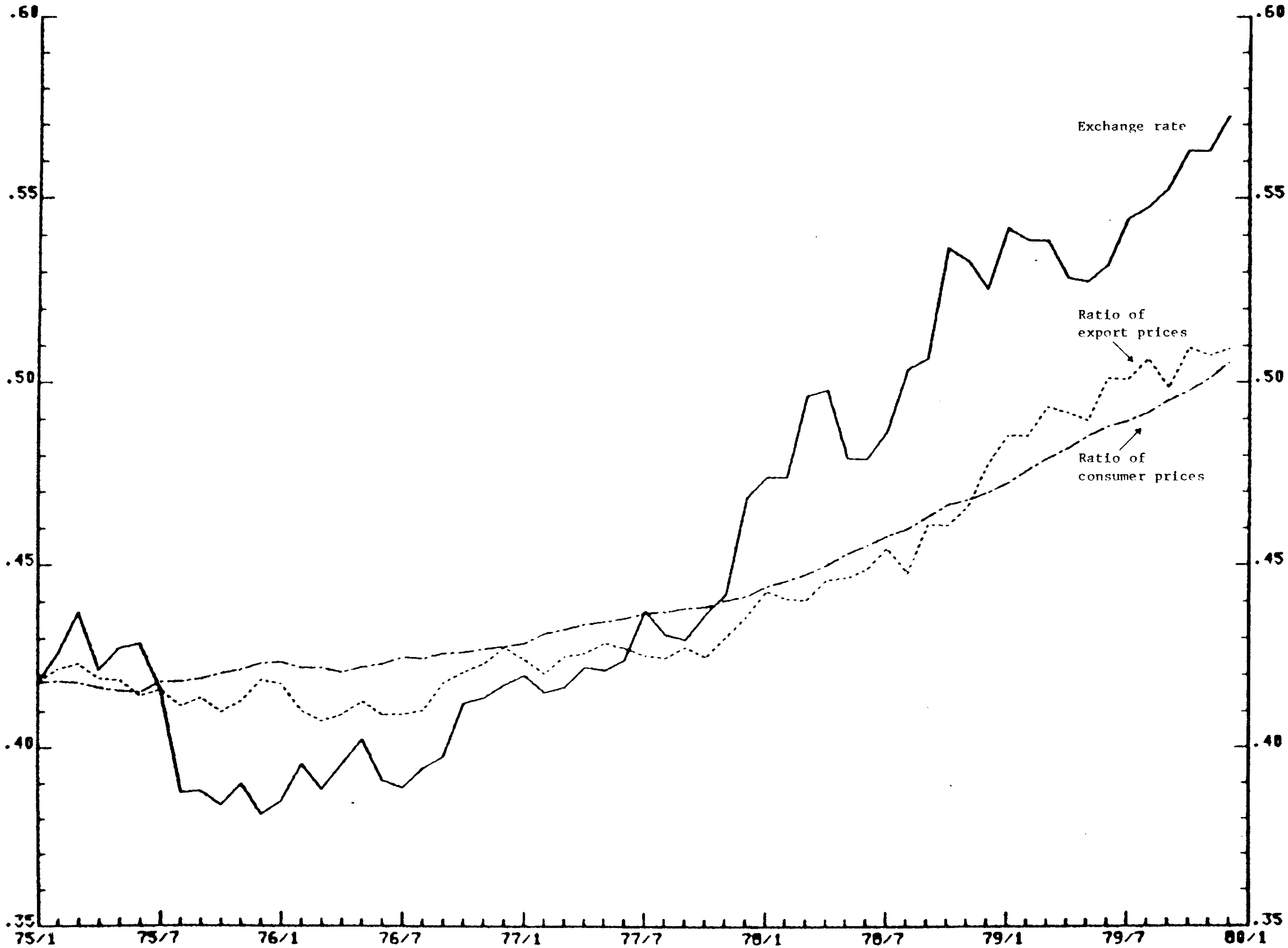
The first and second terms on the right-hand side of (11) can be directly observed and have unit coefficients that require no estimation. The first right-hand-side term is the purchasing-power parity factor, and Figure 2 shows that it "explains" almost two-thirds of the appreciation of the Mark during our sample period, whether measured in terms of export prices or consumer prices.

Figure 3 focusses on the relationship between movements in the real exchange rate - i.e. movements in the nominal exchange rate that are not explained by the purchasing power parity factor - and changes in the compounded nominal interest differential. As mentioned in Section 2, we have chosen to compound nominal interest differentials and expected inflation differentials over a 5-year horizon on the assumption that it takes no more than five years to reach the "long run". Conceptually, the "long run" is defined to begin at the point beyond which poor foresight makes steady "equilibrium" growth the best prediction.

The striking points about Figure 3 are the close parallel between the two curves and the fact that the correlation is inverse:

