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The Foreign Exchange Market: A Random Walk With a Dragging Anchor

By

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DISCUSSION PAPER 1

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DISCUSSION PAPER SERIES

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Inaugural Lecture

The Foreign Exchange Market:

A Random Walk with a Dragging Anchor*

A. Introduction

It is a matter of great regret to me that I had not been able to complete and present this Inaugural Lecture before Eric Sosnow's unexpected and sudden death this winter. Eric was the person whose generous intervention transformed the prospects of the success of the School's Appeal to the financial world for money to endow the Chair which was then named in honour of his son, Norman, whose early death was even more untimely and tragic. Eric would have so greatly enjoyed, and would have been rightly proud, of this occasion that combines two fo the great loves of his life, love of family and love of scholarship. I am delighted that Sylvia and Fiona, Eric's wife and daughter, are here this evening.

I shall always remember Eric most vividly as a dear, good, kind friend. But this evening I want to recall particularly his alert, inquisitive, analytical, darting intelligence. During his working life he

*The advice and assistance of colleagues, both among my academic and practitioner friends, has been invaluable in the gestation of this paper. In particular, I have relied heavily on Mark Taylor, especially in the econometric exercises. Besides Mark, I have greatly benefited from comments and suggestions from Bill Brainard, Patrick McMahon and Larry Summers, and also from A.D. Bain, M. Beenstock, D. Blake, J. Davidson, J. Flemming, M. King, D. Lomax and S. Wadhwani and from members of the LSE Financial Markets Group and staff seminars at Dundee and Edinburgh Universities. I am also most grateful to practitioners in the City, who have guided me through the practical complexities of the forex market and/or provided me with data, notably H.T.Alldis, C. Curle, T. Ellis, G.M. Gill, M. Hendricks, S. Mazloumian, C.D. Rand, T. Smeeton, R.C. Staggs, C. Thanassoulas, and J. Young. I received much helpful research assistance from M. Bonham, G. Kanaginis and H. Jalilian, and I am grateful to the ESRC for providing the funds to make this latter possible. I have been guided by friends away from so many errors in my earlier work that I am uncomfortably aware how many may well remain, but they are, of course, purely my own responsibility.

used his great abilities primarily in more practical spheres of activity in the course of his full and varied career, first as a financial journalist in London -- a profession for which he had been initially trained in his native Poland-- and then using his many skills, of languages, of financial knowledge and of sheer acumen, to found a trading firm in the City, United City Merchants, which he made highly successful. At the same time, however, he always remained convinced of the value and importance of academic scholarship, not only in general, as his many close connections both with Christ's College, Cambridge, Norman's college, and also with this School, where his daughter, Fiona, studied; but also notably so in the particular field of banking and finance, as his endowment of this Chair most clearly signifies. After I was appointed, he kindly wrote to me, expressing the hope that "study and research will help us to understand the problems which arise when the City of London is undergoing such a great revolution, and such reorganization in depth, in the field of banking and, indeed, of all financial services."

Indeed the proximity of the School, the most renowned centre of research into the Social Sciences in this country, and probably in Europe, to the City of London, one of the three leading financial markets in the world, provides a raison d'etre, indeed a positive compulsion, for LSE to be a great centre for learning, teaching and research in the field of money, banking and finance. Given the comparative advantage of having these financial institutions and markets on our own doorstep, we should surely seek to base our study and research about the functioning of financial markets on the practical experience and actual current problems of the City, to provide a union between practitioners' knowledge and academic analysis that Eric himself personally embodied and subsequently sought to promote by establishing this Chair.

This concern with re-inforcing close connections between the City and LSE is one that, naturally, I fully share; but I am also conscious of the fact that any single person can only play a small, strictly limited, role in the development of such links. For any one person, time and expertise

are simply insufficient, though one must treat, I suppose, Richard Layard, as a counter-example to this dictum.

Be that as it may, it was soon clear to my friend and colleague, Mervyn King, as it was to me, that we needed to build on the reawakening enthusiasm for research in the financial field, an enthusiasm that in turn was generated by the arrival of many new, excellent, and mostly young, members of the faculty, working in this field, in order to provide a focus for our studies and research into this subject. As you already know, our programme to establish an LSE Financial Markets Group has been most warmly supported by the Bank of England, and David Walker is the Chairman of our Steering Committee, by the City Capital Markets Committee, and by a number of other most generous donors, including Nomura, Citicorp, Salomon Brothers, National Westminster Investment Bank and Investors in Industry, alias 3is. I am glad that members of these institutions can be with us this evening.

The launch of this Group has, however, taken place, earlier in January this year. Much of my own research over the next few years will be bound up with it. Although my work on the subject that I shall develop this evening, i.e. concerning the foreign exchange market, was initiated before the Group took shape, it does, I think, illustrate a continuing theme, that is the need for communication and partnership between practitioner and theoretical analyst, if we are to understand the workings of markets in general, and of financial markets in particular. We need to study the working of markets and their associated institutions as they actually exist, and not just in some abstract, idealized form.

