Explaining the Demand for Dollars: International Rates of Return, and the Expectations of Chartists and Fundamentalists

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The careening path of the dollar in recent years has shattered more than historical records and the financial health of some speculators. It has also helped to shatter faith in economists' models of the determination of exchange rates. We have understood for some time that under conditions of high international capital mobility, currency values will move sharply and unexpectedly in response to new information. Even so, actual movements of exchange rates have been puzzling in two major respects.

First, the proportion of exchange-rate changes that we are able to predict seems to be, not just low, but zero. According to rational expectations theory we should be able to use our models to predict that proportion of exchange rate changes that are correctly predicted by exchange market participants. Yet neither models based on economic fundamentals, nor simple time series models, nor the forecasts of market participants as reflected in the forward discount or in survey data, seem able to predict better than the lagged spot rate. Second, the proportion of exchange rate movements that can be explained even <u>after</u> the fact, using contemporaneous macroeconomic variables, is disturbingly low.

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FUNDAMENTALS, BUBBLES, AND TESTS OF RATIONAL EXPECTATIONS

Most of the models of exchange rate determination that were developed after 1973 are driven by countries' supplies of assets: supplies of money alone in the case of the monetary models, and supplies of bonds and other assets as well in the case of the portfolio-balance models.[1] But observed supplies of dollar assets versus other currencies are no help in explaining the 1981-85 appreciation of the dollar. The supply of U.S. assets was increasing rapidly, as measured by the federal government deficit (or the money supply). At the same time, the stock of net claims against foreigners has been decreasing rapidly as measured by the current account deficit.

There is general agreement that the 1981-85 appreciation of the dollar was attributable to an increase in the demand for dollars on the part of investors worldwide. There is much less agreement as to the cause of that change in demand. Four hypotheses have been commonly proposed as to why investors found U.S. assets more attractive in the early 1980s. The first, which might be termed "monetarist," is that there was a decline in the rate of expected inflation and depreciation after 1980 because of a reduced rate of money growth.[2] The second is that there was an increase in the interest differential relative to the expected rates of inflation or depreciation; this is the "overshooting" explanation.[3] The third is that there was a self-confirming fall in the expected rate of dollar depreciation; this is the "speculative bubble" hypothesis. Each of these three attributes the increase in demand for assets to an increase in the expected rate of return, variously defined. The fourth, the "safe haven hypothesis" is different; it attributes the shift in demand to an increase in the perceived safety of U.S. assets relative to other countries' assets.

In the first half of the paper we consider briefly each of these four explanations by means of the data on expected returns for the period reported in Table 2.1. Of the three that depend on economic fundamentals--the monetarist, overshooting, and safe haven hypotheses--we argue that only the second is capable of explaining the large real appreciation of the dollar from 1981 to 1985 and its subsequent depreciation. But even the overshooting model seems unable to explain entirely the path taken by the dollar and particularly the last 20 percent of appreciation preceding the February 1985 peak and subsequent rapid decline.

TABLE 2.1
Rate of Return Differentials on US Assets Relative to Trading Partners
(% per annum)

Expected Inflation Differential	Years 1976-78	1979-80	1981-82	1983-84	1985-86
1 One-Year lag	-1.01	3.54	0.88	-0.35	0.06
2 Three-Year distributed lag	-1.96	2.7	1.89	-0.18	-0.16
3 DRI three-year forecast**	NA	2.20	0.96	0.23	0.15
4 OECD two-year forecast***	1.42	2.24	0.62	0.61	0.78
5 American Express Survey+	NA	NA	4.11	2.68	-0.16
Nominal Interest Differential					
6 One-Year interest differential*	-0.48	2.29	3.00	1.73	1.15
7 One-Year forward discount****	0.18	2.57	3.34	1.85	0.21
8 Ten-Year interest differential	-0.50	0.56	1.91	2.47	2.92
Real Interest Differential					
9 One-Year (6-1)	0.53	-1.24	2.12	2.09	1.08
10 Ten-Year w/ distributed lag (8-2)	1.47	-2.15	0.02	2.64	3.08
11 Ten-Year w/ DRI forecast (8-3)	NA	-1.64	0.95	2.24	2.77
12 Ten-Year w/ OECD forecast (8-4)	-1.92	-1.68	1.29	1.86	3.12
Expected Depreciation From Surveys++					
13 Economist 3 Month	NA	NA	12.99	10.10	1.50
14 Economist 6 Month	NA	NA	10.62	10.78	4.99
15 Amex 6 Month	2.08	NA	9.54	7.21	1.39
16 Economist 12 Month	NA	NA	8.57	8.60	5.41
17 Amex 12 Month	0.61	NA	6.67	6.99	3.75
18 (7/15)	NA	NA	0.31	0.17	0.04

*Calculated as ln(1+i), 1985 contains data through June, rates for Japan not available 1976-77. **Averages of various forecast dates, through March 1985. ***OECD forecasts available during 1976-78 only for 12/78, during 1985 for June 1985. ****Available at 11 survey dates. +Available at 11 survey dates only for US, UK, WG, and at 4 survey dates (76-78) for France. ++See Frankel and Froot (1985) for an explanation of the survey data, including the dates on which surveys were conducted. Expected depreciation uses GNP-weights for UK, FR, WG and JA. ****Includes data through February 1986.

Sources: IMF International Financial Statistics, DRI FACS financial data base and forecasts, OECD Economic Outlook, Capital International Perspective, AMEX Bank Review, and Economist Financial Review.

Note: Differential calculated as US - foreign, where foreign is a GNP weighted average of UK, FR, WG, and JA unless otherwise specified.

In the second half of this paper we propose the outlines of a model of a speculative bubble that is not constrained by the assumption of rational expectations. The model features three classes of actors: fundamentalists, chartists and portfolio managers. None of the three acts utterly irrationally; each performs the specific task assigned him in a reasonable, realistic way. Fundamentalists think of the exchange rate according to a model--say, the overshooting model for the sake of concreteness--that would be exactly correct *if there were no chartists in the world.* Chartists do not have fundamentals such as the long-run equilibrium rate in their information set; instead they use autoregressive models--say, simple extrapolation for the sake of concreteness--that have only the time series of the exchange rate itself in the information set. Finally portfolio managers, the actors who actually buy and sell foreign assets, form their expectations as a weighted average of the predictions of the fundamentalists and chartists. The portfolio managers update the weights over time in a rational Bayesian manner according to whether the fundamentalists or the chartists have recently been doing a better job of forecasting. Thus each of the three is acting rationally subject to certain constraints. Yet the model departs from the reigning orthodoxy in that the agents could do better, in expected value terms, if they knew the complete model. When the bubble takes off, agents violate rational expectations in the sense that they learn about the model more slowly than they change it. Furthermore, the model may be unstable in the neighborhood of the fundamentals equilibrium, but stable around a value for the dollar that is far from that equilibrium.

Part 1 establishes the shortcomings of the conventional approaches, including rational expectations, to accord fully with simple empirical facts of the 1981-85 period. Part 2 elaborates the distinction between chartists and fundamentalists and offers some evidence from expectations survey data that respondents seem to form very short-term expectations more like chartists and more long-term expectations like fundamentalists. Part 3 describes the model in more detail and shows how it can work to explain the 1980-85 path of the dollar.

STANDARD EXPLANATIONS OF THE 1981-1985 APPRECIATION OF THE DOLLAR BASED ON RATES OF RETURN

We begin with the simplest view of how the demand for dollars depends on rates of return, the model associated with the monetarists. In this model there are three equivalent ways of measuring the rate at which the value of the dollar is expected to change in the future relative to foreign currencies: the expected inflation differential, the expected rate of depreciation, and the nominal interest differential. The first two variables are equal if purchasing power parity holds: the goods of different countries are essentially perfect substitutes in consumers' utility functions, and barriers to instantaneous adjustment in goods markets are low. The second and third variables are equal if uncovered interest parity holds: the assets of different countries are essentially perfect substitutes in investors' portfolios, and barriers to instantaneous adjustment in asset markets are low.

At any point in the late 1970s, the U.S. dollar was expected to lose value against foreign currencies, the mark and the yen in particular, whether the expected rate of change was thought of as the expected inflation differential, the expected rate of nominal depreciation, or the nominal interest differential. In response, investors, seeking to protect themselves against expected capital losses, had a relatively low demand for dollars and high demand for marks and yen. When a firm anti-inflationary U.S. monetary policy began to take hold in 1980, investors' expectations that the dollar would lose value began to diminish rapidly. This would account for an increase in the demand for dollars and the large appreciation of the dollar in the early 1980s.

There is no single accepted way of measuring inflation expectations. The first five rows of Table 2.1 report five measures of expected inflation that are available for the United States as well as four trading partners (France, Japan, the United Kingdom, and West Germany.) The five measures are the actual inflation rate over the preceding year, a distributed lag over the preceding three years, forecasts by Data Resources, Inc., at a three-year horizon, forecasts by the OECD at a two-year horizon, and results of a survey conducted by American Express of active participants in foreign exchange markets at a one-year horizon. By the available measures, expected inflation in the U.S. by 1979-80 had climbed to a level 2-3 points above the weighted average of trading partners. The differential declined rapidly thereafter, reaching approximately zero by 1985. Thus the expected inflation numbers appear to support the first of the three explanations of the dollar appreciation listed above.

The problem is that the decline in the expected inflation differential was not at all matched by developments in other concepts of the expected rate of change of relative currency values. Directly measuring expected changes in the exchange rate is more difficult than measuring expected changes in the price level, because the former is much more volatile than the latter. A new data set is applied to this task below. But first we look at interest rate differentials.

Row 6 in Table 2.1 reports the differential in one-year nominal interest rates between the United States and the weighted average of four trading partners. Row 7 reports the one-year forward discount; the two series should be identical if covered interest parity holds. The numbers show that by 1981-82 the short-term interest differential had reached a level of 3 per cent. Thus the real interest differential, reported in row 9, rose from -1 per cent in 1979-80 to +2 percent in 1981-82. The short-term interest differential, nominal or real peaked in 1982. However, the long-term real interest differential, which rose by 2-3 points from 1979-80 to 1981-82, depending on the measure of expected inflation used, continued to rise over the next three years. In early 1985 it stood at about 3 points by any of the three measures (up from about -2 points in 1979-80).

The increase in the real interest differential offers the explanation needed for an increase in the real value of the dollar. An increase in the nominal interest differential, if it were not offset by an increase in expected inflation or expected depreciation of the currency, would make domestic assets more attractive than foreign assets. The increased demand for domestic assets causes the dollar to appreciate until investors are happy with their holdings. If the dollar is perceived as having appreciated above its long-run equilibrium, there will be an expectation of future depreciation. The short-run equilibrium will occur where the expected future depreciation is sufficient in investors' minds to offset the interest differential.

This much is familiar from the Dornbusch (1976) overshooting model. One reason for looking at the long-term differential, rather than the short-term differential that he used, is as follows.[4] The return of the exchange rate to its long-run equilibrium value could be slow and irregular. If we want to choose a length of time long enough to be confident of having reached long-run equilibrium, 10 years might be necessary. Assume that the 10-year nominal interest differential measures the 10-year expected rate of change of the nominal exchange rate. Then the 10-year real interest differential measures the 10-year expected rate of change of the real exchange rate. With our argument that 10 years is long enough for the real exchange rate to be at its equilibrium value, it follows that the currently measured 10-year (per annum) real interest differential (multiplied by ten) tells us how far from long-run equilibrium investors consider the current real exchange rate to be. Following this logic, as of early 1985 the long-term real interest differential could "explain" a real "over-valuation" of the dollar of about 30 percent relative to its perceived long-run equilibrium and could explain a real appreciation of about 50 percent relative to 1979-80.