Figure 2

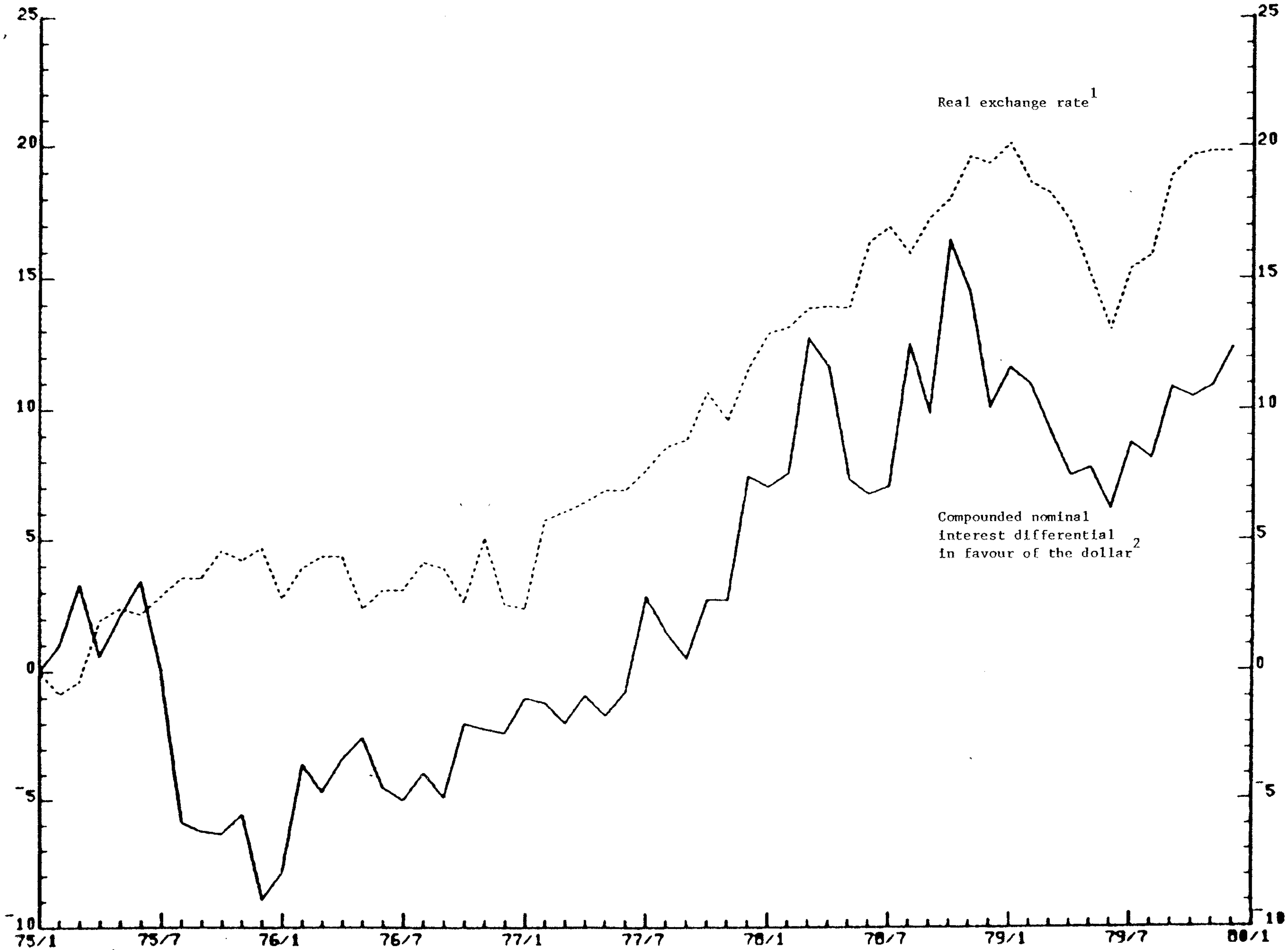
The nominal exchange rate versus relative price levels*



* Cumulative changes since January 1975.

Figure 3

The real exchange rate versus the compounded nominal interest differential



1 Cumulative percentage change since January 1975, based on export price indexes.
2 Cumulative change since January 1975, in percentage points.

appreciations of the Mark are associated with increases in the nominal interest differential in favour of the dollar. The suggested explanation of the inverse correlation, which is supported by regression results reported below, is that despite their pursuit of monetary growth targets, central-bank authorities resisted letting the nominal interest differential move as widely as would have been necessary to offset changes in expected inflation differentials, thereby generating a strong negative correlation between the nominal interest differential and the estimated real interest differential.

Regression estimates of equation (11) require behavioural assumptions that model the expected inflation differential and changes in the expected long-run real exchange rate in terms of variables that can be observed. An explanation of month-to-month changes in exchange rates requires behavioural assumptions that can pinpoint the timing as well as the magnitudes of shifts in these expectational variables. Much less sophistication is required to explain the level of the exchange rate, and indeed the empirical literature on exchange rate determination, with few exceptions, is directed at explaining levels rather than changes.

This paper also concentrates on explaining the level of the exchange rate, using simple behavioural models of the expectational variables. Regarding behavioural assumptions about the expected compounded 5-year inflation differential - i.e. the third term on the right-hand side of equation (11) - we have tested the simple assumption that expectations are formed by looking at the most recent inflation rates along with prevailing rates of unemployment. More specifically, our tests assume that

$$(12) \quad (\hat{P}^e_A - \hat{P}^e_B) = c + a_1\hat{P}_A - a_2\hat{P}_B - a_3U_A + a_4U_B$$

where

$\hat{P}_A$, $\hat{P}_B$ are the most recent available monthly observations of percentage changes in price levels (measured over 12 months) and

U_A, U_B are the most recent avaiable monthly observations of unemployment rates

Such a formulation does not make a serious attempt to incorporate perceptions of policy reaction functions into the expectations formation process, nor does it recognise that inflation expectations adapt gradually and depend not only on the most recently observed states of the two economies but also on how the economies have evolved to those states. Rather, it merely assumes that expected inflation rates are projected from prevailing inflation rates, with dampening factors that can be estimated. The inclusion of unemployment rates as explanatory variables serves a double purpose, allowing the expected dampening of inflation to be sensitive to the degree of macroeconomic slack, and also providing broad indicators of shifts in the basic policy attitudes and strategies that govern the outlook for inflation over the long run.