As you will know, I worked at the Bank of England for some seventeen years. While my role there remained primarily on the domestic monetary side in an advisory and academic capacity, I could not help but observe that some of the features of the forex market did not seem to tally closely with current theory. Let me mention four such discrepancies. First, the current state-of-the-art theory suggests that the spot exchange rate should overshoot in response to news, for example of unanticipated changes in monetary policy. While there is no doubt that financial markets, including

the exchange market, do react to 'news', I could see no sign of immediate overshooting in market reactions. If anything, these seemed rather to exhibit some inertia and persistence in the short run. Thus, the 'overshooting' model implied -- I thought -- more short-term volatility than actually occurred in practice. Second, one key element of the overshooting model is that the forward rate should be anchored by longer term, rational expectations of where the spot rate would move in the future. In practice, it was difficult to see this. Rather the forward rate appeared to adjust passively to movements in the interest differential. Third, the theory suggested more consistent pressure for a reversion towards a medium and longer term equilibrium level for real exchange rates than had been apparent in recent years. Fourth, the previously mentioned anchoring of the forward rate was supposed to be brought about by speculators acting to eliminate any divergence between the forward rate and their own expectations of the future spot rate. While there is an enormous volume of very short-term position-taking, which is incidentally concentrated in the spot rather than in the forward market, my practitioner colleagues were adamant that they felt that such longer-term speculation was striclty limited in total.

These observations made me feel that I should turn to a study of this market on my return to academic life. This has been rather a perilous exercise, since I had not done much previous work in this field, or been well acquainted with the massive literature on it. In the course of this study, I have already been rescued from several wrong turnings. It certainly is a market that exhibits a number of features that we find difficult to explain. I do not have the temerity to suggest that I, or others, will be able to resolve these problems and apparent anomalies simply by observation or by asking the practitioners exactly how they operate. But equally I believe that an informed appreciation of how each market does actually work in reality must help to provide an appropriate basis for further analysis. Anyhow that is why I have begun on this study, though I should emphasize that this represents a beginning, not a completed exercise.

B. Does the Overshooting Model Fit the Facts?

But I am running ahead of myself. I should really begin by outlining for you again the main elements of the current dominant 'overshooting' model. Then I shall try to present evidence to support my contention that this model exaggerates both the extent of short-term overshooting and of longer-term reversion to a (real) equilibrium. Next I shall present evidence that the forward rate is not an unbiassed efficient predictor of the future spot rate. I shall attempt to draw analogies between the working of the foreign exchange market and of other financial markets. Finally if time permits, I shall try tentatively to suggest a relatively new line of attack that might help to explain some part of these anomalies.

Anyhow, let me start by trying to recapitulate for you the current state of thinking, and model building, about the determination of exchange rates, broadly based on the 'overshooting' model, e.g. as developed by Rudi Dornbusch, in which relatively sticky goods prices are complemented by rapid adjustments in financial markets. We start with the assumption that, when in due course prices do fully adjust to clear markets, the spot exchange rate must become such as to bring the prices of tradeable goods in the two countries invloved towards equality, i.e. that Purchasing Power Parity will in the end hold, in its relative if not in its absolute form. This terminal, or transversality, condition then fixes the forward rate one period prior to the terminal condition, since the forward rate must then equal the next period's, that is the terminal period's, assumed known spot rate. Meanwhile, the current spot rate is determined in this same period, one before the horizon, by the relative interest rates then expected to rule, in order to satisfy covered interest parity. By similar repeated steps, one works back to the determination of the present spot and forward rates. So, present movements in spot and forward exchange rates are seen as dependent on a long-term forward-looking convolution of expectations about relative goods prices at a quite far distant horizon, and on relative interest rates in the intervening period. Meanwhile, the existence of

relatively sticky goods prices ensures that real interest rates will shift in response to nominal monetary shocks, and this in turn leads to the famous 'overshooting hypothesis', that is that spot rates will have to jump by more than consistent with long-term equilibrium in response to 'news', for example of such monetary shocks, because, while the n-period forward rate is supposed to adjust into line with the expected n-period ahead future spot rate, the current spot rate must adjust by more in order to maintain covered interest parity, as the interest differential becomes more favourable in the country tightening monetary policy.

There is much that is intuitively attractive about this general line of argument. It is firmly based on a realistic appreciation of relative speeds of adjustment in the goods markets on the one hand and in financial markets on the other. It does provide, at a pinch, a plausible account of the quantitative extent of misalignment, for example of sterling in 1980/81 and of the $ in more recent years, in some large part as a consequence of the conduct of monetary policies in the countries concerned. Given the stark and remarkable facts about the behaviour of exchange rates in the flexible exchange rate era, it is not suprising that most of us have embraced a theory that explains how 'overshooting' can occur.

And yet I do not believe that it will do, at least not in its present standard form. Although the theory may, with the help of some good will, provide an explanation of the broad magnitude of misalignment, it is hard to reconcile the actual time path of exchange rates with the predictions of the theory. The overshooting theory would seem to imply sudden, major jump responses to unanticipated news, for example of elections, announced policy changes, changes in administered interest rates, etc., with subsequent auto-correlated reversions towards an equilibrium, whereas the actual path of the exchange rate appears both less subject to major jump changes and more akin to a random walk with, perhaps at times, some persistent drift.

Let me now present my evidence that exchange markets tend to under-react rather than over-react in the short-term. Let me start with some good old-fashioned ad hoc casual empiricism. What are the really

important, newsworthy events for our economy? I would include general elections and budgets among them. Now, in so far as the results or changes in these are anticipated, they do not really represent news; but budgets are certainly meant to be secret, and even with the advent of opinion polls actual election results must dispel some doubts. On table 1 I report the percentage change in the foreign exchange markets from the close of the day before the last two general elections to the close on the day after the elections when the results are known. Similarly I report the change in the exchange rate from the close before Budget day, to the close both on the day itself, and the day after the Budget, since Budget speeches may overlap the formal closing hour. In order to provide some comparison, I had the absolute daily percentage from June 2, 1986 to October 30th, 1986 calculated. The average daily change, without regard to sign, over this fairly quiet period was 0.46%.