The foregoing calculations are rather crude, and in particular are very sensitive to the term of maturity chosen. Several points can be made in defense of the approach. First, it is supported by several regression studies.[5] Furthermore, the increases in the real interest differential and in the real value of the dollar are the results that the standard macroeconomic theory of high international capital mobility predicts will result from a fiscal expansion such as that undertaken in the United States between 1981 and 1985, that is, a fiscal expansion not accommodated by either a monetary expansion or an offsetting increase in private saving. Finally, the large depreciation of the dollar in late 1985 and early 1986, as the U.S. Congress took steps to bring the fiscal deficit under control and the Federal Reserve allowed real interest rates to fall, fits the theory well. However, as always with exchange rate theories, there are problems if one tries to fit the data on as finely as a monthly basis. In particular, the long-term real interest differential was already declining during the second half of 1984, even though the dollar continued to appreciate rapidly until February 1985. The fiscal contraction did not begin until the Gramm-Rudman budget reduction bill was passed in December 1985, or at the earliest when the Congress voted to slow the future rate of growth of military spending in mid-1985. The final stages of the dollar's ascent appear unexplained.

An alternative fundamentals explanation sometimes given for the 1981-85 appreciation of the dollar is the safe-haven hypothesis: a world wide increase in investors' demand for U.S. assets in response to a perceived decrease in the risk of assets held in the United States relative to those held elsewhere. Such a portfolio shift by itself would be inconsistent with the increase in the interest rate differential observed in Table 2.1. But the argument runs that a common set of developments--the improved treatment of investment in the 1981 tax bill and the generally improved climate for business under the Reagan Administration--is responsible for both the 1983-84 investment boom (after the investment slump of 1981-82) and the safe-haven portfolio shift, and that the former had an upward effect on real interest rates that dominated any downward effect of the latter. We will be offering some evidence against the safe-haven hypothesis in section 1.3 below. We will then turn from theories based on fundamentals to theories based on bubbles.

As early as 1982, Dornbusch applied the notion of stochastic rational bubbles to the case of the strong dollar. According to this theory, there is a probability at any point in time that the bubble will burst during the subsequent period and the value of the currency will return to the equilibrium level determined by fundamentals. The differential in interest rates fully reflects and compensates for the possibility of the bubble bursting.

More recently it has been suggested that the dollar may in fact have been on an irrational bubble path. Two influential papers, written when the dollar was still near its peak--Marris (1985) and Krugman (1985)--argued that the mounting U.S. indebtedness to foreigners represented by record current account deficits would eventually force the dollar down sharply, and that this prospective depreciation was not correctly reflected in the small forward discount or interest differential (either short-term or long-term). "It appears that the market has simply not done its arithmetic, and has failed to realize that its expectations about continued dollar strength are not feasible" (Krugman (1985), p. 40).[6]

RATIONAL EXPECTATIONS AND THE FORWARD DISCOUNT

Meanwhile, evidence has continued to accumulate that the forward discount is a biased predictor of the future spot rate. A favorite way of explaining away such apparent statistical rejections of rational expectations is to appeal to the sort of "peso problem" that might arise in a speculative bubble. But, as explained in the following subsection, one of the present authors has presented calculations that tend to undermine the hypothesis that the dollar could have been on a single rational bubble from 1981 to 1985.[7] The expected probability of collapse that investors built in to the observed interest differential was high enough that it is very unlikely the dollar would have made it through four years without the bubble bursting, if that expectation was rational. This leaves the possibility of a bubble where the true probability of collapse may be different from the expected probability that investors build in to the forward discount.

Both Krugman and Marris have mentioned as partial support for their claim that the foreign exchange market may not be rational the large econometric literature that statistically rejects the hypothesis that the forward discount (or equivalently, by covered interest parity, the interest differential) is an unbiased predictor of the future spot rate. The most common test in this literature is a regression of the ex post change in the spot exchange rate against the forward discount at the beginning of the period. Under the null hypothesis the coefficient should be unity. But most authors have rejected the null hypothesis, finding that the coefficient is much closer to zero, and some even finding that the coefficient is of the incorrect sign. The implication is that one could expect to make money by betting against the forward discount whenever it is non-zero.[8] Bilson (1981) interprets this finding as "excessive speculation:" investors would do better if they would routinely reduce toward zero the magnitude of their expectations of exchange rate changes.

This forward market finding poses a puzzle in the context of the Krugman-Marris characterization of the dollar. It implies that as of 1985 (or for that matter at any time over the previous five years) the rationally expected rate of future dollar depreciation was less than the 3 percent a year implied in the forward discount.[9] The Krugman-Marris argument was that the rationally expected rate of future dollar depreciation would be much greater than the 3 percent a year implicit (against the mark or yen) in the market.[10] If we are to allow expectations to fail to be rational, we must somehow reconcile the two conflicting kinds of failure.

More discussion of the alleged bias in the forward exchange market is required. Most of the literature (for example the papers cited in footnote 8) does not interpret the finding as necessarily rejecting the hypothesis of rational expectations. Two other possible explanations are routinely offered: the existence of a risk premium and the "peso problem." We believe that, while both factors can be very important in other contexts, neither explains the systematic prediction errors made by the forward market during the strong-dollar period. We consider the risk premium briefly here, and the peso problem in the next subsection.

The first possible explanation is that the systematic component of the apparent prediction errors is really a risk premium separating the forward rate from investors' true expectations. It is a difficult argument either to refute or confirm, because expectations are not directly observable.

There are few sources of information to help isolate the risk premium out of the prediction errors made by the forward discount. One promising possibility is the surveys of market participants' exchange rate expectations conducted by the Economist's *Financial Report* and the *American Express Bank Review*.[11] The surveys allow us to measure expectations without the interference of the risk premium. In Frankel and Froot (1985) and Froot and Frankel (1986), we showed that those data for the 1981-85 period reflect a considerably greater expectation of dollar depreciation than do the forward discount or interest differential. (The biyearly averages are reported in rows 13-18 of Table 2.1.) We repeated standard tests of unbiasedness in expected depreciation and found even more significant rejections when the survey data, which must be free from any risk premium, are used than when the forward discount is used. First, we found unconditional bias: one would have persistently made money over the period June 1981-March 1985 by following the rule "buy and hold dollars." A related finding was that expectations were formed regressively--that is, the expected future spot rate puts some weight on a long-run equilibrium rate--but that the actual spot process did not bear out this expectation. Investors overestimated the speed of regression to a statistically significant degree.

An updating of the sample period to include data through December 1985 shows a dramatic shift in the nature of the bias: now it appears that investors on average underestimated the speed of regression toward long-run equilibrium to a statistically significant degree (Frankel and Froot (1987)). But the most robust finding, even with investors' expectations measured by the survey data instead of the forward discount, is excessive speculation in the sense of Bilson (1981): investors would have done better during the 1981-1985 period if they had routinely reduced their expectations of exchange rate changes. The rejection of rational expectations holds up even if one allows for measurement error in the survey data (provided it is random): one can reject the hypothesis that expectations are rational and that the apparent bias in the survey numbers is entirely attributable to measurement error. In addition, Froot and Frankel (1986) tests the hypothesis that no information about the risk premium is revealed in regressions of the ex post change in the spot rate on the forward discount. This hypothesis cannot be rejected, suggesting that the risk premium does not help explain why changes in the forward discount mispredict future changes in the spot rate. The rational expectations hypothesis appears in trouble.

AN EVALUATION OF THE SAFE-HAVEN AND RATIONAL BUBBLE HYPOTHESES

If the survey numbers are taken seriously as measuring investors' rate of expected depreciation, they imply a large *negative* risk premium paid on dollar assets during the 1981-85 period (a sharp decline from the near-zero risk premium in the 1970s). This is very different from the positive risk premium implied by standard tests of bias in the forward discount. Is a negative risk premium plausible nevertheless? Standard portfolio considerations would suggest not. The exchange risk premium in theory should depend on such variables as asset supplies and on return variances and covariances. The large U.S. government budget deficit and current account deficits mean that asset supplies should recently have been driving the dollar risk premium up, not down. One could posit an increase in the perceived riskiness of European currencies relative to the dollar, attributable for example to an increase in uncertainty regarding European monetary policy relative to U.S. monetary policy. But in that case it would be difficult to explain the increase in the U.S. interest differential after 1980; by itself a shift in demand toward U.S. assets due to uncertainty should have driven U.S. interest rates down.[12]

There is one explanation that has been seriously proposed for the dollar appreciation that is consistent with both a fall in the risk premium on dollars and an increase in the interest differential, in other words, consistent with the expected rate of depreciation increasing even more than the interest differential. That is the "safe haven" explanation mentioned above: an exogenous shift in demand toward U.S. assets due to perceptions of reduced country risk in the United States relative to abroad. According to this theory, risk has declined in the United States because of an improved business climate, in particular improved tax treatment for investment after 1981, which also explains the increase in U.S. real interest rates via an alleged investment boom.[13] Risk has increased in the rest of the world, not just because of debt problems in Latin America (which would alone not be relevant for the exchange rate or return differentials between the United States and Europe) but also because of political or country risk in Europe. Dooley and Isard (1985), for example, speak of a perceived threat of penalties on capital in Europe, "where the term 'penalty' is loosely defined to include formal taxation, the postponement of interest and principal payments, confiscation, destruction of property, and so forth."

We here propose a simple test be used to evaluate the safe haven hypothesis: a comparison of interest rates paid on securities that are physically located offshore, but that are denominated in dollars or otherwise covered on the forward exchange market to get around the problem of exchange risk, with interest rates paid on securities in the United States. That is, we are testing international closed, or covered, interest parity, not uncovered interest parity.

Tests of the offshore-onshore differential have been frequently employed to illustrate a number of points about the existence of capital controls or country risk: a negative differential for Germany until 1974 showed that capital controls discouraged capital inflow (Dooley and Isard (1980)); a positive differential for the United Kingdom until 1979 showed that capital controls discouraged outflow; positive differentials for France and Italy show that controls still discourage outflow (e.g.; Giavazzi and Pagano (1985), Classen and Wyplosz (1982)); a negative differential for Japan until 1979 showed that controls discouraged inflow (Otani and Tiwari (1981); Ito (1984) and Frankel (1984)); and, but for the foregoing exceptions, the generally small magnitude of differentials shows that capital mobility is very high among the major industrialized countries (e.g., Frenkel and Levich (1975), McCormick (1979), Boothe et al. (1985)).[14]

Table 2.2 reports mean daily differentials between offshore interest rates (covered) and domestic U.S. interest rates, for seven different pairs of securities. Remarkably, there was a relatively substantial positive differential in almost all cases, until recently, regardless whether one observes the offshore interest rate in the Euromarket, in the domestic U.K. market, or in the domestic German market.[15] From 1979 to 1982, the Euromarket rates exceeded the U.S. interbank rate by an average of about 100 basis points. A number of studies have noted that the Eurodollar rate does not move perfectly with the U.S. interbank or CD rate (Hartman (1983), Kreicher (1982)). They attribute the differential primarily to the fact that U.S. banks face reserve requirements against domestic deposits but not against Eurodeposits, so they are willing to pay a higher interest rate to depositors offshore. But the differential has been mostly swept under the rug in more general studies of covered interest parity.