Regarding behavioural assumptions about the fourth right-hand-side term in equation (11) - changes in the expected long-run real exchange rate - the main difficulty, as discussed in Section 3, is to quantify the unexpected changes in balance-of-payments flows that, once recorded, are "expected to be corrected" via movements in the real exchange rate. The results reported below rely on the oversimplified assumption that the unexpected trade balance in any month can be measured as the recorded trade balance for that month minus the average trade balance for the previous three months. Since trade elasticities are normally conceived to be volume concepts, our focus here is on volume trade balances, and we choose to measure import volumes in terms of the export quantities that would be required to purchase them - that is, we use the same export price index to deflate both exports and imports. The unexpected changes in volume trade balances are denoted TBU_A and TBU_B. Because unexpected trade balances that are viewed as transitory - e.g. due to cyclical factors - are unlikely to influence expectations regarding the long-run real exchange rate, we attempt to purge TBU_A and TBU_B of their cyclical components by regressing them on both a domestic cyclical variable and a foreign cyclical variable; see appendix C for details. The residuals from these regressions, denoted $TBUN_A$ and $TBUN_B$, represent estimates of the unexpected changes in trade balances that can be attributed to non-cyclical factors. And we assume that expectations regarding the long-run real exchange rate are revised in response to unexpected non-cyclical changes in trade balances according to the simple relationship

$$(13) \quad \% \Delta SREAL^{e} = a_5 TBUN_B - a_6 TBUN_A$$

By substituting assumptions (12) and (13) into (11) we arrive at an estimable exchange rate equation

$$(14) \quad \% \Delta SREALADJ = a_1 \Delta \hat{P}_A - a_2 \Delta \hat{P}_B - a_3 \Delta U_A + a_4 \Delta U_B$$

$$+ a_5 TBUN_B - a_6 TBUN_A - a_7 \Delta AW$$

where the dependent variable - the percentage change in the real exchange rate adjusted for the nominal interest differential - has been constructed by transposing the first two right-hand-side terms of equation (11), both of which have unit coefficients that should be imposed on the analysis

$$(15) \quad \% \Delta SREALADJ = \% \Delta S - (\% \Delta P_A - \% \Delta P_B) - \Delta (R_B - R_A)$$

As a result of this transposition, the regression analysis avoids assuming that changes in relative price levels cause changes in the nominal exchange rate, but rather remains consistent with general assumptions about the direction or mix of causation between relative price levels and the exchange rate.

As suggested above, equation (14) yields poor estimates of month-to-month changes in exchange rates. A strong presumption is that the right-hand-side variables - as behavioural models of changes in expectational variables - do a poor job of pinning down the timing of expectational changes month by month. Accordingly, we focus on explaining levels or cumulative percentage changes in exchange rates using the integral form of (14)

$$(16) \quad \log(\text{SREALADJ}) = a_0 + a_1\hat{P}_A - a_2\hat{P}_B - a_3U_A + a_4U_B$$

$$+ a_5\Sigma \text{TBUN}_B - a_6\Sigma \text{TBUN}_A - a_7 \text{AW}$$

Table 2 reports estimates of equation (16). Details of data sources and construction are presented in Appendix C. Basic points about the data are that exchange rates and interest rates are measured on the second Wednesday of each month and that right-hand-side variables are lagged by one or two months to correspond to the most recent monthly data available at the times that the exchange rate was observed. For the regressions reported in Table 2, price and inflation variables are based on export prices in view of the focus of the accounting framework on the real exchange rate, and $\hat{P}_A$, $\hat{P}_B$ are measured as percentage changes over 12 months. Countries A and B correspond to the United States (US) and Germany (G), with the exchange rate measured in dollars per Mark.

In the case 0 estimates of equation (16), AW is constructed as discussed in connection with definition (9) of Section 5. The construction uses condition (A21) of Appendix B and regression estimates, on a least-squares basis (and corrected for first-order serial correlation), that 32 per cent. of OPEC financial wealth and 11 per cent. of non-OPEC financial wealth were denominated in Marks during the sample period. As the first row of Table 2 reveals, this leads to an implausible positive estimate of the coefficient on AW.

Case 1 reflects an attempt to adjust for the fact that AW, particularly insofar as it reflects cumulative official exchange-market interventions, is not independent of the exchange rate. An instrumental variables procedure, designed to avoid this source of simultaneity bias, simply replaces AW with the fitted values (AWFIT) from a regression (corrected for first-order serial correlation) of AW on all the other right-hand-side variables of equation (16) along with an index of time. With this modification, the case 1 regression correctly estimates the expected signs on all coefficients. When the case 1 results are corrected for first-order serial correlation in case 2, the coefficient on the German trade balance loses its correct sign but remains insignificant. Cases 3 and 4 confirm, in comparison with cases 1 and 2, that the inclusion of the AWFIT variable has little influence on estimates of the coefficients attached to other variables.

Table 2

Regression results[a]

	Constant	$\hat{P}_{US}$	$\hat{P}_G$	U_{US}	U_G	$\Sigma TBUN_{US}$	$\Sigma TBUN_G$	AW	$\bar{R}^2$	D.W. (RHO)	R.M.S.E.[b]
Expected sign ...	?	+	-	-	+	-	+	-			
Case 0[c]...	- 1.59 (-8.74)	.315 (2.48)	-.594 (-1.47)	- 3.77 (-2.43)	2.93 (.758)	-.0314 (-3.85)	-.0178 (-2.98)	4.89 (7.07)	.950	1.60	2.39%
								AWFIT			
Case 1[c]...	- .539 (-3.03)	.867 (6.16)	-.893 (-1.44)	-11.5 (-6.26)	4.83 (.884)	-.00711 (-.684)	.00041 (.0487)	-.437 (-.541)	.901	.947	3.35%
Case 2[d]...	- .466 (-2.67)	.696 (3.96)	-1.01 (-1.44)	- 9.93 (-4.67)	.0920 (.0160)	-.00584 (-.433)	-.00274 (-.306)	-.282 (-.416)	.997	1.72 (.450)	3.15%
Case 3[c]...	- .583 (-3.69)	.866 (6.19)	-1.04 (-1.86)	-11.1 (-6.82)	4.45 (.827)	-.00717 (-.695)	-.00148 (-.192)	-	.902	.942	3.36%
Case 4[d]...	- .485 (-2.93)	.693 (3.96)	-1.18 (-2.07)	- 9.45 (-5.09)	- .671 (-.122)	-.00617 (-.458)	-.00411 (-.489)	-	.997	1.74 (.461)	3.17%

a Numbers in parentheses are t-values. Coefficients on the $\hat{P}$ and U variables can be interpreted as the estimated percentage effects on the exchange rate of one percentage point changes in inflation rates and in unemployment rates.

b The root mean squared error as a percentage of the mean of the dependent variable.

c Ordinary least squares estimates.

d Estimates corrected for first-order serial correlation.