In the case of the elections there was clearly no jump. Admittedly 1983 was a foregone conclusion, but were there no doubts dispelled by the 1979 result? Again many of the changes on, and after, Budget day hardly represent jumps, scarcely a skip, hardly a hop; even on occasions such as the 1980 unveiling of the MTFS or the 1981 complete abandonment of Keynesian demand stabilisation. The clear exception, of course, is the change in the exchange rate around the time of the 1985 Budget. But it is not at all clear that this particular jump was due to the Budget, which was not particularly memorable for measures that could be expected to reduce future UK nominal demand and price levels. Instead, as shown at the bottom of Table 1, March 1985 was an extraordinarily volatile month in the foreign exchange market, as the market finally broke decisively away from its flirtation with a possible £1 = 1$. The Budget simply occurred in the middle of this.

This latter illustrates one feature of foreign exchange markets, that there are short periods of extreme volatility interspersed among quieter spells; or in the jargon heteroscedasticity occurs. This latter is inconsistent with a true random walk, which besides the property that it is equally likely to fall as to rise, so that the best expected future value

is simply its present value, should also exhibit a constant variance. I should formally instead use the term martingale, but I will not do so, primarily because the term random walk is so splendidly evocative.

Fun though it is to point out that the foreign exchange market hardly reacted to the most extreme announcement of a long term targetted reduction in monetary growth -- ie the MTFS- in British history, it hardly represents a formal test. I did then try to formulate myself a test of the overshooting hypothesis. Briefly, what I did was to observe those occasions, events, when the authorities acted in the UK to bring about a shift change in bank base rates, and then seek to estimate how much of such a change was unanticipated, by a comparison of (various alternative) market interest rates at the close of business in the day before the change with the rate ruling at the close on the day of the change. Having then obtained an estimate of the extent of unanticipated change in interest rate (differentials), I would then examine the contemporaneous, (and subsequent), effect of such an unanticipated change on spot and forward exchange rates ruling in the market.

I shall not report the format and results of this econometric test to this audience in full detail. They are presented instead in an accompanying appendix. The results do not support the overshooting hypothesis. Instead, they indicate that what needs explanation is rather why exchange rates, both spot and forward, in the event react <u>so little</u> to unanticipated interest rate changes. While the spot-forward premium <u>did</u> react, as one would have expected given covered interest parity, [to changes in interest rates and interest rate differentials, (except when the 3-month Treasury Bill rate was the rate used in the test)], the results showed no significant positive response of either spot, or forward exchange rate levels to an unanticipated change in interest rates.

I had not expected such an extremely negative result, [nor that the volatility of the exchange rate, as measured by its absolute % change, was not significantly different on the day of the change in base rates, at 0.61%, than the average for the days immediately preceding and the two subsequent days, at 0.64%]. One possible explanation for the lack of any

significance is that markets often believe that the authorities have private information about future economic events. If so, an administered rise in base rates could be treated as a signal that the authorities knew that conditions were even worse than expected, rather than just as a policy measure that should strengthen the exchange rate. Maybe. Anyhow my friends reckon that this possibility makes the result of this test moot.

So let me try yet another approach. If markets over-react, jump, in response to monetary shocks, then the basic relationships, auto-regressions, between price changes at time t and time t+1, t+2, etc., should be negative. If the market follows a random walk, the auto-regressions should be insignificantly different from zero. If the market under-reacts, exhibits persistence, the auto regressions should be positive.

When Richard Smith and I did our study on 'The Relationship between Exchange Rate Movements and Monetary Surprises: Results for the United Kingdom and the United States Compared and Contrasted', Manchester School Journal, 1985, we found some puzzling signs of persistence*, a finding that I rechecked recently. This finding was that much of the impact of the unanticipated change in the UK money stock appeared to affect the £/$ exchange rate on the day after the announcement. I should add, however, that all the US findings indicated a virtually immediate response.

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* In a comment in the Manchester School Journal (1987), entitled 'On Testing the Relationship between Exchange Rate Movements and Monetary Surprises: A Comment on Smith and Goodhart', Peel and Pope criticized Richard Smith and myself for implicitly assuming, in our earlier study, 'The Relationship between Exchange Rate Movements and Monetary Surprises: Results for the United Kingdom and the United States Compared and Contrasted', that the spot $/£ exchange rate followed a random walk, and also for ignoring the time lag between the formation of the expectations incorporated in the expectational survey series and the announcement, eg of the actual change in the money stock.

Thus in an equation,

$$\Delta \$/£ = a + b_1 (\Delta £M3 - \Delta \hat{£M3}),$$

where $\Delta \hat{£M3}$ is the previously formed expectation of the change in £M3, the true value of b_1 will be biassed if there is any information available which will allow the prior expectation to be systematically improved, (or,

Again, tests whether the series for changes, first differences, of spot exchange rates generally exhibit signs of auto-correlation, either positive or negative, have quite commonly been carried out in the context of tests whether such series were random walks. I know of several tests, usually using high frequency data, daily or weekly changes in foreign rates, that have rejected random walk behaviour because of positive auto-regression. Patrick McMahon and Richard Baillie find such significant positive auto-correlation in a study of four weekly nominal spot exchange rates.+

+Table 4 in their paper on 'Empirical Regularities in Exchange Rate Behaviour', unpublished paper prepared for the International Economics Study Group conference, Sussex University, September 1985, also included in Chapter 4 of McMahon's forthcoming book.

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less plausibly, worsened), over the time interval between sampling the expectations and the announcement itself.