Even those who have studied the Eurodollar-U.S. interbank differential treat it as a peculiarity of that particular market. This would make sense only if, on the one hand, the U.S. interbank rate were depressed below other U.S. interest rates (by U.S. reserve requirements) or if, on the other hand, Eurocurrency interest rates

TABLE 2.2
Deviations from Closed Interest Parity: Offshore Interest Rate (covered for exchange risk) Minus the United States Interest Rate (three-month interest rates in percentage per annum)

Offshore rate / U.S. rate	Euro-$ / T-Bill	Euro-$ / Interbank	Euro £ + fd / Interbank	U.K. Ib + fd / Interbank	U.K. T-Bill + fd / T-Bill	Euro-DM + fd / Interbank	Ger. Ib + fd / Interbank
Means							
Year							
1978	1.573	0.564	0.618	-0.840	-0.301	0.738	1.075
1979	1.894	0.786	0.886	0.622	1.656	1.047	1.491
1980	2.581	1.016	1.145	0.989	2.070	1.384	1.931
1981	2.190	0.923	1.080	1.085	2.105	1.242	1.778
1982	2.091	0.900	1.074	1.082	2.066	1.208	1.640
1983	0.660	0.546	0.676	0.691	0.577	0.786	1.127
1984	0.878	0.408	0.566	0.558	0.583	0.709	1.008
1985	0.571	0.295	0.414	0.410	0.305	0.396	0.622
Standard Deviations							
Year							
1978	0.666	0.262	0.390	0.846	0.975	0.477	0.484
1979	0.690	0.272	0.376	0.498	0.751	0.410	0.549
1980	1.027	0.371	0.785	0.795	1.233	0.526	0.565
1981	0.578	0.280	0.353	0.316	0.742	0.344	0.455
1982	0.736	0.205	0.242	0.223	0.746	0.308	0.357
1983	0.156	0.116	0.201	0.222	0.282	0.140	0.186
1984	0.401	0.078	0.143	0.134	0.418	0.194	0.234
1985	0.176	0.109	0.301	0.275	0.498	0.552	0.555

Note: Ib ≡ interbank rate.
fd ≡ adjustment for the forward exchange discount.

were raised above domestic European interest rates (either by analogous reserve requirements in European countries or by perceived default risk in the Euromarket). But neither of these effects seems to hold. Table 2.2a shows small spreads between the Eurodollar rate and the Europound or Euromark rates (covered) or between them and the domestic U.K. and German interest rates. Indeed, Table 2.2 shows that the spread between covered pound or mark interest rates and domestic U.S. rates is even higher, and comes down even more after 1982, when Treasury bill rates are used than when banking rates are used. This finding contradicts the hypothesis that U.S. reserve requirements are the only factor driving a wedge between the Euromarket and the U.S. interbank market and that more direct arbitrage through other means works to reduce that wedge.

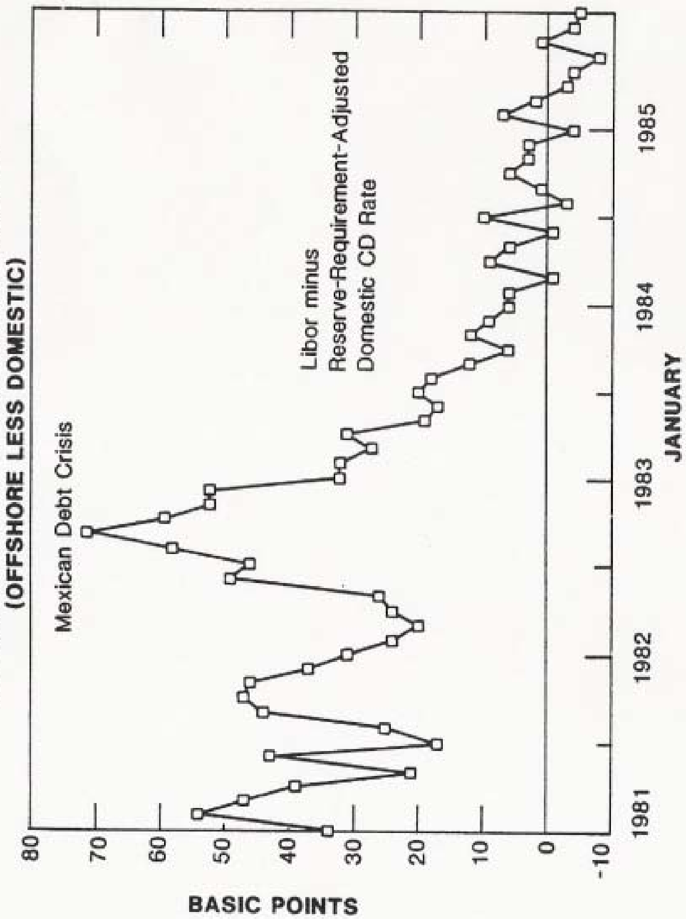
Why were foreigners and U.S. residents buying U.S. Treasury bills in 1979-1982 when they paid about 2 percent less than U.K. Treasury bills? The obvious response is that U.S. securities were preferred for safe-haven reasons. But since the differential predates the appreciation of the dollar, there is some difficulty in associating the two. This is particularly true after 1982, when the differential declines sharply. By 1985, when the dollar had appreciated much further, the Eurodollar rate was only 30 basis points above the domestic U.S. interbank interest rate, in the same range as the differentials for the pound, mark, yen, Canadian dollar, and Swiss franc. Chart 1 shows a comparison of the London Interbank Offer Rate (LIBOR) with a domestic U.S. CD rate, adjusted for reserve requirements. The differential, which was clearly positive in the early 1980s, peaked during the Mexican debt crisis in August 1982 and declined steadily afterward, reaching zero in early 1985, about the time when the dollar's value peaked. The evidence thus suggests that the United States was perceived as <u>increasingly</u> risky after 1982. The story based on safe-haven fundamentals does not explain the continued appreciation of the dollar from 1982 to February 1985 any better than the story based on real interest fundamentals. The field would appear to be open to bubble theories.

The possibility of speculative bubbles leads to the second explanation, besides the risk premium, that is often given for the econometric findings of biasedness in the forward exchange market: the peso problem. The standard tests presume that the error term, the difference between expected depreciation and the ex post realization, is distributed normally and independently over time. But if there is a small probability of a big decline in the value of the

Table 2.2a
Deviations from Interest Parity Within Jurisdictions
(Three-month interest rates in percentage per annum)

	Euro \$ – fd / Euro	Euro £ / U.K. Interbank	Euro £ / U.K. T-bill	Euro \$ – fd / Euro DM	Euro DM / Ge. Interbank
Means					
Year					
1978	-0.066	1.432	1.895	-0.187	-0.335
1979	-0.103	0.289	0.363	-0.220	-0.444
1980	-0.123	0.156	0.658	-0.373	-0.549
1981	-0.161	-0.004	0.228	-0.319	-0.525
1982	-0.179	0.003	0.207	-0.311	-0.431
1983	-0.131	-0.010	0.217	-0.239	-0.341
1984	-0.158	0.009	0.451	-0.300	-0.296
1985	-0.121	0.008	0.393	-0.100	-0.222
Standard Deviations					
Year					
1978	0.280	0.866	0.822	0.350	0.175
1979	0.272	0.288	0.466	0.408	0.253
1980	0.719	0.335	0.605	0.376	0.292
1981	0.286	0.250	0.470	0.250	0.317
1982	0.214	0.188	0.300	0.270	0.168
1983	0.179	0.143	0.240	0.088	0.113
1984	0.143	0.125	0.233	0.173	0.100
1985	0.285	0.119	0.418	0.552	0.094

CHART 1
DEVIATIONS FROM CLOSED INTEREST PARITY
(OFFSHORE LESS DOMESTIC)



Source: Federal Reserve Board

currency, the distributional assumption will not be met, the estimated standard errors will be incorrect, and unbiasedness may be spuriously rejected.[16] This problem is thought to be relevant for pegged currencies like the Mexican peso up until 1976, and generally less relevant for floating currencies. But if the dollar has been on a single speculative bubble path for four years, there could well be a small probability of a large decline in the form of a bursting of the bubble. It has been suggested that the forward discount may properly reflect that possibility, and that tests find a bias only because the event happens not to have occurred in the sample.

Calculations in Frankel (1985) tend to undermine the hypothesis that the forward discount during the period 1981-85 reflected rational expectations of a small probability of a large decline in the value of the dollar. Under the hypothesis that the bursting of the bubble would reverse half of the real appreciation of the dollar against the mark that has taken place since the 1970s, a 3 percent forward discount in March 1985 implied a 2.8 percent perceived probability of collapse during that month. One can multiply out the implied probabilities of non-collapse since January 1981, with no distributional assumptions needed, to find that the chance that such a bubble would have persisted for four years without bursting is only 3 percent. Thus the peso problem does not "get the forward exchange market off the hook." The period during which the forward discount was positive with no realized depreciation simply went on too long for the rational expectations hypothesis to emerge intact.

FUNDAMENTALISTS AND CHARTISTS

We can gather the conclusions reached so far into five propositions, each with elements of paradox.

(1) The dollar continued to rise even after all fundamentals (the interest differential, current account, etc.) apparently began moving the wrong way. The only explanation left would seem to be, almost tautologically, that investors were responding to a rising expected rate of change in the value of the dollar. In other words, the dollar was on a bubble path.

(2) Evidence suggests that the investor-expected rate of depreciation reflected in the forward discount is not equal to the rationally-expected rate of depreciation. The failure of a fall in the dollar to materialize in four years implies that the rationally-expected rate of depreciation was <u>less</u> than the forward discount.

(3) On the other hand, Krugman-Marris current account calculations suggested that the rationally-expected rate of depreciation was greater than the current forward discount.

(4) The survey data show that the respondents have since 1981 indeed held an expected rate of depreciation substantially greater than the forward discount. But interpreting their responses as true investor expectations, and interpreting the excess over the forward premium as a negative risk premium, raises a problem. If investors seriously expected the dollar to depreciate so fast, why did they buy dollars?

(5) In the safe-haven theory, a perceived shift in country risk rather than exchange risk might seem to explain many of the foregoing paradoxes. However, the covered differential between European and U.S. interest rates actually fell after 1982 suggesting that perceptions of country risk, if anything, shifted against the United States.

The model of fundamentalists and chartists that we are proposing has been designed to reconcile these conflicting conclusions. To begin with, we hypothesize that the views represented in the American Express and Economist 6-month surveys are primarily fundamentalist, like the views of Krugman and Marris (and most other economists). But it may be wrong to assume that investors' expected rate of depreciation is necessarily the one reported in the 6-month surveys or that there even is such a thing as "the" expected rate of depreciation (as most of our models do). Expectations are heterogeneous. Our model suggests that the market gives heavy weight to the chartists, whose expected rate of change in the value of the dollar has been on average much closer to zero, perhaps even positive. Paradox (4) is answered if fundamentalists' expectations are not the only ones determining positions that investors take in the market.

The increasing dollar overvaluation after the interest differential peaked in 1982 (measured short-term) or 1984 (measured long-term) would be explained by a falling market-expected rate of future depreciation (or rising expected rate of appreciation), with no necessary basis in fundamentals. The market-expected rate of depreciation declined over time, not necessarily because of any change in the expectations held by chartists or fundamentalists, but rather because of a shift in the weights assigned to the two by the portfolio managers. They are the agents who take positions in the market and determine the exchange rate. They gradually put less and less weight on the big-depreciation forecasts of the fundamentalists, as these forecasts continue to be proven false, and more and more weight on the chartists.

Before we proceed to show how such a model works, we offer evidence that there is not a single homogeneous expected rate of depreciation reflected in the survey data: the very short-term expectations (one-week and two-week) reported in a third survey of market participants, by Money Market Services, Inc., behave very differently from the medium-term expectations (3, 6, or 12 month) reported in any of the three surveys.[17]

EMPIRICAL RESULTS ON SHORT-TERM AND LONG-TERM EXPECTATIONS

One way of distinguishing empirically between the shorter- and longer-term expectations is to examine the weight survey respondents place on variables other than the contemporaneous spot rate in forming their expectations at different time horizons. Suppose, for example, that investors assign a weight of g to the lagged spot rate and a weight of 1-g to the current spot rate in forming their expectation of the future spot rate:

$$s^m_{t+1} = (1-g)s_t + gs_{t-1} \qquad (1)$$

where s_t is the logarithm of the current spot rate, and s^m_{t+1} is the market's expected future spot rate at time t. Subtracting s_t from both sides we have that expected depreciation is proportional to the current change in the spot rate:

$$\Delta s^m_{t+1} = -g\Delta s_{t+1} \qquad (2)$$

We term the model in equation (2) extrapolative expectations. If investors place positive weight on the lagged spot rate, so that g is positive, then equation (1) says that investors' expected future spot rate is a simple distributed lag. On the other hand, if investors tend to extrapolate the most recent change in the spot rate, so that g is negative, then equation (2) may be termed "bandwagon" expectations. We might, for instance, associate the fundamentalist viewpoint with a tendency to expect a currency which has recently appreciated to depreciate in the future ($g > 0$), and the chartist viewpoint with a tendency to expect on average some continuation of the past trend ($g < 0$).