Because the appropriateness of using mechanical techniques to correct for serial correlation is a controversial issue, we focus jointly on cases 1 and 2 as our selected equations. Except for the estimated coefficient attached to the German unemployment rate, the two equations are broadly similar. Changes of one percentage point in either the US or the German rate of export price inflation, as measured over 12 months, are estimated to have an effect of only about one percentage point on the expected compounded 5-year inflation differential. By contrast, a one percentage point decline in the US unemployment rate revises US inflation expectations upwards by estimates of 9.36 or 11.0 percentage points over a 5-year horizon, while a one percentage point decline in the German unemployment rate revises German inflation expectations upwards by a compounded 4.8 per cent. according to the case 1 estimates. Such estimated unemployment effects are striking. To the extent that changes in policy attitudes were reflected much more quickly and/or clearly by unemployment rates than by inflation rates during the 1975-79 period, it is not surprising that expectations regarding compounded rates of inflation over a 5-year horizon appear to have been more sensitive to unemployment rates than to recent rates of inflation. Contrary to this view, however, it might be argued that the unemployment effects are overestimated in association with underestimates of the balance-of-payments effect and the portfolio balance effect, which will be discussed in connection with Table 3 below.

Although Table 2 reports overall goodness-of-fit statistics that are impressive by conventional standards, it should be noted that a root-mean-squared error of 3.3 per cent. amounts to an error of about 1½ cents per Mark, and in the presence of positive serial correlation - which is not completely eliminated by the autoregressive corrections - the series of monthly residuals may during some periods dominate the explained change in the exchange rate. It should also be noted that the high $\bar{R}^2$ statistics may largely reflect the correlation between the nominal interest differential, as absorbed into the dependent variable, and the estimated expected inflation differential.

Table 3 translates the regression results into estimates of the contributions of various factors to movements in the dollar/Mark rate between several selected points in time. Except for the first and last months in the sample, the selected dates correspond, loosely speaking, to

Table 3

Components of exchange rate changes

(in percentages)

	February 1975 to December 1975		December 1975 to July 1977		July 1977 to September 1978		September 1978 to December 1979		February 1975 to December 1979	
Observed change in the exchange rate ..	- 11.1		13.7		14.6		12.3		29.5	
- Change in relative price level	- 0.7		1.6		8.0		9.9		18.8	
= Change in real exchange rate	- 10.4		12.1		6.6		2.4		10.7	
- Change in compounded nominal interest differential	- 5.5		- 3.1		- 10.6		- 3.1		- 22.2	
= Change in adjusted exchange rate ...	- 4.9		15.2		17.2		5.5		32.9	
of which, estimated change due to	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
Revisions in inflation expectations	- 6.5	- 8.1	14.9	9.7	15.4	10.4	1.4	3.6	25.2	15.6
Balance-of-payments factors	- 0.9	0.2	1.3	0.7	0.3	0.4	- 0.2	0.5	0.4	1.8
Portfolio-balance or risk factors ..	0.5	0.3	- 0.5	- 0.3	- 0.3	- 0.2	- 0.1	- 0.1	- 0.4	- 0.3
Unexplained factors	2.0	2.7	- 0.5	5.1	1.8	6.6	4.4	1.5	7.7	15.8
Memorandum item :										
Change in compounded real interest differential (line 4 plus line 6)	- 12.0	- 13.6	11.8	6.6	4.8	- 0.2	- 1.7	0.5	3.0	- 6.6

turning points in either the exchange rate or its explanatory factors.[18] December 1975 corresponds to the lowest value of the Mark during the sample period, preceding a shift of the US trade balance into deficit in early 1976 and a sharp increase in the US trade deficit in early 1977. July 1977 is the month in which the Euopean Community governments made a formal commitment to establish a European Monetary System and the month before talk emerged about measures to stimulate the German economy. September 1978 preceded a month of heavy speculation that catalysed the US anti-inflation actions during October and on 1st November, and also represents the last month before the German unemployment rate was revealed (with a lag) to have finally moved below the 3.8 to 4 per cent. range in which it had been stuck since mid-1976.

Focussing first on the size of the unexplained factors (next to bottom row), it can be noted for the sample period as a whole that the case 1 results leave unexplained roughly one-fourth of both the observed change in the exchange rate (top row) and the change in the adjusted exchange rate (the dependent variable, shown in the fifth row). The case 2 results fail to explain roughly half of the changes for the sample period as a whole. It is noteworthy that the unexplained factors are proportionately smaller for the case 2 results in all four sub-periods and for the case 1 results in all but the final sub-period. The reason is that the results for both cases repeatedly err in the direction of underexplaining the appreciations and overexplaining the depreciation of the Mark (with the minor exception of the case 1 results for the second sub-period), and the failure of the Mark to appreciate in all four sub-periods then makes the cumulative error look proportionately larger.

Turning to the explanatory factors, it can be noted first that the change in relative price levels or purchasing power parity factor "explains" roughly two-thirds of the overall movement of the exchange rate during the sample period as a whole (i.e. 18.8 out of 29.5 per cent.). By comparing the third line with the bottom line, it can also be noted that most of the volatility of the exchange rate (after subtracting the purchasing power parity factor) is apparently explained by changes in the compounded real interest differential.

The results show only weak evidence of the balance-of-payments factor and the portfolio balance or risk factor. The surprisingly sharp swing of the US trade balance into deficit during 1976-78, in particular, is estimated to have weakened the dollar by only 1 to 2 per cent. against the Mark between December 1975 and September 1978. Such results cannot be accepted as conclusive, however, partly because of the oversimplified behavioural assumptions that have been adopted about the expectations and risk variables, and partly because the repeated underestimates of the appreciation of the Mark are consistent with both a strong balance-of-payments effect and with the conjecture that the risk factor became increasingly more favourable to the Mark during the sample period.