While this criticism is fair and valid, Peel and Pope are even more concerned about the possibility that the exchange rate may not be a random walk. If so, they claim that persistence, (eg a positive correlation between an appreciation of £ and an unanticipated rise in £M3 on the day after the announcement), may be due to non-random-walk behaviour in the spot rate, not necessarily to market inefficiency, though non-martingale behaviour in high frequency, eg daily, data is itself generally inconsistent with market efficiency. Second, positive autocorrelation in spot rates could lead to an association between the formation of monetary expectations some days back and the current change in spot rates. Third, this could lead to serially correlated error terms in equations such as that above with accompanying loss of efficiency. While Peel and Pope referred to other studies that rejected the random walk model for daily data, they did not actually examine this hypothesis on the Smith/Goodhart data set; so I did.

The results showed that there were signs both of significant positive first order auto-correlation, and of day-of-the-week effects in the daily data. The latter appeared to arise, prior to October 1981, from a particular feature in the settlement for foreign exchange deals in the USA, which could then be made either in Federal Funds, good value and investible on the day received (t + 2 in the case of a foreign exchange deal) or, as most payments were, in clearing house funds which were not investible until the day following the value date, i.e. t + 3. Even thereafter the standard two day settlement period in the forex market might be expected to make it slightly more profitable to sell the currency with the higher interest rate on Thursday or Friday (to enjoy the higher interest yield over the weekend), and to buy in the earlier part of the week, but any such residual effects are much weaker.

While the majority of such tests have usually reaffirmed random walk behaviour, a significant minority have found signs of consistently positive auto-correlation.° Both these kinds of econometric study, and the more recent variance ratio tests, tend to suggest signs of initial slight persistence, under-reaction at first, in financial markets, including the forex market.

° The only examples of negative auto-correlation that I am familiar with in financial markets have occurred in studies of ultra high-frequency hourly data in the forex market, both by Diana Whistler here and by Ito and Roley in their study of the Yen/$ exchange rate ('News from the U.S. and Japan: Which Moves the Yen/Dollar Exchange Rate?', NBER Working Paper, No. 1853, March 1986). This needs more examination, but it may result from the market trying to 'hunt' towards a new equilibrium after being disturbed by some (major) news story.

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An ordinary least squares equation in daily first differences of the spot $/£ exchange rate (cents per £), from 1977-1983, 1823 observations, gave the result,

$$\Delta \$/£ = \underset{(0.00059)}{0.00196} - \underset{(0.00084)}{0.00171}\ \text{Monday} - \underset{(0.00084)}{0.00259}\ \text{Tuesday}$$

$$- \underset{(0.00084)}{0.00310}\ \text{Thursday} - \underset{(0.00084)}{0.00307}\ \text{Friday} + \underset{(0.02343)}{0.04867}\ \Delta \$/£_{t-1}$$

$R^2 = 0.0096$ D.W. = 1.998 F(5,1817) = 4.54.

On the other hand, as noted later, there is rather more support for random walk behaviour in the series for <u>weekly</u> first differences in spot exchange rates, (though there are still some cases of significant positive auto-correlations reported in the literature); and there is virtual unanimity that <u>monthly</u> first differences of spot exchange rates do approximate very closely to a random walk.

If, however, one tries to take some account both of possible revisions to expectations and of the positive daily autocorrelation in the daily exchange rate series by regressing the change in the exchange rate between the close on the day after the announcement, to take account of the already mentioned indication of slight persistence, and the close a <u>week</u> previously, on the unanticipated component of the money stock announcement, the results still show a positive impact, but one that is much weaker and not strictly significant, as follows:-

$$\%\Delta S_{t+1} - S_{t-4} = \underset{(.14)}{-.06} + \underset{(.19)}{.30}\ (\Delta M3 - \Delta \hat{M3})$$

$\bar{R}^2 = .02$ D.W. = 2.01 F(1,68) = 2.36

Once again, this is not conclusive evidence against the overshooting model, since it is only in response to monetary shocks that such models should unambiguously exhibit overshooting. If the majority of shocks were, in practice, to be non-monetary, it might be possible to reconcile findings of slight persistence with the existing model. Even so, I hope to have established at least a prima facie case against.

The real problem that we may have to explain in the forex market over short periods, i.e. in high frequency data, is not why it jumps so much, but why it more regularly appears to under-react to 'news'. While I accept that the Dornbusch 'overshooting' model provides a good story of why the market might over-react in theory, I have to challenge those who believe this to show equivalent empirical evidence that the market does over-react to 'news' in fact.

Per contra, the same theoretical model has the lower frequency, longer term evolution of the real exchange rate firmly anchored by PPP, purchasing power parity. Here the evidence is rather the reverse. While the theory exaggerates short-term volatility, it seems to understate longer term misalignments. The stabilising pull of equilibrium conditions is apparently less than most economists would have expected. I can be brief in outlining the evidence for this, since I have done none of the empirical work myself. First let me appeal once again to ad hoc casual empiricism. You will recall that the path of the $/£ exchange rate, and indeed of all bilateral exchange rates with the US $, have been dominated by the extraordinary misalignment of the $ up till the early months of 1985, and its subsequent reversal. Certainly anyone looking at events up till the end of 1985 could only conclude that the pull of PPP was weak, or even non-existent.

A recent study, in the March 1987 Economic Journal, by Koromzay, Llewellyn and Potter, on "The Rise and Fall of the Dollar: Some Explanations, Consequences and Lessons", notes that it would be difficult, if not impossible to believe that these developments were consistent with a rational reaction to 'news' in the context of the standard Dornbusch overshooting model. Thus, they state, "Historically, the problem with this

is that it requires 'news' over the 1980-6 period to have exhibited a pattern of serial correlation that belies its definition", [P. 27]. Moreover, having asked whether there is "any explanation for the implied massive upward revision of the real expected equilibrium rate for the dollar over the period up to 1985 that is robust in the face of the subsequent dollar fall?" [,P.30], they finally come to the view "that markets just got it wrong.... still seems more plausible"[P. 32].