Table 2.3 reports regression estimates of equation (2), using the survey expected depreciation as the lefthand-side variable.[18] The findings are ordered by the forecast horizon, from the shortest-term 1 and 2 week expectations, to the longer-term 12 month expectations. It is immediately evident that the shorter term expectations--1 week, 2 weeks and 1 month--all exhibit significant bandwagon tendencies: that $g < 0$. In the 1 week expectations, for example, an appreciation of 10 percent over the past week by itself generates the expectation that the spot rate will appreciate another 1.35 percent in the next seven days. This result is characteristic of destabilizing expectations, in which a current appreciation generates self-sustaining expectations of future appreciation.

In contrast with the shorter-term expectations, the longer-term results all point toward stabilizing distributed lag expectations. Each of the regressions at the 6 and 12 month forecast horizons estimates g to be significantly greater than zero.[19] The Economist 12 month data, for example, imply that a current 10 percent appreciation by itself generates an expectation of a 2.02 percent <u>depreciation</u> over the coming 12 months. Thus longer-term expectations feature a strongly positive weight on the lagged spot rate rather than complete weight on the contemporaneous spot rate, and in this sense they are stabilizing.

A second popular specification for the expected future spot rate is that it is a weighted average of the current spot rate and the (log) long-run equilibrium spot rate, $\bar{s}_t$:

$$s^m_{t+1} = (1-\theta)s_t + \theta\bar{s}_t \tag{3}$$

or in terms of expected depreciation:

$$\Delta s^m_{t+1} = \theta(\bar{s}_t - s_t) \tag{4}$$

If θ is positive, as, for example, in the Dornbusch overshooting model, the spot rate is expected to move in the direction of $\bar{s}_t$. Expectations are therefore regressive. This formulation for expectations is perhaps closest to the fundamentalists' view, because the long-run equilibrium to which investors expect the spot rate to return, $\bar{s}_t$, is determined by (fundamental) factors in the real economy. Alternatively, a finding of $\theta < 0$ implies that investors expect the spot rate to move away from the long-run equilibrium.

Table 2.4 presents tests of equation (4). Once again, there is strong evidence that shorter-term expectations are formed in a different manner than longer-term expectations. The shorter

TABLE 2.3
Extrapolative Expectations (Independent variable: $s_{t-1} - s_t$)

SUR Regressions (1) of Survey Expected Depreciation: $s^m_{t+1} - s_t = a+g(s_{t-1}-s_t)$

Data Set	Dates	coefficient $\hat{g}$	t:g=0	DW(2)	DF	R^2
MMS 1 Week	10/84-2/86	-0.1345 (0.0254)	-5.30***	1.89	239	0.76
MMS 2 Week	1/83-10/84	-0.0565 (0.0267)	-2.12**	1.76	179	0.33
MMS 1 Month	10/84-2/86	-0.0536 (0.0217)	-2.47**	1.48	171	0.40
Economist 3 Month	6/81-12/85	0.0416 (0.0210)	1.98*	1.81	184	0.30
MMS 3 Month	1/83-10/84	-0.0391 (0.0168)	-2.32**	1.49	179	0.37
Economist 6 Month	6/81-12/85	0.0730 (0.0225)	3.25***	1.36	184	0.54
Amex 6 Month	1/76-8/85	0.2994 (0.0487)	6.15***	1.89	45	0.81
Economist 12 Month	6/81-12/85	0.2018 (0.0296)	6.82***	1.47	184	0.84
Amex 12 Month	1/76-8/85	0.3796 (0.0798)	4.76***	0.94	45	0.72

(1) Amex 6 and 12 Month regressions use OLS due to the small number of degrees of freedom.
(2) The DW statistic is the average of the equation by equation OLS Durbin-Watson statistics for each data set. *Represents significance at the 10 percent level. **Represents significance at the 5 percent level. ***Represents significance at the 1 percent level. R^2 corresponds to an F test on all nonintercept parameters. Some of the above results are reported in Frankel and Froot (1987). Constant terms for each currency were included in the regressions, but not reported above.

TABLE 2.4
Regressive Expectations II (Independent variable: $\bar{s}_t - s_t$)
Long Run Equilibrium PPP

SUR Regressions (1) of Survey Expected Depreciation:
$s^m_{t+1} - s_t = a + \theta(\bar{s}_t - s_t)$

Data Set	Dates	coefficient θ	$t{:}\theta=0$	DW(2)	DF	R^2
MMS 1 Week	10/84-2/86	-0.0283 (0.0080)	-3.53***	2.10	219	0.58
MMS 2 Week	1/83-10/84	-0.0299 (0.0079)	-3.78***	2.15	179	0.61
MMS 1 Month	10/84-2/86	-0.0782 (0.0134)	-5.84***	1.40	151	0.79
Economist 3 Month	6/81-12/85	0.0223 (0.0126)	1.78*	1.66	184	0.26
MMS 3 Month	1/83-10/84	-0.0207 (0.0146)	-1.41	1.55	179	0.18
Economist 6 Month	6/81-12/85	0.0600 (0.0159)	3.77***	1.32	184	0.61
Amex 6 Month	1/76-8/85	0.0315 (0.0202)	1.56	1.22	45	0.21
Economist 12 Month	6/81-12/85	0.1750 (0.0216)	8.10***	1.25	184	0.88
Amex 12 Month	1/76-8/85	0.1236 (0.0276)	4.48***	0.60	45	0.69

(1) Amex 6 and 12 Month regressions use OLS due to the small number of degrees of freedom.
(2) The DW statistic is the average of the equation by equation OLS Durbin-Watson statistics for each data set. *Represents significance at the 10 percent level. **Represents significance at the 5 percent level. ***Represents significance at the 1 percent level. R^2 corresponds to an F test on all nonintercept parameters. Some of the above results are reported in Frankel and Froot (1987). Constant terms for each currency were included in the regressions, but not reported above.

forecast horizons all yield estimates of θ that are negative, additional evidence that shorter term speculation may be destabilizing. Indeed, the 1 week data suggest that the contemporaneous deviation from the long-run equilibrium is expected on average to grow by 3 percent over the subsequent seven days. In other words, short-term expectations are explosive. The significantly positive estimates of θ in the longer-term data sets suggest by contrast the longer-term expectations are strongly regressive. In the Economist 12 month data, for example, respondents expect any current deviation from the long-run equilibrium to decay by 17.5 percent over the following 12 months.

The final specification we consider is adaptive expectations. In this case, agents are hypothesized to form their expectation of the future spot rate as a weighted average of the current spot rate and the lagged expected spot rate:

$$s^m_{t+1} = (1-\gamma)s_t + \gamma s^m_t \tag{5}$$

Expected depreciation is now proportional to the contemporaneous prediction error:

$$\Delta s^m_{t+1} = (s^m_t - s_t) \tag{6}$$

Table 2.5 reports estimates of equation (6). The R^2 statistics are generally lower than in Tables 2.3 and 2.4, suggesting that the surveys are not characterized as well by adaptive expectations as they are by regressive and extrapolative expectations. Nevertheless, the results are qualitatively comparable with those of the previous two tables. The shorter-term expectations place significantly negative weight on the lagged expectation. At the same time there is evidence that the longer-term data place positive weight on the lagged expectation, that longer-term expectations are adaptive.

The results of Tables 2.3, 2.4 and 2.5 suggest that in all three of our standard models of expectations--extrapolative, regressive and adaptive--short-term and long-term expectations behave very differently from one another. In terms of the distinction between fundamentalists and chartists views, we associate the longer-term expectations, which are consistently stabilizing, with the fundamentalists, and the shorter-term forecasts, which seem to have a destabilizing nature, with the chartist expectations. Within each of the above tables, it is as if there are actually two models of expectations operating, one at each end of the spectrum of forecast horizons, and a blend in between. Under this view, respondents use

TABLE 2.5
Adaptive Expectations (Independent variable: $s^m_t - s_t$)

SUR Regressions(1) of Survey Expected Depreciation:
$s^m_{t+1} - s_t = a + \gamma(s^m_t - s_t)$

Data Set	Dates	coefficient γ	t:γ=0	DW(2)	DF	R^2
MMS 1 Week	10/84-2/86	-0.1047 (0.0256)	-4.09***	1.69	211	0.65
MMS 2 Week	1/83-10/84	-0.0296 (0.0255)	-1.16	1.68	175	0.13
MMS 1 Month	10/84-2/86	0.0121 (0.0235)	0.52	1.31	135	0.03
Economist 3 Month	6/81-12/85	0.0798 (0.0203)	3.93***	2.01	169	0.63
MMS 3 Month	1/83-10/84	-0.0272 (0.0215)	-1.27	1.29	159	0.15
Economist 6 Month	6/81-12/85	0.0516 (0.0161)	3.20***	1.12	159	0.53
Amex 6 Month	1/76-8/85	-0.0702 (0.1200)	-0.59	2.10	15	0.04
Economist 12 Month	6/81-12/85	-0.0093 (0.0244)	-0.38	1.10	139	0.02
Amex 12 Month	1/76-8/85	0.0946 (0.0212)	4.46***	0.55	31	0.69

(1) Amex 6 and 12 Month regressions use OLS due to the small number of degrees of freedom.
(2) The DW statistic is the average of the equation by equation OLS Durbin-Watson statistics for each data set. *Represents significance at the 10 percent level. **Represents significance at the 5 percent level. ***Represents significance at the 1 percent level. R^2 corresponds to an F test on all nonintercept parameters. Some of the above results are reported in Frankel and Froot (1987). Constant terms for each currency were included in the regressions, but not reported above.

some weighted average of the chartist and fundamentalist forecasts in formulating their expectations for the value of the dollar at a given future date, with the weights depending on how far off that date is.

These results suggest an alternative interpretation of how chartist and fundamentalist views are aggregated in the marketplace, an aggregation that takes place without the benefit of portfolio managers. It is possible that the chartists are simply people who tend to think short-term and the fundamentalists are people who tend to think long-term. For example, the former may by profession be "traders", people who buy and sell foreign exchange on a short-term basis and have evolved different ways of thinking than the latter, who may by profession buy and hold longer-term securities.[20]

In any case, one could interpret the two groups as taking positions in the market directly, rather than merely issuing forecasts for the portfolio managers to read. The market price of foreign exchange would then be determined by demand coming from both groups. But the weights that the market gives to the two change over time, according to the groups' respective wealths.[21] If the fundamentalists sell the dollar short and keep losing money, while the chartists go long and keep gaining, in the long run the fundamentalists will go bankrupt and there will only be chartists in the marketplace. The model that we develop in the next section pursues the portfolio manager's decision-making problem instead of the marketplace-aggregation idea, but the two are similar in spirit.

Yet another possible interpretation of the survey data is that the two ways of thinking represent conflicting forces within the mind of a single representative agent. When respondents answer the longer-term surveys they give the views that their economic reason tells them are correct. When they get into the trading room they give greater weight to their instincts, especially if past bets based on their economic reason have been followed by ruinous "negative reinforcement." A respondent may think that when the dollar begins its plunge, he or she will be able to get out before everyone else does. This opposing instinctual force comes out in the survey only when the question pertains to the very short-term--one or two weeks; it would be too big a contradiction for his conscience if a respondent were to report a one-week expectation of dollar depreciation that was (proportionately) just as big as the answer to the 6-month question, at the same time that he or she was taking a long position in dollars. Again, we prefer the interpretation where the survey reflects the true expectations of the respondent, and the market trading is done by some higher authority; but others may prefer the more complex psychological interpretation.

The fragments of empirical evidence in Tables 2.3, 2.4, and 2.5 are the only ones we will offer by way of testing our approach. The aim in what follows is to construct a model that reconciles the apparent contradictions discussed in Part 1. There will be no further hypothesis testing.