Nevertheless, the regression estimates as they stand have a plausible if inconclusive three-part interpretation. First, inflation expectations, particularly in the United States, appear strongly attuned to changes in unemployment rates as indicators of policy commitments and the likely course of prices over a long 5-year horizon. Second, unexpected payments imbalances, to the extent that they are accurately represented by our oversimplified measures, may have been largely viewed as cyclical or transitory and may, therefore, have had little impact on expectations regarding the long-run real exchange rate. Thus, the estimates suggest that despite the strong correlation between the depreciation of the dollar and the emergence of a surprisingly large US trade deficit during 1976-78, the depreciation of the dollar may have largely reflected the shift in expected inflation rates and real interest differentials that accompanied, but were not caused by, the growing trade deficit. Third, the estimates do not reject the view that Euro-Mark and Euro-dollar deposits are near perfect substitutes, which would imply that - except insofar as nominal interest rates or inflation expectations are affected - exchange rates are influenced only negligibly by sterilised exchange-market interventions, public-budget deficits and shifts in the global distribution of private wealth.

7. Summary and conclusions

Investors take currency positions from which they expect to profit. Given the prevailing levels of interest rates, accordingly, the exchange rates at which currencies are bought and sold today are influenced fundamentally, through profit calculations, by expectations about the exchange rates at which currencies will be traded in the future. Such expectations may vary widely among market participants, are held with different degrees of confidence, and often prove wrong. But to understand the observed behavior of exchange rates it is necessary to try to understand how expectations are formed and revised. It is not sufficient to argue that average market expectations about future exchange rates are closely approximated by forward exchange rates, since the observed behavior of forward exchange rates requires just as much explanation as the observed behavior of spot exchange rates.

Expectations have a time dimension. Currency positions may be taken on the expectation of profits over either a short time horizon or over the long term. The ability to arrange in advance to buy and sell currencies at any two future dates imposes a link, through the arbitraging of perceived profit opportunities, between expectations about the exchange rates that will prevail on the two future dates. Accordingly, there is an internal consistency in the term structure of expectations, and in seeking to understand the observed behavior of exchange rates, the decision of whether to focus on expectations about the short term or the long term is largely a matter of convenience.

This paper has developed and tested a model that links the current exchange rate to the value of the exchange rate that is expected to prevail in the long run. Two popular assumptions have been adopted in attempting to explain expectations about the long run. The first assumption is that the expected nominal value of the exchange rate in the long run reflects the relative rates of inflation that are expected to occur over a horizon that extends until the long run is reached. The second assumption is that the real exchange rate (i.e. the nominal exchange rate adjusted for changes in relative price levels) is expected to adjust in the long run to "correct" balance of payments disequilibria that are not perceived to be transitory or cyclical in nature. When risk factors are considered along with expectations, these assumptions lead to an approximate accounting identity that separates changes in exchange rates into four additive components: a relative price level or purchasing power parity factor, a balance-of-payments factor, a real interest rate factor, and a risk or portfolio balance factor.

The four-part accounting framework is applied to testing specific assumptions about the behavior of the expectations and risk variables in terms of their ability to explain monthly data on the US dollar/Deutsche Mark rate during the 1975-79 period. As an operational definition that reflects the maturities for which interest rate data are available (for Euro-currency deposits), the long run is assumed to be reached in 5 years. The empirical tests are limited to the following three sets of specific behavioral assumptions about the expectations and risk variables. (1) Only unexpected and non-cyclical balance-of-payments flows are assumed to cause revisions in expectations about the real exchange rate in the long run; unexpected balance-of-payments flows are measured in an oversimplified manner as changes in balances of trade from recent average levels; and the cyclical components that are subtracted from these unexpected trade balances are the components that can be explained econometrically using both domestic and foreign cyclical indicators. (2) The expected inflation rates that affect the real interest rate factor are assumed to depend in an oversimplified manner on the most recently reported values of observed inflation rates and unemployment rates. And (3) the risk premium - which can be viewed as a change in currency values that is required to compensate private investors in the aggregate for dividing their global portfolio into the currency composition that is imposed by the available stocks and currency denominations of public debts - is assumed to depend on (a) the relative stocks of public debts denominated in different currency units, (b) the distribution of global private wealth between countries that may have different preferences for assets denominated in different currency units, and (c) both the degree to which private investors are risk averse and the magnitude of the exchange risk that they perceive.

For the 1975-79 period as a whole, roughly two-thirds of the appreciation of the Deutsch Mark against the dollar is explained by relative price movements or the purchasing power parity factor. By contrast, the shorter-term volatility of the exchange rate seems to have primarily reflected the widening and narrowing of real interest differentials. The accounting framework emphasises that the exchange rate response to a change in the nominal interest differential or the expected inflation differential is equal in magnitude to the compounded value of the change in the real interest differential over an horizon that extends until the long run is reached, which has been assumed to be five years. Changes of one or two percentage points in nominal interest differentials or expected inflation differentials, per annum, can be associated with much larger changes in real interest differentials compounded over five years and, therefore, with much larger percentage swings in exchange rates.

The empirical findings are inconclusive in assessing the importance of the balance-of-payments factor and the risk or portfolio balance factor. If the behavioral assumptions were not oversimplified, the small importance attached to these factors by the statistical results would have to be accepted as fair judgement. The small balance-of-payments effect would then suggest that surprises about balance-of-payments flows during the sample period were apparently perceived as cyclical or transitory, giving rise to only small revisions in expectations about the real exchange rate in the long run. On the other side of this coin, the strong depreciation of the dollar that accompanied the surprisingly large deficits in the US balance of payments during 1977-78 would appear attributable largely to the influence of changing cyclical positions on inflationary expectations. In addition, the estimates of a small risk or portfolio balance factor would support the view that Euro-Mark and Euro-dollar deposits are near perfect substitutes, and that - except to the extent that nominal interest rates or inflation expectations are affected - exchange rates are influenced only negligibly by official exchange market interventions, by public budget deficits, and by shifts in the global distribution of private wealth.