Let me revert to more formal studies. Adler and Lehmann in their 1983 Journal of Finance article present results for their data set that indicate that changes in real exchange rates even for annual data are not significantly different from a martingale. Admittedly it is difficult to distinguish a martingale from a series with a first-order autoregression with a coefficient of 0.9, but in that case "it would typically take 20 years for the real exchange rate to achieve 90% of the return to PPP after an initial shock".

More recently my colleague, Mark Taylor, has run tests on real exchange rate series over the period 1973-1985. In one of these he looked for the presence of a unit root in the time series representations of such real exchange rates, and could not reject the hypothesis of its presence. He noted that these "findings imply the absence of any tendency of the nominal exchange rate to converge on purchasing power parity, even in the long run." In a further test over the same data period he examined whether the series for monthly nominal exchange rates and relative prices for five countries, each relative to the USA, were cointegrated, as they must be if PPP is to hold at all. His conclusion was that the exchange rate and relative prices did not appear to be cointegrated for any of the countries examined. *

I find it extremely hard to believe either that relative prices have absolutely no effect on nominal exchange rates, even in the long run, or alternatively that real interest rate differentials can widen without bound. Now that the US $ has collapsed from the remarkable high levels of 1984/85, and appears to have passed back through its PPP level on the way down, the results of the formal exercises may, I guess, change somewhat,

*Mark Taylor is currently working at the Bank of England, The two unpublished working papers cited here are'On Unit Roots and Real Exchange Rates: Empirical Evidence and Monte Carlo Analysis',(1986), and 'An Empirical Examination of Long-Run Purchasing Power Parity Using Cointegration Techniques',(Revised 1987).

and the use of variance ratio tests may also show some signs of mean reversion. Be that as it may, and casual or formal, the evidence is surely clear that the long run equilibrating forces in the forex market appear weak and uncertain both in strength and timing, notably much weaker than many current forward-looking rational expectations models imply. If economists wish to base their models on transversality conditions, they may be less firm than we might like.

C. Is the Forward Rate a Good Predictor?

I want to turn now to my next puzzle, which concerns the inability of the forward exchange rate to serve as an efficient predictor of future spot rates. Let me start by rehearsing some stylised facts about the forex market, which I can support with empirical results. First the nominal spot exchange rate approximates closely to a random walk in most cases that have been studied. It can hardly be the case that this remains so for highly inflationary, or hyperinflationary, countries, or, if it does hold, it must do so with significant drift. In addition, as already noted, there are a number of high frequency data sets in which the first differenced series exhibits significant positive auto-correlation. Apart from these exceptions, the now standard Dickey-Fuller tests for a random walk are usually satisfied, at least for weekly and monthly data series, and again generally exhibit no significant drift. The daily data series need more careful handling. Because of peculiarities in the procedure for settling foreign exchange deals in the USA up till October 1981, there were day-of-the-week effects up till that date. Even thereafter, the two day lag in settlement might imply some advantage in selling the currency with a higher interest rate on Thursday or Friday, rather than earlier in the week, to enjoy the higher interest rate over the week-end also, and this can inject a significant day-of-the-week effect. Anyhow, the results of applying such Dickey-Fuller tests to the data set assembled for my exercise is presented in another Appendix, which was authored by Mark Taylor, and shows once again that the Dickey-Fuller tests were satisfied for our weekly and monthly series, without significant drift, except in one borderline case.

The next stylised fact is that covered interest parity holds in the forex market.* So long as the interest bearing financial instruments

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* My colleague, Mark Taylor, in a forthcoming Economica paper, entitled 'Covered Interest Parity: A High Frequency, High-Quality Data Study', has sampled actual market data at ten minute intervals for a period of three days to see if he could detect any evidence of deviations from covered interest parity. In the course of 3,456 possible arbitrage opportunities, only one tiny deviation was found, which could be fully accounted for by brokerage costs.

involved have exactly the same credit-risk, and are not subject to potential, or actual, exchange control or to differential risks of blocking, or repudiation, then any deviation from such covered parity, in a market where transactions costs for market dealers are negligible, would allow for absolutely riskless arbitrage profits. These conditions hold exactly in the euro-markets, where the euro-rate on any currency's instrument can be exactly estimated from the equivalent maturity euro-$ rate and forward exchange rate, and similarly where the forward exchange rate can be exactly calculated from the relationship between the two euro-currency rates involved.* Again we ran statistical tests to see how closely our data series for spot, forward and euro-interest rates matched up to the theoretical expectations implied by CIP. The results are also shown in an Appendix, which indicate that the fit is close to that expected, but exhibits in a few cases a small, but still significant difference, which we cannot explain.

Be that as it may, let us provisionally accept both random walk and covered interest parity as being approximately true. If a series has historically been a random walk, then its expected future value should be the same as its present value. But if CIP holds, the forward rate will diverge from the present spot rate by the extent of the interest differenital, and will thus <u>not</u> be an efficient predictor of future spot rates.

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* Indeed, in the data from Barings this was how the forward exchange rates were calculated.

Before I demonstrate this, let me just indicate the data set° that we have used for these tests in Table 2. As I have stated, what we find is that the forward rate is generally in these tests a less good predictor of the future spot rate, than is the current spot rate; and that its coefficient in an equation relating it, and a constant, to the future spot rate is generally further away from unity than is the coefficient in the equation relating the spot rate to its own past value; and in a number, but not all, of our data sets, the coefficient on the forward rate is significantly different from unity. All this is set out in Table 3.