AN ESTIMATE OF THE WEIGHTS

We think of the value of the dollar as being driven by the decisions of portfolio managers who use a weighted average of the expectations of fundamentalists and chartists. Specifically,

$$\Delta s^{m}_{t+1} = \omega_t \Delta s^{f}_{t+1} + (1-\omega_t)\Delta s^{c}_{t+1} \tag{7}$$

where Δs_{t+1}^{m} is the rate of change in the spot rate expected by the portfolio managers, Δs_{t+1}^{f} and Δs_{t+1}^{c} are defined similarly for the fundamentalists and chartists, and ω_t is the weight given to fundamentalist views. For simplicity we assume $\Delta s_{t+1}^{c} = 0$. Thus equation (7) becomes

$$\Delta s^{m}_{t+1} = \omega_t \Delta s^{f}_{t+1} \tag{8}$$

or

$$\omega_t = \frac{\Delta s^{m}_{t+1}}{\Delta s^{f}_{t+1}}$$

If we take the 6-month forward discount to be representative of portfolio managers' expectations and the 6-month survey to be representative of fundamentalists' expectations, we can get a rough idea of how the weight, ω_t, varies over time.

Table 2.6 contains estimates of ω_t from the late 1970s to 1985. (There are, unfortunately, no survey data for 1980.) The table indicates a preponderance of fundamentalism in the late seventies; portfolio managers gave almost complete weight to this view. But beginning in 1981, as the dollar began to rise, the forward discount increased less rapidly than fundamentalists' expected depreciation, indicating that the market (the portfolio managers in our story) was beginning to pay less attention to the fundamentalists' view. By 1985, the market's expected depreciation had fallen to about

TABLE 2.6
Estimated Weights Given to Fundamentalists by Portfolio Managers

	Year					
	1976-79	1981	1982	1983	1984	1985
Forward Discount fd	1.06	3.74	3.01	1.10	3.07	-0.16
Survey Expected Depreciation Δs^{m}_{t+1}	1.20	8.90	10.31	10.42	11.66	4.00
$\omega_t \equiv (fd/\Delta s^{m}_{t+1})$	0.88	0.42	0.29	0.11	0.26	-0.04

Notes: Forward discount, 1976-85 is at 6 months and includes data through September 1985 for the average of five currencies, the pound, French franc, mark, Swiss franc and yen. Survey expected depreciation 1981-85 is from the Economist 6 month survey data, and for 1976-79 is from the AMEX survey data for the same five currencies.

zero. According to these computations, fundamentalists were being completely ignored.

While the above scenario solves the paradox posed in proposition (4), it leaves unanswered the question of how the weight $_t$, which appears to have fallen dramatically since the late 1970s, is determined by portfolio managers. Furthermore, if portfolio managers have small risk premia, and thus expect depreciation at a rate close to that predicted by the forward discount, we still must account for the spectacular rise of the dollar discount (proposition (1)), and resolve how the rationally expected depreciation differs from the forward discount (propositions (2) and (3)).

PORTFOLIO MANAGERS AND EXCHANGE RATE DYNAMICS

Up to this point we have characterized the chartist and fundamentalist views of the world, and hinted at the approximate mix that portfolio managers would need to use if the market risk premium is to be near zero. We now turn to an examination of the behavior of portfolio managers, and to the determination of the equilibrium spot rate. In particular, we first focus exclusively on the dynamics of the spot rate which are generated by the changing expectations of portfolio managers. We then extend the framework to include the evolution of fundamentals which eventually must bring the dollar back down.

DETERMINATION OF THE EXCHANGE RATE

A general model of exchange rate determination can be written:

$$s_t = c\Delta s^m_{t+1} + z_t \qquad (9)$$

where s(t) is the log of the spot rate, Δs^m_{t+1} is the rate of depreciation expected by "the market" (portfolio mangers) and z_t represents other contemporaneous determinants. This very general formulation, in which the first term can be thought of as speculative factors and the second as fundamentals, has been used by Mussa (1976) and Kohlhagen (1979). An easy way to interpret equation (9) is in terms of the monetary model of Mussa (1976), Frenkel (1976)

and Bilson (1978). Then c would be interpreted as the semi-elasticity of money demand with respect to the alternative rate of return (which could be the interest differential, expected depreciation or expected inflation differential; as noted in section 1.1, the three are equal if uncovered interest parity and purchasing power parity hold), and z_t would be interpreted as the log of the domestic money supply relative to the foreign (minus the log of relative income, or any other determinants of real money demand). An interpretation of equation (9) in terms of the portfolio-balance approach is slightly more awkward because of nonlinearity. But we could define:

$$z_t = d_t - f_t - c(i_t - i^*_t) \qquad (10)$$

where d_t is the log of the supply of domestic assets including not only money but also bonds and other assets, f_t is the log of the supply of foreign assets, and $i_t - i^*_t$ is the nominal interest differential. Then equation (9) can be derived as a linear approximation to the solution for the spot rate in a system where the share of the portfolio allocated to foreign assets depends on the expected return differential or risk premium, $i_t - i^*_t - \Delta s^m_{t+1}$. If investors diversify their portfolios optimally, c can be seen to depend inversely on the variance of the exchange rate and the coefficient of relative risk-aversion.[22] In any case, the key point behind equation (9), common throughout the asset-market view of exchange rates, is that an increase in the expected rate of future depreciation will reduce demand for the currency today, and therefore will cause it to depreciate today.

The present paper imbeds in the otherwise standard asset pricing model given by equation (9) a form of market expectations that follows equation (7). That is, we assume that portfolio managers' expectations are a weighted average of the expectations of fundamentalists, who think the spot rate regresses to long-run equilibrium, and the expectations of chartists who use time series methods:

$$\Delta s^m_{t+1} = \omega_t \Delta s^f_{t+1} + (1-\omega_t)\Delta s^c_{t+1} \qquad (11)$$

We define $\bar{s}$ to be the logarithm of the long-run equilibrium rate and θ to be the speed of regression of s_t to $\bar{s}$. In the view of fundamentalists:

$$\Delta s^f_{t+1} = \theta(\bar{s} - s_t) \qquad (12)$$

In the context of some standard versions of equation (9)--the monetary model of Dornbusch (1976) in which goods prices adjust slowly over time or the portfolio-balance models in which the stock of foreign assets adjusts slowly over time--it can be shown that equation (12) might be precisely the rational form for expectations to take if there were no chartists in the market, $\omega_t = 1$. Unfortunately for the fundamentalists, the distinction is crucial; equation (12) will not be rational given the complete model.

For example, if we define z_t in equation (9) as the interest differential we have:

$$s_t = a + c\theta(\bar{s} - s_t) - b(i_t - i_t^*) \qquad (13)$$

Uncovered interest parity, $i_t - i_t^* = \theta(\bar{s} - s(t))$, implies that $\theta = 1/(\beta - c)$ and $a = \bar{s}$. It is then straightforward to show that θ can be rational within the Dornbusch (1976) overshooting model.[23]

In the second group of models (Kouri (1976) and Rodriguez (1980) are references), overshooting occurs because the stock of net foreign assets adjusts slowly through current account surpluses or deficits. A monetary expansion creates an imbalance in investors' portfolios which can be resolved only by an initial increase in the value of net foreign assets. This sudden depreciation of the domestic currency sets in motion an adjustment process in which the level of net foreign assets increases and the currency appreciates to its new steady-state level. In such a model (which is similar to the simulation model below), the rate of adjustment of the spot rate, θ, may also be rational, if there are no chartists. Repeating equation (13) but using the log of the stock of net foreign assets instead of the interest differential as the important fundamental, we have in continuous time:

$$s(t) = a + c\theta(\bar{s} - s(t)) - df(t) \qquad (14)$$

Suppose the actual rate of depreciation is $s(t) = \nu(\bar{s} - s(t))$. Equation (14) then can be rewritten in terms of deviations from the steady-state levels of the exchange rate and net foreign assets, $\bar{s}$ and $\bar{f}$.

$$\dot{s}(t) = \frac{-\nu}{c\theta}(\bar{s} - s(t)) - \frac{d\nu}{c\theta}(\bar{f} - f(t)) \qquad (15)$$

where rationality implies that $\nu = \theta$. Following Rodriguez (1980), the normalized current account surplus may also be expressed in deviations from steady-state equilibrium:

$$\dot{f} = -q(\bar{s} - s(t)) + \gamma(\bar{f} - f(t)) \qquad (16)$$

where q and γ are the elasticities of the current account with respect to the exchange rate and the level of net foreign assets, respectively. The system of equations (15) and (16) then has the rational expectations solution:

$$\theta = \frac{c\gamma - 1 + [1 - c\gamma)^2 + 4c(\gamma + dq)]^{\frac{1}{2}}}{2c} \qquad (17)$$

THE MODEL WITH EXOGENOUS FUNDAMENTALS

We now turn to describe the complete model, assuming for the time being that important fundamentals remain fixed. Regardless of which specification we use for the fundamentals, the existence of chartists whose views are given time-varying weights by the portfolio managers complicates the model. For simplicity, we study the case in which the chartists believe the exchange rate follows a random walk, $\Delta s^c_{t+1} = 0$. Thus equation (7) becomes:

$$\Delta s^m_{t+1} = \omega_t \theta(\bar{s} - s_t) \qquad (17a)$$

Since the changing weights by themselves generate self-sustaining dynamics, the expectations of fundamentalists will no longer be rational, except for the trivial case in which fundamentalist and chartist expectations are the same, $\theta = 0$.

The "bubble" path of the exchange rate will be driven by the dynamics of portfolio managers' expected depreciation. We assume that the weight given to fundamentalist views by portfolio managers, ω_i, evolves according to:

$$\Delta\omega_t = \delta(\hat{\omega}_{t-1} - \omega_{t-1}) \qquad (18)$$

$\hat{\omega}_{t-1}$ is in turn defined as the weight, computed ex post, that would have accurately predicted the contemporaneous change in the spot rate, defined by the equation:

$$\Delta s_t = \hat{\omega}_{t-1}\theta(\bar{s}-s_{t-1}) \tag{19}$$

Equations (18) and (19) give us:

$$\Delta\omega_t = \delta \frac{\Delta s_t}{\theta(\bar{s}-s_{t-1})} - \delta\omega_{t-1} \tag{20}$$

The coefficient δ in equation (20) controls the adaptiveness of ω_t.

One interpretation for δ is that it is chosen by portfolio managers who use the principles of Bayesian inference to combine prior information with actual realizations of the spot process. This leads to an expression for δ which changes over time. To simplify the following analysis we assume that δ is constant; in the first appendix we explore more precisely the problem that portfolio managers face in choosing δ. The results that emerge there are qualitatively similar to those that follow here.