The reasons for resisting such conclusions, however, are not only because the empirical results are based on oversimplified behavioral assumptions about the expectations and risk variables, but also because the results provide only a partial explanation of the exchange rate movements that occurred during the sample period. Specifically, the empirical results fail to explain roughly one-fourth of the appreciation of the Mark against the dollar during the 1975-79 period as a whole, and the unexplained residual is consistent both with a strong balance-of-payments effect and with the conjecture that risk considerations became increasingly more favourable to the Mark during those years. Thus, conclusions on the importance of balance of payments and risk factors in the dollar/Deutsche Mark case must await further application of the accounting framework under more sophisticated models of expectations and risk variables.

A relatively clear implication of the accounting framework, by contrast, is that unexpected policy actions, or revisions in expectations about prospective policy actions, can lead to large revisions in compounded real interest differentials and to equally large movements in exchange rates. Accordingly, by directing policies along well-defined and easily anticipated courses, and by holding to such courses, policy authorities, if they so desired, might substantially reduce the volatility of exchange rates.

Appendix A

In deriving the approximate accounting identity (1) as presented in Section 2 it is convenient to work with the logarithmic transformations of conditions (2) - (4), using lower case letters to denote logarithms:

(A1) $s = f + \log((1+R_B)/(1+R_A))$

(A2) $risk^e = s^e - f$

(A3) $sreal = s + p_B - p_A$

Condition (A3) can be transformed by taking expectations of both sides:[19]

(A4) $sreal^e = s^e + p_B^e - p_A^e$

In addition, expected future price levels can be expressed in terms of current price levels and expected future inflation rates:

(A5) $p_A^e = p_A + \log(1+\hat{P}_A^e)$

(A6) $p_B^e = p_B + \log(1+\hat{P}_B^e)$

From (A2) and (A4) - (A6) it then follows that

(A7) $f = p_A - p_B + sreal^e + \log((1+\hat{P}_A^e)/(1+\hat{P}_B^e)) - risk^e$

Accordingly after abbreviating the notation by defining

(A8) $r_A = \log((1+R_A)/(1+\hat{P}_A^e))$

(A9) $r_B = \log((1+R_B)/(1+\hat{P}_B^e))$

we can substitute (A7) - (A9) into (A1) to arrive at

$$(A10) \quad s = (p_A - p_B) + sreal^e + (r_B - r_A) - risk^e$$

Since changes in logarithms correspond, as an approximation, to the percentage changes in levels, the approximate accounting identity (1) can be seen to correspond to the first difference form of (A10). Noting also that log(1+X) is approximately equal to X for small values of any variable X, it can be seen that conditions (5) and (6) are approximations to (A8) and (A9).

Appendix B

This appendix applies the theory of portfolio selection to a variation of the model developed lucidly by Dornbusch (1980b), who provides references to earlier groundwork by Solnik (1973), Kouri and Macedo (1978) and others. The investor starts with initial wealth W, as measured in units of currency A. Exchange rates are given spot (S) and forward (F) in units of currency A per unit currency B. Also given are the respective own nominal rates of interest (R_A, R_B) on assets denominated in currencies A and B. Uncertainty attaches only to the future spot rate ($\tilde{S}$), and the investor's only decision variable is the share (x) of his wealth that he chooses to hold in assets denominated in currency B. The currency-A value of the investor's terminal wealth ($\tilde{W}$) can thus be described as

$$\text{(A11)} \quad \tilde{W} = (1-x).W.(1+R_A) + \frac{xW}{S}.(1+R_B)\tilde{S}$$

Equivalently, for simplification, we can focus on the ratio of the present discounted value of terminal wealth to the value of initial wealth

$$\text{(A12)} \quad \tilde{w} = \frac{\tilde{W}/(1+R_A)}{W} = 1 - x + \frac{x\tilde{S}}{F}$$

where we have introduced the forward exchange rate F by substituting from the interest rate parity condition (i.e. equation 2 of Section 2).

The traditional portfolio-choice framework views the investor to choose x by maximising a utility function that depends on the mean and variance of a wealth variable, which we conveniently take to be $\tilde{w}$. The mean and variance in question can be represented as

$$\text{(A13)} \quad \text{MEAN}(\tilde{w}) = 1 - x + \frac{xS^e}{F}$$

and

$$\text{(A14)} \quad VAR(\tilde{w}) = x^2.VAR(\tilde{S}/F)$$

where S^e is the mean or expected value of the future spot rate. Thus, the utility-maximising solution is

$$\text{(A15)} \quad x = \frac{-U_1}{2U_2} \; \frac{(S^e/F)-1}{VAR(S/F)}$$

where U_1 and U_2, respectively, are the positive and negative derivatives of the utility function with respect to the mean and the variance of $\tilde{w}$. It is notationally convenient to define

$$\text{(A16)} \quad u = \frac{-2U_2}{U_1}$$

which is conventionally called the coefficient of risk aversion.