[Table 3]

You will note that in every case, except with data set H, the coefficient on the spot rate, in equation 1, is closer to unity and better defined, than the coefficient on the forward rate, in equation 2. Moreover, in every case, the fit of the equation is better, albeit often marginally so, when the current spot rate, rather than the forward rate, is the predictor of the future spot rate. You will also, however, observe the generally low level of the Durbin-Watson ratio, which indicates not surprisingly given that the basic series approximates to a random walk, that there are econometric shortcomings in running this consciously simple exercise. In fact, considerably more powerful econometric tests can be run.

° I began with a data set provided by the Bank of England, giving end-of-week figures for the £/$ exchange rate, the 1 and 3 month forward premium, and the related 1 and 3 month values for the euro-dollar and £ inter-bank interest rates, covering the period 1977 Week 1 to 1984 Week 46. Subsequently, however, and as a cross-check on my original results, my colleague, Mark Taylor and I have expanded our data set to include three other similar data sources, providing similar sets of spot exchange rates, one and three month forward exchange rates and one and three month interest rates. These data sets were obtained respectively from the Harris Bank, covering the DM/$ and Swiss Fr/$ exchange rates and associated interest rates, weekly from the begining of 1974 to end-1980; from the OECD again covering the DM/$ and Swiss Fr/$ exchange rates and interest rates, using monthly data from January 1974 to June 1986; and from Baring Brothers, using daily data for the DM/$, Yen/$ and Swiss Fr/$ exchange rates and interest rates from January 1981 to September 1986. These nine data sets thus cover differing bilateral exchange rate relationships, over differing time periods, and sampled with differing frequencies.

to prove that the forward rate is not an unbiassed efficient estimator of the future spot rate. A good example can be found in the work of Patrick McMahon of Birmingham who has used vector auto-regressions for this purpose.

Just to go one step further here, the equation relating the level of the future spot rate to the current level of the forward rate can be transformed into first difference form, by relating the actual change in spot rates from t to t+1 to the forward premium between the current forward and spot rate at time t. This equation was examined by Fama in his 1984 paper on 'Forward and Spot Exchange Rates', Journal of Monetary Economics, who found that the coefficient on the forward premium in this equation was generally markedly different from the expected value of unity, often significantly so, and was more often negative than positive. We reproduce the same form of equation in Table 4 and generally replicate his findings on our own data sets.

[Table 4]

Now these results leave us with a conundrum, because it appears that not only do forward rates provide, by themselves, no useful information at all on the likely future path of spot rates, (note the uniformly abysmal value of R^{-2}) but also that there appears to be better information to hand in the guise of the current level of spot rates than that contained in the forward rate.

Is there really no information whatsoever about future exchange rates to be found in forward rates? Clearly taken by themselves they have virtually no informational value, but some further tests that I ran suggested that if you regressed the future spot rate against both the current forward rate and the interest differential, with both those variables unconstrained, then the coefficient on the forward rate reverted

close to unity, and the explanatory power (R^{-2}) was higher than for a random walk.

[Table 5]

Moreover, in some associated work, Patrick McMahon has been reporting that tri-variate auto-regressions, using data for forward rates and interest differentials, as well as prior spot rates, appear to predict quite a lot better than the pure random walk model.

I should like to end this Section by noting that, if the forward rate was always held equal, or very close to, the spot rate, say by speculation based on the historical random walk properties of the spot rates, then nominal interest differentials could not differ greatly from zero, given CIP. This implies that an administered increase in nominal interest rates would have to lead to such a large appreciation in exchange rates that the economic consequences would be to force domestic interest rates immediately back into line with those abroad. It is the passivity, the slackness, in forward rates -- that they are not unbiassed predictors -- that largely allows for national monetary autonomy, without causing excessive volatility in exchange rates.

D. Analogies with Other Markets.

Let me now try to summarise what I claim to have established for the forex market. First, it exhibits some signs of persistence, under-reaction, in high frequency data: second, it often remains misaligned for long periods, in the sense that the forces driving it back to a long term equilibrium are notably weak: third, there is virtually no information contained in the pattern of forward rates.

What interests and excites me is the similarity between these findings and those that have been recently obtained for the fixed interest, money and debt markets. Ever since Tom Sargent's 1972 Journal of Money, Credit and Banking, article 'Rational Expectations and the Term Structure of Interest Rates', we knew that, given the historical auto-regressive structure of short rates, longer term rates under-reacted to (administered) changes in short rates. This finding, of under-reaction, has more recently been reconfirmed in a number of further tests, eg by Shiller, Campbell and Schoenholtz, 'Forward Rates and Future Policy: Interpreting the Term Structure of Interest Rates', Brookings Papers (1983), and Mankiw and Summers, 'Do Long-Term Interest Rates Over-React to Short-Term Interest Rates', Brookings Papers (1984).

Again, work by Shiller, for example in his 1985 NBER working paper, 'Conventional Valuation and the Term Structure of Interest Rates', and in the Mankiw/Summers paper raises the question whether the previously academically dominant expectations theory had any role to play in the determination of the term structure. There is hardly any more information about future movements of short-term interest rates to be derived from observing the yield curve than there is information on future spot rates to be obtained from looking at forward exchange rates.