Taking the limit to continuous time, we can rewrite equation (20) as:

$$\dot{\omega}(t) = \delta\left[\frac{\dot{s}(t)}{\theta(\bar{s}-s(t))} - \omega(t)\right] \quad \text{if } 0<\omega(t)<1 \tag{21}$$

$$\text{if } \omega(t)=0 \text{ then } \begin{cases} \dot{\omega}(t)=0 & \text{if } \dot{s}(t)\le 0 \\ \dot{\omega}(t)=\dfrac{\delta\dot{s}(t)}{\theta(\bar{s}-s)} & \text{if } \dot{s}(t)>0 \end{cases} \tag{21a}$$

$$\text{if } \omega(t)=1 \text{ then } \begin{cases} \dot{\omega}(t)=0 & \text{if } \dot{s}(t)\ge\theta(\bar{s}-s(t)) \\ \dot{\omega}(t)=\dfrac{\delta\dot{s}(t)}{\theta(\bar{s}-s(t))}-\delta & \text{if } \dot{s}(t)<\theta(\bar{s}-s(t)) \end{cases} \tag{21b}$$

where a dot over a variable indicates the total derivative with respect to time. The restrictions that are imposed when $\omega(t) = 0$ and $\omega(t) = 1$ are to keep $\omega(t)$ from moving outside the interval [0,1]. These restrictions are in the spirit of the portfolio managers choice

FIGURE 1

SIMULATED VALUE OF THE DOLLAR ABOVE ITS LONG RUN EQUILIBRIUM

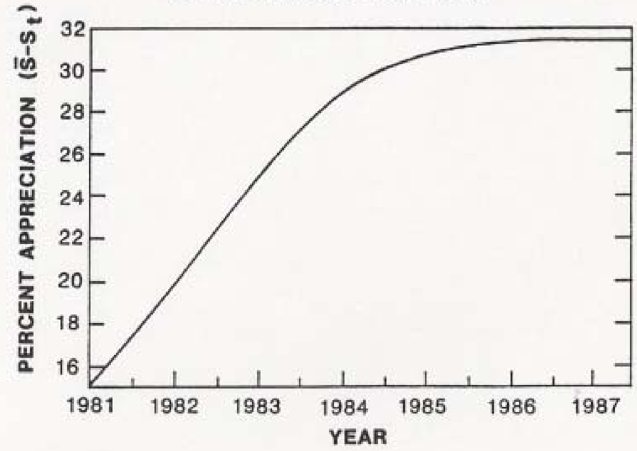
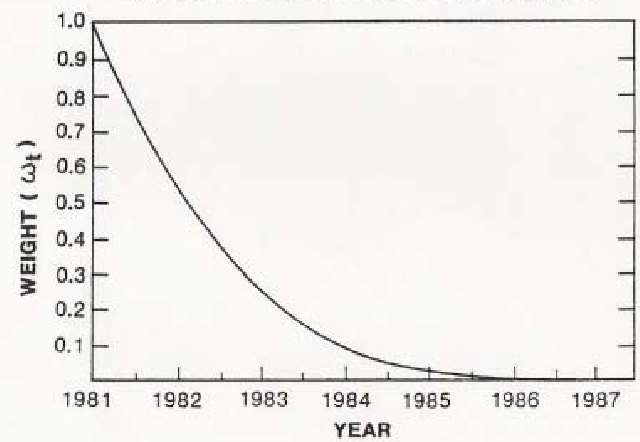


FIGURE 2

SIMULATED WEIGHT PLACED ON FUNDAMENTALIST EXPECTATIONS BY PORTFOLIO MANAGERS



set: the portfolio manager can at most take one view or the other exclusively.

The evolution of the spot rate can be expressed by taking the derivative of equation (9) (for now holding z and the long-run equilibrium, $\bar{s}$, constant):

$$\dot{s}(t) = \left[\frac{\dot{\omega}(t)c\theta}{1 + c\theta\omega(t)}\right](\bar{s} - s(t)) \tag{22}$$

Equations (21) and (22) can be solved simultaneously and rewritten, for interior values of ω, as:

$$\dot{\omega}(t) = \frac{-\delta\omega(t)\,(1 + c\theta\,\omega(t))}{1 + c\theta\omega(t) - \delta c} \quad \text{if } 0 < \omega(t) < 1 \tag{23}$$

$$\dot{s}(t) = \left[\frac{-\delta\omega(t)c\vartheta}{1 + c\theta\omega(t) - \delta c}\right](\bar{s} - s(t)) \tag{24}$$

In principle, an analytic solution to the differential equation (23) could be substituted into (24), and then (24) could be integrated directly.[24] For our purposes it is more desirable to use a finite difference method to simulate the motion of the system. In doing so we must pick values for the coefficients, c, θ and δ, and starting values for $\omega(t)$ and s(t).

To exclude any unreasonable time paths implied by equations (23) and (24), we impose the obvious sign restrictions on the coefficients. The parameter θ must be positive and less than one if expectations are to be regressive, that is, if they are to predict a return to the long-run equilibrium at a finite rate. By definition, δ and $\omega(t)$ lie in the interval [0,1] since they are weights. The coefficient c measures the responsiveness of the spot rate to changes in expected depreciation and must be positive to be sensible.

These restrictions, however, are not enough to determine unambiguously the sign of the denominator of equations (23) and (24). The three possibilities are that: $1 + c\,\theta\omega(t) - \delta c < 0$ for all ω; $1 \gtreqless 0$ as $\omega(t) \gtreqless \omega^*$, where $0 < \omega^* < 1$. If $1 + c\,\theta\omega(t) - \delta c < 0$, the system will be stable and will tend to return to the long-run equilibrium from any initial level of the spot rate. This might be the case if portfolio managers use only the most recent realization of the spot rate to choose $\omega(t)$, that is, if $\delta \approx 1$. If, on the other hand, portfolio managers give substantial weight to prior information so that δ is small, the expression $1 + c\,\theta\omega(t) - \delta c$ will be positive.

will be positive. In this case the spot rate will tend to move away from the long-run equilibrium if it is perturbed.[25]

Let us assume that portfolio managers are slow learners.[26] What does this assumption imply about the path of the dollar? If we take as a starting point the late 1970s, when $s(t) \approx \bar{s}$ and when $\omega_t \approx 1$ (as the calculations presented in Table 2.6 suggest), equation (24) says that the spot rate is in equilibrium, that $\dot{s}(t) = 0$. From equation (21b), we see that $\dot{\omega}(t) = 0$ as well. Thus the system is in a steady-state equilibrium, with market expectations exclusively reflecting the views of fundamentalists.

But given that $1 + c\,\theta\omega(t) - \delta c > 0$, this equilibrium is unstable, and any shock starts things in motion. Suppose that there is an unanticipated appreciation (the unexpected persistence of high long-term US interest rates in the early 1980s, for example). The sign restrictions imply that $\omega(t)$ is unambiguously falling over time. Equation (23) says that the chartists are gaining prominence, since $\dot{\omega}(t) < 0$. The exchange rate begins to trace out a bubble path, moving away from long-run equilibrium; equation (24) shows that $\dot{s}(t) < 0$ when $\bar{s} > s(t)$. This process cannot, however, go on forever, because market expectations are eventually determined only by chartist views. At this point the bubble dynamics die out since both $\omega(t)$ and $\dot{\omega}(t)$ fall to zero. From equation (24), the spot rate then stops moving away from long-run equilibrium, as it approaches a new, higher equilibrium level where $\dot{s}(t) = 0$. In the words of Dornbusch (1983), the exchange rate is both high and stuck.

Figures 1 and 2 trace out a "base-case" simulation of the time profile of the spot rate and ω. They are intended only to suggest that the model can potentially account for a large and sustained dollar appreciation. The figures assume that the dollar is perturbed out of a steady state equilibrium where $\bar{s} = s(t)$ and $\omega(0) = 1$ in October 1980. The dollar rises at a decreasing rate until sometime in 1985, when, as can be seen in Figure 2, the simulated weight placed on fundamentalist expectations becomes negligible. A steady state obtains at a new higher level, about 31 percent above the long-run equilibrium implied by purchasing power parity. Although we tried to choose reasonable values for the parameters used in this example, the precise level of the plateau and the rate at which the currency approaches it are sensitive to different choices of parameters. In a second appendix, available on request, we give more detail on values used in the simulation.

It is worth emphasizing that the demand for dollars increases and the currency appreciates along its bubble path even though <u>none</u> of the actors expects appreciation. This result is due to the implicit stock adjustment taking place. As portfolio managers reject their fundamentalist roots, they reshuffle their portfolios to hold a greater share in dollar assets. For fixed relative asset supplies, a greater dollar share can be obtained in equilibrium only by additional appreciation. This unexpected appreciation, in turn, further convinces portfolio managers to embrace chartism. The rising dollar becomes self-sustaining. In the end when the spiral finally levels off at $\omega(t) = 0$, the level at which the currency becomes stuck represents a fully rational equilibrium: portfolio managers expect zero depreciation and the rate of change of the exchange rate is indeed zero.

The sense in which the model violates rational expectations can be seen by inspecting equation (24). Recall that market-expected depreciation, that of portfolio managers, is a weighed average of chartist and fundamentalist expectations, $\omega(t)\,\theta(\bar{s} - s(t))$. But the actual, or rational, expected rate of depreciation is given by $\left[\frac{-\delta c}{1 + c\,\theta\omega(t) - \delta c}\right]\omega(t)\theta(\bar{s} - s(t))$. The two are not equal, unless $\omega = 0$.[27] The problem we gave portfolio managers was to pick $\omega(t)$ in a way that best describes the spot process they observe (given the prior confidence they had in fundamentalist predictions). But theirs is a thankless task, since the spot process is more complicated.

THE MODEL WITH ENDOGENOUS FUNDAMENTALS

The results so far offer an explanation for the paradox of proposition (1), that sustained dollar appreciation occurs even though all agents expect depreciation. But a spot rate that is stuck at a disequilibrium level is an unlikely end for any reasonable story. The next step is to specify the mechanism by which the unsustainability of the dollar is manifest in the model.

The most obvious fundamental which must eventually force the dollar down is the stock of net foreign assets. Reductions in this stock, through large current account deficits, cannot take place indefinitely. Sustained borrowing would, in the long run, raise the level of debt above the present discounted value of income. But long before this point of insolvency is reached, the gains from a U.S. policy aimed at reducing the outstanding liabilities (either through direct taxes or penalties on capital, or through monetization) would increase in comparison to the costs. If foreigners associate large current account deficits with the potential for moral hazard, they would treat U.S. securities as increasingly risky and would force a decline in the level of the dollar.

To incorporate the effects of current account imbalances, we consider the model, similar to Rodriguez (1980), given in equation (14):

$$s_t = a + c\Delta s^m_{t+1} - df \qquad (25)$$

where Δs^m_{t+1} is defined in equation (7a) and where f represents the log of cumulated US current account balances. The coefficient, d, is the semi-elasticity of the spot rate with respect to transfers of wealth, and must be positive to be sensible. The differential equations (23) and (24) now become:

$$\dot{\omega}(t) = \left[\frac{\delta}{1+c\theta\omega(t)-\delta c}\right]\left[-\omega(t)(1+c\theta\omega(t)) - \frac{d\dot{f}}{\theta(\bar{s}-s(t))}\right] \text{ if } 0<\omega(t)<1 \qquad (26)$$

$$\dot{s}(t) = \frac{-\delta\omega(t)c\theta(\bar{s} - s(t)) + d\dot{f}}{1 + c\omega(t)\theta - \delta c} \qquad (27)$$

If we were to follow the route of trying to solve analytically the system of differential equations, we would add a third equation giving the "normalized" current account, $\dot{f}$, as a function of s(t). (See, for example, equation (16) above.) But we here instead pursue the simulation approach.

In the simulation we use actual current account data for $\dot{f}$, the change in the stock of net foreign assets. Figures 3 and 4 trace out paths for the differential equations (26) and (27). During the initial phases of the dollar appreciation, the current account, which is thought to respond to the appreciation with a lag, does not noticeably affect the rise of the dollar. But as ω becomes small, the spot rate becomes more sensitive to changes in the level of the current account, and the external deficits of 1983-1985 quickly turn the trend. When ω is small and portfolio managers observe an incipient depreciation of the dollar, they begin to place more weight on the forecasts of fundamentalists, thus accelerating the depreciation initiated by the current account deficits. There is a "fundamentalist revival." Ironically, fundamentalists are initially driven out of the market as the dollar appreciates, *even though they are ultimately right about its return to s.*

Naturally, all of our results are sensitive to the precise parameters chosen. To gain an idea of the various sensitivities, we

FIGURE 3

SIMULATED VALUE OF THE DOLLAR ABOVE ITS LONG RUN EQUILIBRIUM

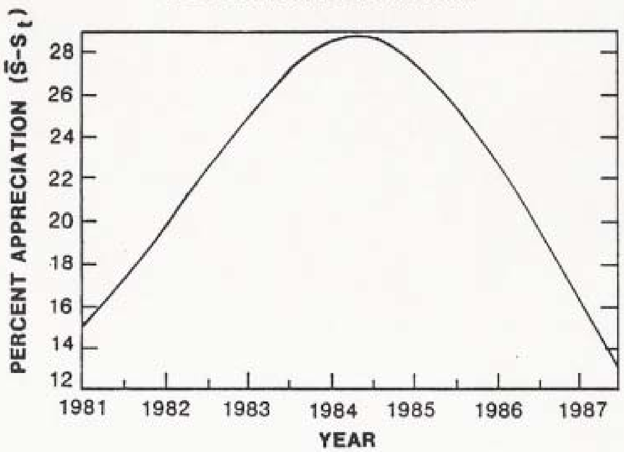
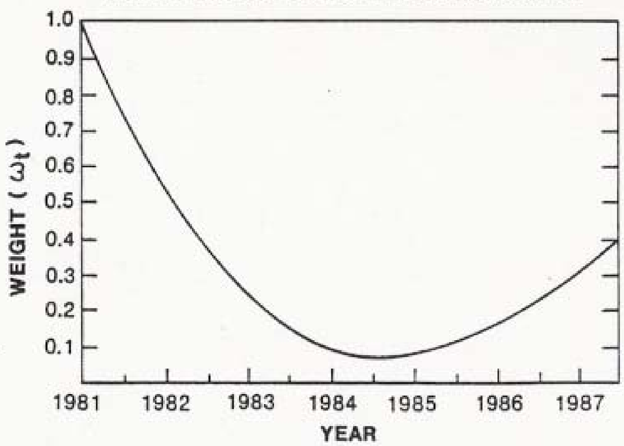


FIGURE 4

SIMULATED WEIGHT PLACED ON FUNDAMENTALIST EXPECTATIONS BY PORTFOLIO MANAGERS



report in Table 2.7 results using alternative sets of parameter values in the simulation of Figure 3 (or equation (27)). While there is some variation, the qualitative pattern of bubble appreciation, followed by a slow turnaround and bubble depreciation, remains evident in all cases.