We now distinguish two wealth holders with subscripts 0 (for OPEC) and N (for non-OPEC). Q_B denotes the global stock of currency-B denominated assets (valued in units of currency B) that are available for 0 and N to hold, and the market clearing condition is thus

$$\text{(A17)} \quad x_0W_0 + x_NW_N = SQ_B$$

Accordingly, using (A15) and (A16) to substitute for x_0 and x_N,

$$\text{(A18)} \quad S^e/F = 1 + \frac{VAR(\tilde{S}/F).SQ_B}{(W_0/u_0) + (W_N/u_N)}$$

Equivalently, denoting global wealth by

(A19) $W = W_0 + W_N$

and using the definition $RISK^e = S^e/F$ (equation 3 of Section 2), we have

$$\text{(A20)} \quad RISK^e = 1 + \frac{u_N . VAR(\tilde{S}/F) . (SQ_B/W)}{1 + \frac{(u_N - u_0)}{u_0} (W_0/W)}$$

Thus the risk factor depends on (i) the non-OPEC coefficient of risk aversion, which equals zero in the limiting case of risk neutrality; (ii) the subjectively-perceived variance of the ratio of the future spot rate to the forward rate; (iii) the share of currency-B assets that must be held in the combined global portfolio; and (iv) the share of OPEC wealth in global wealth multiplied by the proportionate difference between OPEC and non-OPEC coefficients of risk aversion. The latter proportionate difference between coefficients of risk aversion is equivalent, from condition (A15), to the proportionate difference between the portfolio shares that are allocated to currency B:

$$\text{(A21)} \quad \frac{u_N - u_0}{u_0} = \frac{x_0 - x_N}{x_N}$$

Appendix C

The exchange rate and Euro-dollar rate on 5-year deposits (as bid in London) are measured on the second Wednesday of each month (or the previous trading day when the second Wednesday is a holiday) as taken from issues of The Money Manager. The use of Wednesday data is intended to minimise any distorting effects of the weekend book-keeping transactions that are employed by US banks to reduce the burden of reserve requirements. The second Wednesday of the month conveniently follows the release of data on unemployment rates for the previous month and price levels and trade balances for the month before last. These lags are incorporated into the regression equations. Data on 5-year Euro-Mark rates were not conveniently available so we use a monthly series, published by the Bundesbank, on market yields on DM-bonds of foreign issuers. The yields pertain to fully taxed fixed-interest bearer bonds with original terms of issue exceeding four years and remaining period to maturity exceeding three years. See Statistical Supplements to the Monthly Reports of the Deutsche Bundesbank, Series 2, Securities Statistics, Table 8b.

Data on prices, unemployment rates and trade balances are seasonally adjusted from national sources. In most of the empirical analysis the price variables are represented by the German export price index paired with the US export unit value index; in Figure 2 the consumer price ratio is constructed from the German cost-of-living index and the US consumer price index. Data on volume trade balances are constructed by deflating value trade balances with export price indexes; normalised volume trade balances are constructed as volume trade balances divided by industrial production indexes; and the unexpected components of each of the normalised volume trade balances is defined, for each month, as the total normalised volume trade balance for that month minus the average normalised volume trade balance for the previous three months. For each country the non-cyclical component of the unexpected normalised volume trade balance ($TBUN_G$ or $TBUN_{US}$) is taken to be the residual component that is not explained by regressing the total unexpected normalised volume trade balance (TBU_G or TBU_{US}) on both the change in a domestic cyclical indicator and the change in a foreign cyclical indicator. To be consistent with the construction of TBU_G and TBU_{US}, changes in cyclical indicators are measured as changes from average levels for the previous three months. For Germany, the domestic cyclical indicator is constructed as the ratio of the number of workers unemployed to the number of job vacancies, each seasonally adjusted, from Statistical Supplements to the Monthly Reports of the Deutsche Bundesbank, Series 4. For the United States, the domestic cyclical indicator is the Federal Reserve Board's capacity utilisation index for manufacturing, seasonally adjusted. For both countries the external cyclical indicator is the deviation from trend of the OECD's index of total OECD industrial production.

In constructing the portfolio-balance variables ASSETRATIO and WEALTHRATIO, the stock of privately-held outside assets denominated in Marks is constructed as total German Federal Government debt plus Bundesbank holdings of US-dollar investments, as taken from Tables VII.10 and IX.6 of the Monthly Report of the Deutsche Bundesbank. The stock of privately-held outside assets denominated in dollars is constructed as gross US Federal Government debt held by the public minus US liabilities to foreign official institutions; the former measure is taken from the Commerce Department's Business Statistics and Survey of Current Business, while the latter is taken from the Annual Statistical Digest of the Federal Reserve Board and from Treasury Bulletins. The stock of global private financial wealth is constructed as the dollar value of the combined constructed stock of outside assets denominated in Marks and dollars, implicitly defining the global private sector to include the public sectors of all countries other than Germany and the United States. The stock of OPEC financial wealth is constructed as the cumulative dollar value of the current-account surplus of the OPEC countries, beginning in March 1973, based on estimates provided in the IMF's World Financial Outlook. For each of the years 1975-79 the construction equates monthly OPEC current-account surpluses to one-twelfth of the annual estimates. All portfolio variables are measured end-of-month and the exchange rate on the second Wednesday of the month is regressed on the value of the composite portfolio variable at the end of the previous month.

Footnotes

1 This paper was written while I was on leave from the Federal Reserve Board to the Bank for International Settlements. I have benefited from numerous discussions with William A. Allen, Bruce Brittain, Kengo Inoue and Warren McClam at the Bank for International Settlements, and from past collaboration with Michael Dooley at the Federal Reserve Board. The views presented herein are not necessarily shared by either institution, nor are they entirely accepted by my acknowledged colleagues.

2 Mussa (1979, page 21).

3 This point has been emphasised by Dooley and Isard (1979).

4 To the extent that nominal interest differentials per annum are much the same on 10-year maturities as on 5-year maturities, the analysis is only insensitive to the choice of 5 years if the market either expects inflation differentials to be equal to nominal interest differentials after 5 years or expects the real exchange rate to change along an equilibrium path after 5 years at a rate equal to the real interest differential that remains.

5 The count can be reduced to two out of four by modelling $RISK^e$ in terms of observable variables. See Dooley and Isard (1979), Dornbusch (1980b), or Section 5 below.

6 Although most empirical work on exchange rate determination has not attempted to isolate the unexpected components of explanatory variables, the idea has been promoted conceptually by Barro (1978), Mussa (1976, 1979), Dornbusch (1978) and Dooley and Isard (1979), and in recent empirical work by Frenkel (1980) and Dornbusch (1980a).