Misalignment is, perhaps, less easy to spot in the fixed interest market, since we have less theory about the appropriate equilibrium values for real rates of interest, long and short, than we have for the real

exchange rate. Even so, the experience of the last two decades, with real interest rates generally appearing remarkably and persistently low in the 1970s and high in the 1980s perhaps suggests that equilibrating forces are no stronger in the debt market than in the forex market. Indeed economists such as Shiller and Summers argue that much of the longer term behaviour of financial markets, such as the Stock Exchange as well as the debt market, has to be seen as subject to long-term, only slowly-unwinding, 'fads and fashions'.

All this sounds to me as if there is accumulating evidence of a general pattern for the behaviour of financial markets, notably including the forex market. This pattern is <u>not</u>, however, consistent with many economists' current view of the world, in which a combination of rational expectations, long term confident expectations of future equilibria and certain sticky current prices forces the remaining free variables, e g exchange rates and interest rates into discrete jumps, followed by steady adjustments to some longer term equilibrium. Marshall said that 'natura non facit saltum'; nature does not exhibit jumps. I believe that he was right. Even more worrying, perhaps, the adjustment back to long term equilibrium seems uncertain and halting.

E. Any Explanations?

So far, I have been engaging in the simpler task of contrasting the empirical regularities that I have observed with some current theories. It is going to be much harder to suggest why these theories are flawed, and what causes the results that I have put before you.

One instinctive reaction, of those who believe that markets ought to work as they model them in theory, is that any discrepancy must be due in some large part to official intervention. There is one aspect of these puzzling features that may be exacerbated by such intervention: that is the short term tendency towards persistence and under-reaction may well have been intensified by the authorities' penchant for 'leaning into the wind' in the markets in which they operate. How much of such high frequency positive auto-correlation is due to their efforts at stabilisation, I do not have the data to test, but I am pretty confident that the authorities' responsibility for this anomaly is slight. As for the other two puzzles, I cannot see why the authorities -- who have not engaged in any large volume of outright forward operations in recent years -- should have any responsibility for the negligible forecasting record of forward rates; nor, why, except in so far as their general policy stances are part of the overall background against which agents form their decisions, the authorities should be held responsible for misalignments.

The standard current response to such anomalies is to ascribe them to time varying risk premia. But that is not so much an explanation as almost a tautological, and certainly a jargon, way of restating the problem. I cannot really do better than quote from Mankiw and Summers, who dealing with exactly the same problem, mutatis mutandis, for the term structure, note that, "once it is extended to include a time-varying liquidity premium, the expectations theory becomes almost vacuous. The liquidity premium is a deus ex machina. Without an explicit theory of why there is such a premium and why it varies, it has no function but tautologically to save the theory. If fluctuations in the liquidity premium are needed to

account for a large fraction of the variance in the slope of the yield curve, then the expectations theory fails to provide a strong basis for understanding these fluctuations." Exactly the same can be said about risk premia and the inability of forward rates to predict future spot rates in the forex market. Moreover, the recent studies by Frankel and Froot of the inter-relationship between market surveys of expectations of future exchange rates, which should presumably be clean of risk premia, and forward and spot rates give no support to the suggestion that fluctuations in the forward discount can readily be explained by such time varying risk premia; rather the reverse.

Surely it is the case that people's attitudes towards the risk of taking speculative market positions must be responsible for much of what we observe. I have not, however, seen any good explanations i.e. ones that convince me, about what particular facets of risk may be responsible for such risk premia as seem inherent in the data. My own hunch, supported by much direct practitioner opinion, is that the risks are so great that the extent of longer-term speculation, i.e. that is not intended to be closed within hours, is both less in volume and, as I shall argue, much less clear in direction, (since expectations of future spot rates may reasonably differ between agents at any time, being based on differing information sets), than would be required for the standard theory to hold.

This latter view, that the risks and costs of speculation simply cause there to be a shortage of speculators has remained a rather muted theme in the literature, though repeated from time to time by some economists and practitioners with close market links. Thus Ronald McKinnon in his 1976 paper on 'Floating Foreign Exchange Rates, 1973-74' *stated, page 83, that.

> "The questions of who was to be a stabilizing speculator, and what would be the source of private capital for such speculations were never directly addressed. Rather, this particular issue was superseded by a rough-and-tumble debate over whether private speculation would be stabilizing or destabilizing. An implicit consensus has been reached that there would be no restraints on the availability of private speculative capital on the huge scale needed.

* From K Brunner and A H Meltzer, eds.,Carnegie-Rochester:Conference Series on Public Policy, Institutional Arrangements and the Inflation Problems, vol.3, 1976.

The contrary hypothesis, advanced here, is that the supply of private capital for taking net positions in either the forward or spot markets is currently inadequate.... Once a rate starts to move because of some temporary perturbation, no prospective speculator is willing to hold an open position for a significant time interval to bet on a reversal."

Again, in an excellent, though rarely quoted, paper, on 'Uncertainty and Exchange Rate Stability', from International Finance and Global Banking, ed. S.K.Kaushik,(1983) David King of Citibank, New York, stated in his conclusion,(pages 88-89_,that

"In practice, in a floating exchange rate system, actual and potential exchange market participants are overly uncertain about the medium-to-long term path of the exchange rate.... Private sector exchange market participants are highly risk adverse to uncovered FX positions, especially longer-term. As a result ..., long-term positions that would have moderated extreme departures of exchange rates from their longer-term paths have not been adopted, leaving exchange rate determination to the shorter-term position takers, whose expectations are (i) to a significant extent extrapolative, and (ii) affected temporarily by a wide variety of non-fundamental events: since it is known that the fundamentals have a long time to work themselves out, they need impose little threat of loss on a short-maturity position adopted because of events of a temporary or even psychological nature. Therefore, exchange rates have tended to move in broad swings around their central paths under the floating exchange rate system."