Recall that one of the main aims of the model is to account for the two seemingly contradictory facts given by propositions (2) and (3): first that market efficiency test results imply that the rationally expected rate of dollar depreciation has been less than the forward discount, and second that the calculations based on fundamentals, such as those by Krugman and Marris, imply that the rationally expected rate of depreciation, by 1985, became greater than the forward discount.

Table 2.8 clarifies how the model resolves this paradox. The first two lines show the expectations of our two forecasters, the chartists and fundamentalists. The third line repeats the six-month survey expectations to demonstrate that they may in fact be fairly well described by the simple regressive formulation we use to represent fundamentalist expectations in line two. The fourth line contains the expected depreciation of the portfolio managers. Note that these expectations are close to the forward discount in line six, even though the forecasts of the fundamentalists and of the chartists are not. Since only the portfolio managers are hypothesized to take positions in the market, we can say that the magnitude of the market risk premium is small (as mean-variance optimization would predict). Finally, line five shows the actual depreciation in the simulation, which is equivalent to the rationally expected depreciation given the model above. (Of course, none of the agents has the entire model in his information set.) Notice that during the 1981-1984 period, the rationally expected depreciation is not only significantly less than the forward discount, but less than zero. This pattern agrees with the results of market efficiency tests discussed earlier. But the rationally expected depreciation is increasing over time. Sometime in late 1984 or early 1985, the rationally expected rate of depreciation becomes positive and crosses the forward discount. As calculations of the Krugman-Marris type would indicate, rationally expected depreciation is ow greater than the forward discount. The paradox of propositions (2) and (3) is thus resolved within the model.

All this comes at what might seem a high cost: portfolio managers behave irrationally in that they do not use the entire model in formulating their exchange rate forecasts. But another interpretation of this behavior is possible, in that portfolio managers

TABLE 2.7
Sensitivity Analysis for the Simulation of the Dollar

Parameter				Maximum appreciation of the dollar above initial shock	Number of months until peak
delta	c	theta	d	(in percent)	
0.04	25	0.045	-0.005	11.4	41
0.06	25	0.045	-0.005	26.9	27
0.02	25	0.045	-0.005	5.8	44
0.04	15	0.045	-0.005	6.4	38
0.04	35	0.045	-0.005	18.1	40
0.04	25	0.03	-0.005	8.8	36
0.04	25	0.06	-0.005	13.5	44
0.04	25	0.045	0	16.4	80
0.04	25	0.045	-0.0025	11.6	45
0.04	25	0.045	-0.0075	11.4	38

Notes: These estimates correspond to the simulation depicted in figure 8. The parameter delta falls over time according to equation (19).

TABLE 2.8
Alternative Measures of Expected Depreciation (in percent per annum)

		Year					
Expectation from:	Line	1981	1982	1983	1984	1985	1986
Chartists in the simulation	(1)	0	0	0	0	0	0
Fundamentalists in the simulation	(2)	7.63	9.82	11.68	11.98	10.33	7.69
Economist 6 Month Survey	(3)	8.90	10.31	10.42	11.66	4.00	NA
Weighted Average Expected Depreciation in the Simulation	(4)	5.29	3.31	1.59	0.99	1.49	2.08
Rationally Expected Depreciation in the Simulation	(5)	-2.97	-5.61	-4.38	-0.72	3.89	6.22
Actual Forward Discount	(6)	3.74	3.01	1.10	3.07	-0.16	NA

Notes: Fundamentalists in the simulation use regressivity parameter of .045, implying that about 70% of the contemporaneous overvaluation is expected to remain after one year. The Economist 6 month survey includes data through April 1985. Weighted average expected depreciation in the simulation is a weighted average of chartists and fundamentalists, where the weights are those of portfolio managers. Rationally Expected Depreciation is the perfect foresight solution given by equations (19) and (20). The actual 6 month forward discount includes data through September 1985.

are actually doing the best they can in a confusing world. Within this framework they cannot have been more rational; abandoning fundamentalism more quickly would not solve the problem in the sense that their expectations would not be validated by the resulting spot process in the long run. In trying to learn about the world after a regime change, our portfolio managers use convex combinations of models which are already available to them and which have worked in the past. In this context, rationality is the rather strong presumption that one of the prior models is correct. It is hard to imagine how agents, after a regime change, would know the correct model.

CONCLUSIONS AND EXTENSIONS

This paper has posed an unorthodox explanation for the recent acrobatics of the dollar. The model we use assumes less than fully rational behavior in the sense that none of the three classes of actors (chartists, fundamentalists and portfolio managers) conditions its forecasts on the full information set of the model. In effect, the bubble is the outcome of portfolio managers' attempt to learn the model. When the bubble takes off (and when it collapses), they are learning more slowly about the model than they are changing it by revising the linear combination of chartist and fundamentalist views they incorporate in their own forecasts. But as the weight given to fundamentalists approaches zero or one, portfolio managers' estimation of the true force changing the dollar comes closer to the true one. These revisions in weights become smaller until the approximation is perfect: portfolio managers have "caught up," by changing the model more slowly than they learn. In this sense the inability of agents with prior information to bring about immediate convergence to a rational expectations equilibrium may provide a framework in which to view "bubbles" in a variety of asset markets.

Several extensions of the model in this paper would be worthwhile. First, it would be desirable to allow chartists to use a class of predictors richer than a simple random walk. They might form their forecasts of future depreciation by using ARIMA models, for example. Simple bandwagon or distributed lag expectations for chartists would be the most plausible since they capture a wide range of effects and are relatively simple analytically. Second, we might want to consider extensions which give the model local stability in the neighborhood of = 1. Small perturbations from equilibrium would then not instantly cause portfolio managers to begin losing faith in fundamentalist counsel. Only sufficiently large or prolonged perturbations, would upset portfolio managers' views enough to cause the exchange rate to break free of its fundamental equilibrium.

NOTES

1. Two surveys of standard asset-market models of exchange rates are Frankel (1983) and Shafer and Loopesko (1983).

2. To the extent that the monetarist model attributes the decrease in expected inflation to correct perceptions of a decreased rate of money supply growth, it could be considered as one of those mentioned above that are driven by the asset supply process. The same is true of the overshooting model. The point about asset demand versus asset supply is that rates of return are a more promising set of data with which to explain recent developments than are observed asset supplies.

3. The overshooting model, developed by Dornbusch (1976) to explain the price of foreign exchange, also has important implications for the price of agricultural commodities. Frankel (1986) presents the theoretical model in the latter context. Frankel and Hardouvelis (1985) finds empirical support for the model in the weekly Fed money announcements. Frankel (1984) offers an overview of these and other implications for commodity prices.

4. The use of the long-term real interest differential originated with Isard (1983). Other references include Shafer and Loopesko (1983) and Council of Economic Advisers (1984).

5. Sachs (1985), Hooper (1985), Hutchinson and Throop (1985) and Feldstein (1986).

6. Kling (1985) also argues that the value of the dollar rests on market expectations that do not embody a return to steady state. Ten years earlier, McKinnon (1976) attributed exchange rate volatility to a "deficiency of stabilizing speculation" that is, an unwillingness of investors to take open positions based on fundamentals equilibrium, rather than to "high capital mobility with rational expectations" as the orthodoxy has it.

7. Frankel (1985).

8. Studies regressing against the forward discount include Tryon (1979), Levich (1980), Bilson (1981), Longworth (1981), Longworth, Boothe and Clinton (1983), Fama (1984) and Huang (1984). Cumby and Obstfeld (1984) regressed against the interest differential and again found that for most exchange rates the coefficient was significantly less than 1.0 and even less than zero. These findings are also consistent with those of Meese and Rogoff (1983) that the random walk predicts not only better than other models, but better than the forward rate as well.

9. During the period June 1981 to December 1985 the 12-month forward markets were significantly biased (underpredicting the value of the dollar) even *unconditionally*. In other words, one could have made money by following the rule to be always long in dollars regardless what the forward discount was (Frankel and Froot (1986, Table 2.3)).

10. Krugman and Marris did not say that there was any reason to think that the dollar plunge would necessarily come in the next year; the focus was on the market's expected long-term rate of depreciation implicit in the long-term interest differential. We have no tests of unbiasedness going out a year or more. The problem is not the absence of a forward market going out more than a year; we can always use the long-term interest differential. The problem is rather that twelve years of floating-rate data would not offer enough independent observations.

11. The Economist survey covers 13 leading international banks and has been conducted six times a year since 1981. The American Express survey covers 250 to 300 central bankers, private bankers, corporate treasurers and economists, and has been conducted more irregularly since 1976.

12. Similarly an increase in U.S. monetary uncertainty could explain higher U.S. interest rates, but not the appreciation of the dollar. On these points, see Branson (1985) and The Council of Economic Advisers (1984, pp. 54-55).

13. One widely cited piece of evidence against the safe haven hypothesis is that the increase in U.S. real interest rates was accompanied by a lower investment rate averaged over the 1981-85 period, not a higher one. (See, for example, Friedman (1985) or Frankel (1985).) However others dispute this calculation; see Blanchard and Summers (1984). Another piece of evidence against the safe haven hypothesis is that the correlation between U.S. stock market price changes and those abroad (Germany or Japan) has been positive; Obstfeld (1985) argues that if portfolio demands had exogenously shifted from foreign assets to U.S. assets, the U.S. stock market boom should have been accompanied by a stock market decline abroad. See also Feldstein (1986, 7-8).

14. "Small" might be defined as less than 50 basis points, to allow for differences in default risk and tax treatment attaching to the particular security, as well as inevitable minor differences in timing.

15. In 1978 the differential between the domestic U.K. and domestic U.S. interest rate is negative (columns 4 or 5 in Table 2.2). This is because of the above-mentioned U.K.-capital controls that were removed in 1979, as is evident from the differential between the Europound interest rate and domestic U.K. rates (column 2 or 3 in Table 2.2a).

16. Evans (1986) avoids this problem by employing a nonparametric sign test of the forward rate prediction errors.

17. The Money Market Services Survey has been conducted weekly or biweekly since 1983. For a more extensive analyses of this survey data set, see Dominguez (1986), Frankel and Froot (1987), and Froot and Frankel (1986).

18. In the regressions reported in Tables 2.3, 2.4 and 2.5, we use Seemingly Unrelated Squares (SUR) to exploit efficiently the contemporaneous correlation across currencies. Each currency was given its own constant term, but the constants are not reported here. See Frankel and Froot (1987) for more detail on the behavior of the survey numbers in terms of standard models of expected depreciation.