7 Examples of such monetarist models include Frenkel (1976, 1980), Bilson (1978) and numerous references cited therein.

8 Fellner (1979) comes close in stressing the importance of cumulative expected inflation differentials. In addition, Frankel (1979b) and Hooper and Morton (1979) may partly capture the effect of this component indirectly through their use of long-term interest rates as proxy measures of inflation expectations.

9 Attempts to test the portfolio balance view empirically include Branson, Halttunen and Masson (1977), Porter (1977, 1979), Dooley and Isard (1978, 1979), Frankel (1979c) and Martin and Masson (1979).

10 See Einzig (1970).

11 For example, see Dornbusch and Fischer (1980).

12 A third notion of balance-of-payments effects focusses on the portfolio balance or risk factor. In a risk averse world in which residents of different countries have different portfolio

preferences, balance-of-payments surprises can affect exchange rate expectations without necessarily generating expectations of induced policy reactions. An unexpected shift in current-account flows that was regarded as permanent, provided other things remained equal, could accumulate to substantially change the international distribution of financial wealth. Thus, exchange rates would be pressured to move for a combination of two reasons: (i) to induce a reverse shift in the current account in order to prevent or reduce any permanent shift in global wealth; and/or (ii) as will be clarified in section 5, because changes in risk premiums would be required as wealth was redistributed among countries with different portfolio preferences. Of course, to the extent that the risk factor is estimated to be quantitatively unimportant, so is this third notion of balance-of-payments effects.

13 Even with accurate measures of the extent to which balance-of-payments flows represent surprises that, once reported, are "expected to be corrected" by changes in the real exchange rate, there would still remain the empirical challenge of estimating long-run elasticities of balance-of-payments flows to changes in the real exchange rate in order to infer, by inversion, the extent to which the real exchange rate must apparently change to "correct" the balance-of-payments flows that it is expected to correct.

14 One obvious limitation of this measure is the lack of any attempt to subtract out the change in the trade balance (relative to its average level for the previous three months) that represents an expected lagged adjustment to past movements in the exchange rate.

15 Wednesday data are used to minimise any distorting effects of the weekend bookkeeping transactions that are made to reduce the burden of US reserve requirements. The source for all data is The Money Manager. Data on 5-year Euro-Mark rates are constructed estimates based on 3-month and 1-year rates under the assumption of a smooth interest rate term structure in which the difference between the 3-month and 5-year rates is taken to be four times the difference between the 1-year and 5-year rates. Because the Euro-Mark term structure remained fairly flat during January-May 1980, the analysis is not very sensitive to this assumption.

16 To the extent that interest differentials on 10-year maturities are much the same as those on 5-year maturities, the story told graphically in terms of 10-year interest differentials would halve the size of the estimated revisions in expected inflation differentials per annum as averaged over a 10-year horizon. This would not necessarily imply, however, that the inflation differential was expected to vanish after 5 years; recall footnote 4.

17 Anecdotal evidence suggests that these factors, in fact, may have changed over time as investors became more risk averse or more perceptive of risk following repeated experiences of getting "burned" by holding dollar-denominated assets. Such changes could be systematically modelled and estimated using non-linear procedures.

18 The January 1975 observation was sacrificed inadvertently in the process of lagging explanatory variables rather than discarded as a misfit.

19 Covariance is ignored and the terms in (A4) are considered to be logarithms of expected values.

References

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

Bilson, John F.O. "The Monetary Approach to the Exchange Rate: Some Empirical Evidence", IMF Staff Papers, March 1978.

Branson, William H., Hanna Halttunen and Paul R. Masson. "Exchange Rates in the Short Run: The Dollar Deutschemark Rate." European Economic Review, 1977.

Dooley, Michael P. and Peter Isard. "A Portfolio-Balance Rational-Expectations Model of the Dollar-Mark Rate: May 1973 - June 1977." Federal Reserve Board, International Finance Discussion Paper No. 123, 1978.

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

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.

——————————— "Exchange Rates and the Capital Mobility Problem", revised manuscript, April 1980a.

——————————— "Exchange Risk and the Macroeconomics of Exchange Rate Determination", M.I.T., revised manuscript, April 1980b.

——————————— and Stanley Fischer. "Exchange Rates and the Current Account." American Economic Review, forthcoming, December 1980.

Einzig, Paul. The History of Foreign Exchange. London, MacMillan, 1970.

Fellner, William. "The Bearing of Risk Aversion on Movements of Spot and Forward Exchange Relative to the Dollar", manuscript, 1979.

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

——————————— "On the Mark: A Theory of Floating Exchange Rates Based on Real Interest Differentials". American Economic Review, September 1979b.

——————————— "A Test of the Existence of the Risk Premium in the Foreign Exchange Market vs. the Hypothesis of Perfect Substitutability." Federal Reserve Board, International Finance Discussion Paper No. 149, August 1979c.

Frenkel, Jacob A. "A Monetary Approach to the Exchange Rate: Doctrinal Aspects and Empirical Evidence." Scandinavian Journal of Economics 2, 1976.

——————— "Flexible Exchange Rates in the 1970's." Revised manuscript, January 1980.

Hooper, Peter and John Morton. "Fluctuations in the Dollar: A Model of Nominal and Real Exchange Rate Determination", manuscript, July 1979.

Keynes, John Maynard. The General Theory of Employment, Interest and Money. London, MacMillan, 1936.

Kouri Pentti J.K. and Braga de Macedo. "Exchange Rates and the International Adjustment Process." Brookings Papers on Economic Activity, 1978.

Martin, John P. and Paul R. Masson. "Exchange Rates and Portfolio Balance", NBER Working Paper No. 377, August 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." Volume 11 of the Carnegie-Rochester Conference Series on Public Policy, a supplementary series to the Journal of Monetary Economics, 1979.

Porter, Michael G. "The Exchange Rate and Portfolio Equilibrium", manuscript, 1977.

——————— "A Portfolio Model of Exchange Rate Behaviour - Results for Eight Currencies", manuscript, 1979.

Solnik, Bruno H. European Capital Markets: Towards a General Theory of International Investment. Lexington Books, 1973.