19. In Frankel and Froot (1987), we correct for the low Durbin-Watson statistics in these regressions (and those in Tables 2.4 and 2.5) using a three stages least squares estimation technique which allows for first order serial correlation in the residuals. The results are not repeated here since they are very similar to the SUR estimates already reported in Tables 2.3-2.5.

20. It sounds strange to describe 6 to 12 months as "long-term." But such descriptions are common in the foreign exchange markets.

21. Figlewski (1978, 1982) considers an economy in which private information, weighted by traders' relative wealths, is revealed in the market price.

22. See, for example, Frankel (1985).

23. Assume that prices evolve slowly according to $\pi\,(\gamma(s\text{-}p)\ -\ \sigma(i\text{-}i^*))$ (where γ and σ are the elasticities of goods demand with respect to the real exchange rate and the interest rate, respectively), that the interest rate differential is proportional to the gap between the current and long-run price levels, $\lambda\,(i\text{-}i^* + p\text{-}\bar{p}$ (where γ is the semi-elasticity of money demand with respect to the interest rate) and that the long-run equilibrium exchange rate is given by long-run purchasing power parity, $\bar{s} = \bar{p}$. Then it can be shown that rationality implies:

$$\theta = \frac{1}{b-c} = \frac{\pi}{2\lambda}(\gamma\lambda+\sigma+(\gamma^2\lambda^2+ 2\lambda\gamma\sigma + \sigma^2+4)^{\frac{1}{2}})$$

24. In this case, however, $\omega(t)$ does not have a closed analytic form.

25. We do not consider the third case, because equations (23) and (24) are not defined at $1 + c\theta\omega(t) - \delta c = 0$.

26. The following intuition may help see why the system is stable when portfolio managers are "fast" learners and unstable when they are "slow" learners. Suppose the value of the dollar is above $\bar{s}$, so that portfolio managers are predicting depreciation at the rate $\omega\theta\,(\bar{s}\text{-}s(t))$. If the spot rate were to start depreciating at a rate slightly faster than this, portfolio managers would then shift $\omega(t)$ upwards, in favor of the fundamentalists. Under what circumstances would these hypothesized dynamics be an equilibrium? Recall from equations (21) and (22) that if δ is big, portfolio managers place substantial weight on new information. The larger is δ, the more quickly the spot rate changes. It is easy to show that if portfolio managers are fast learners (i.e., if $\delta > 1/c + \theta\omega$), they update ω so rapidly that the resulting rate of depreciation must in fact be greater than $\omega\theta\,(\bar{s}\text{-}s(t))$. Thus the system is stable. Alternatively, if portfolio managers are "slow" learners, $\delta < 1/c + \theta\omega$, they heavily discount new information and therefore change ω (t) too slowly to generate a rate of depreciation greater than $\omega\theta\,(\bar{s}\text{-}s(t))$. If we instead hypothesize an initial rate of depreciation which is less than $\omega\theta\,(\bar{s} - s(t))$, portfolio managers would tend to shift ω downwards, more towards the chartists. From equation (22), a negative $\dot{\omega}(t)$ causes the spot rate to appreciate. Thus slow learning will tend to drive the spot rate further away from the long-run equilibrium (given $0 < \omega < 1$), making the system unstable.

27. There is a second root, $\omega = -1/(\theta c)$, which we rule out since it is less than zero.

28. The assumption that ε_{t+1} exhibits such conditional heteroscedasticity results in a particularly convenient expression for δ_t (equation (A2) below). Under the assumption that ε_{t+1} is distributed normally $(0, \sigma^2)$, δ_t depends on all past values of the spot rate, $\delta_t = \tau / (\tau\theta \sum_{i=1} (\bar{s} - s_{t-i}) + T_0)$.

29. If the prior distribution is normal, the precision is equal to the reciprocal of the variance.

APPENDIX A

In this section we consider the problem which portfolio managers face: how much weight should they give to new information concerning the "true" level of $\omega(t)$. After we obtain an explicit formulation for these optimal Bayesian weights, we report their effects on the simulated path of the dollar.

Even though in the model of the spot rate given by equation (9) the value of the currency is fully deterministic, individual portfolio managers who are unable to predict accurately ex ante changes in the spot rate may view the future spot rate as random. They would then form predictions of future depreciation on the basis of observed exchange rate changes and their prior beliefs. At each point in time, portfolio managers therefore view future depreciations as the sum of their current optimal predictor and a random term:

$$\Delta s_{t+1} = \omega_t \theta(\bar{s} - s_t) + \varepsilon_{t+1} \tag{A1}$$

where ε_{t+1} is a serially uncorrelated normal random variable with mean 0 and variance $\theta(\bar{s} - s_{t-1}) / \tau$.[28] Using Bayes' rule, the coefficient ω_t may be written as a weighted average of the previous period's estimate, ω_{t-1}, and information obtained from the contemporaneous realization of the spot rate:

$$\omega_t = \frac{T_t}{T_t + \tau}\,\omega_{t-1} + \frac{\tau}{T_t + \tau}\left[\frac{\Delta s_t}{\theta(\bar{s} - s_{t-1})}\right] \tag{A2}$$

where $T_t = T_{t-1} + \tau$. Thus, if portfolio managers use Bayesian techniques, the weight they would give to the current period's information may be expressed as:

$$\delta_t = \tau / (\tau t + T_0) \tag{A3}$$

where T_0 is the precision of portfolio managers' prior information.[29] Equation (A3) shows that the weight which portfolio managers give to new information would fall over time as decision makers gain more confidence in their prior distribution, or as the prior distribution for the future change in the spot rate converges to the actual posterior distribution. If, however, portfolio managers suspect that the spot rate is nonstationary, past information would be discounted relative to more recent observations. Instead of

combining prior information in the form of an OLS regression of actual depreciation on fundamentalist expectations (as they do above), portfolio managers might use a varying parameter technique to take into account the nonstationarity. In this case, the weight they put on new information might not decline over time to zero.

Computing δ_t using equation (A3) does not change substantially the results of the simulations presented in the text. Nevertheless the following pages contain the outcome of simulations using Bayesian δ's. Figures 5 and 6 give s(t) and $\omega(t)$ holding fundamentals constant (note that the spot rate approaches the higher equilibrium more slowly than in the comparable figures in the test, Figures 1 and 2). Figures 7 and 8 add to this changing fundamentals according to equations (26) and (27) in the text. Table 2.9 reports the simulated expectations of our three sets of agents as well as the rationally expected depreciation, comparable to Table 2.8 in the text.

FIGURE 5

SIMULATED VALUE OF THE DOLLAR ABOVE ITS LONG RUN EQUILIBRIUM

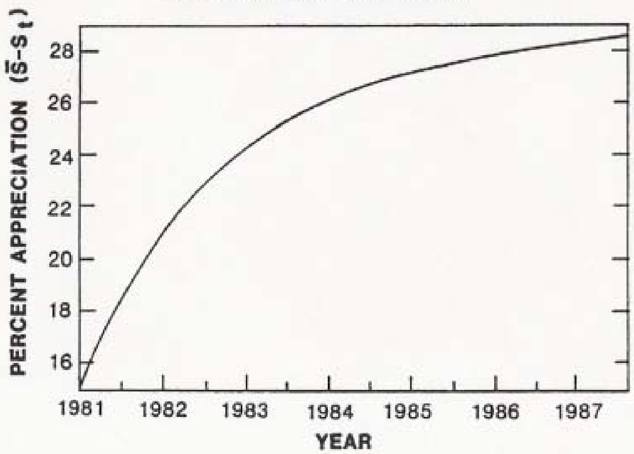


FIGURE 6

SIMULATED WEIGHT PLACED ON FUNDAMENTALIST EXPECTATIONS BY PORTFOLIO MANAGERS

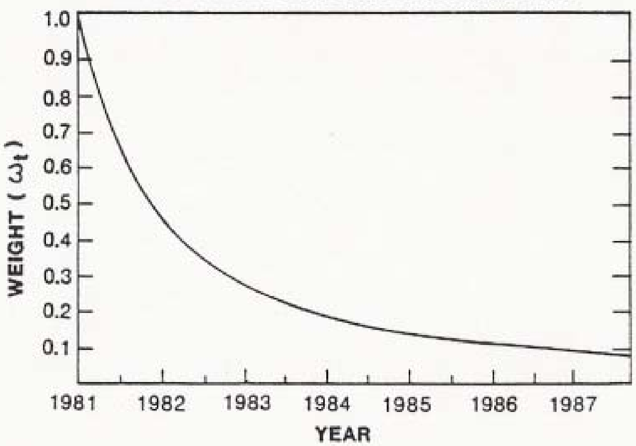


FIGURE 7

SIMULATED VALUE OF THE DOLLAR ABOVE ITS LONG RUN EQUILIBRIUM

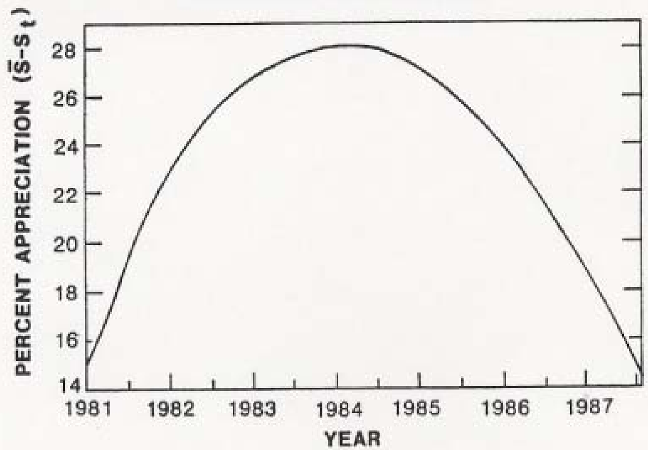


FIGURE 8

SIMULATED WEIGHT PLACED ON FUNDAMENTALIST EXPECTATIONS BY PORTFOLIO MANAGERS

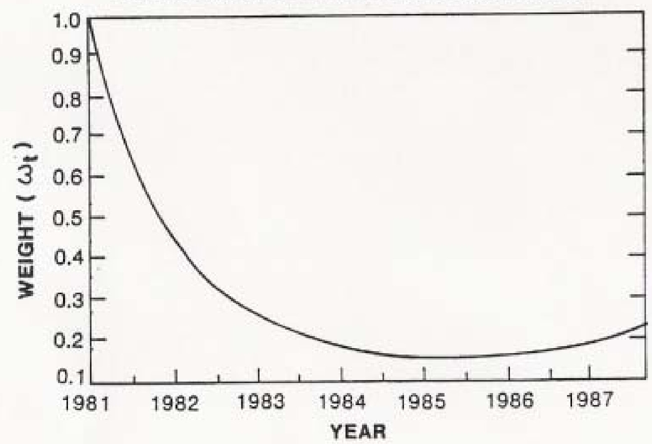


TABLE 2.9
Alternative Measures of Expected Depreciation (in percent per annum)

Expectation from:	Line	1981	1982	Year 1983	1984	1985	1986
Chartists in the simulation	(1)	0	0	0	0	0	0
Fundamentalists in the simulation	(2)	8.12	10.01	10.97	11.10	10.17	8.27
Economist 6 Month Survey	(3)	8.90	10.31	10.42	11.66	4.00	NA
Weighted Average Expected Depreciation in the Simulation	(4)	4.83	3.08	2.20	1.77	1.62	1.56
Rationally Expected Depreciation in the Simulation	(5)	-4.13	-4.45	-2.27	-0.30	2.18	4.48
Actual Forward Discount	(6)	3.74	3.01	1.10	3.07	-0.16	NA

Notes: Fundamentalists in the simulation use regressivity parameter of .045, implying that about 70% of the contemporaneous overvaluation is expected to remain after one year. The Economist 6 month survey includes data through April 1985. Weighted average expected depreciation in the simulation is a weighted average of chartists and fundamentalists, where the weights are those of portfolio managers. Rationally Expected Depreciation is the perfect foresight solution given by equations (19) and (20). The actual 6 month forward discount includes data through September 1985.

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