So, there is some support in the literature, and evidence, consistent with a dearth of speculators prepared to use their own money to bring rates into line either with what should be the rational expectation in the approximate random walk world we have experienced, or with the longer term fundamentals.

Anyhow at this stage I sought not only to do some calculations on whether risk averse persons would find the risk/reward distributions available on speculation in the forex market attractive, but also to carry out a personal qualitative survey among a number of London forex specialists of the existence of open speculative positions among their large corporate customers or any established by banks themselves. These exercises have also been relegated to an Appendix. Broadly the results are as follows. Individual wealth holders of normal risk aversion would have to be extremely wealthy, with net assets of probably well over £½ million, to make them willing to seek the relatively small expected returns, net of transactions costs, from an extremely risky speculation.

In turn, companies and banks, for various reasons, very rarely, virtually never in the case of banks, take an open <u>forward</u> position. They will, however, take strictly limited open spot positions, Even so, in aggregate the volume of such open spot positions could be large. If large, which I doubt, but cannot prove, the operation of multi-nationals and banks undertaking 'synthetic' forward deals, by taking open positions in spot markets, would actually achieve the same result, as if there were speculators driving forward rates into equality with expected future spot rates. Even if there were <u>no</u> (speculative) transactions <u>at all</u> in forward markets, any institution taking a view on expected future spot rates should, having taken proper account of interest differentials, drive present spot rates to a level where the implicit, and entirely slack and passive, forward rate was equal to the expected future spot rate. The likelihood that the forward rate actually does largely adjust passively in response to changes in interest rates and spot rates, therefore, does <u>not</u>

explain the phenomena, for example, of inefficient prediction described earlier.*

The claim that speculators will drive forward rates into equality with expected future spot rates is, therefore, on the basis of direct market evidence, a misnomer. There is not enough speculation in the forward market to do that. But it may be the case that speculation, through the adoption of open spot positions, will drive current spot exchange rates into equality with expected future spot prices, after taking existing interest differentials into account. Although there is no doubt that speculation is limited by risk aversion and uncertainty, I cannot disprove the hypothesis that it remains sufficiently large to do that.

But on what information base will such speculation be undertaken? A crucial feature now seems to me that we possess two, firmly held, and it would seem broadly equally valid items of information which do not rest easily together. First, we are aware, and can demonstrate, that these market processes approximate to random walks in the short run. Second, we believe that the process actually is stationary in some long term context, because there are fundamental conditions in the real world, for example PPP, (or that real interest rates cannot diverge too far from some equilibrium values), that will ultimately bring about a return to equilibrium.

Thus the market, and people observing the market, are inherently schizophrenic. Part of the time they will argue that no one can predict the future, that prices are as likely to go up as down (i.e. random walk behaviour), and that, therefore, one should place assets in the currency

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* There is one possible qualification that might suggest why the concentration of speculative activity in the spot market could lead to forward rates being inefficient predictors. The variance in foreign exchange markets is greatly in excess of the variance in national interest rates. The key, therefore, to successful speculation is getting the future exchange rate 'right'. In such cases the speculator may disregard the current interest differential, and seek to drive the spot rate, not the forward rate, into equality with the subjectively expected future spot rate. Some qualitative comments by market participants suggest that such behaviour could be quite common.

with the highest yield, and buy long-dated assets when the yield curve is upwards sloping. Part of the time, people will argue that a currency, or current short rates, are out of line with the fundamentals, and thereby act to prevent forward rates adjusting into line with the random walk expectation. Economists, like me, are equally schizophrenic. Part of the time we tell ourselves, and our students, that it is a mug's game to pretend that we can forecast exchange rates or interest rates, because they approximately follow a random walk. Part of the time we are out there estimating misalignments, reference ranges and long-run equilibria with all the enthusiasm of, say, John Williamson.

There are, therefore, I believe two, usually opposing, groups of speculators operating at any time in markets, both though possessing limited funds, highly risk averse and conscious of their own forecasting limitations. The first group contains those who take positions on the basis of random walk views; the second seek to rely on fundamentals. The market value of the forward exchange rate (or implicit forward interest rate) simply records the balance of power in their struggle.

A fairly new, and I believe promising, line of research in this field has been to utilize direct evidence on future exchange rate expectations, for example from surveys undertaken by such institutions as the Economist, Money Market Services (MMS) amd Amex. A recent study, by Froot and Frankel (1986) using such survey data came up with the conclusion that the expectations of those sampled tended to diverge from the actual historical experience, (which is, you will remember, that the spot rate approximately followed a random walk), by even more than did the forward rate.* In their data set there appeared to be evidence of a sizeable systematic divergence from rational expectations combined with a smaller, and roughly constant, risk premium of exactly opposite sign to that hypothesised in the work using Fama's approach.

*'Interpreting Tests of Forward Discount Bias Using Survey Data on Exchange Rate Expectations', K.A.Froot and J.A. Frenkel, unpublished working paper,(June 1986). Thus, page 9, "expectational errors are more than 100 percent responsible for the unconditional bias in the forward rate errors". A considerably revised version of this paper was subsequently published under the title,'Using Survey Data to Test Standard Propositions Regarding Exchange Rate Expectations','The American Economic Review, vol,77, (March 1987), pages 133-153.

Similarly, a recent study of exchange rate forecasts by Blake, Beenstock and Brasse, (Economic Journal, 1986), came to the conclusion that, (page 998), "A priori, we should expect these forecasts to be pure forecasts of future movements in the spot exchange rate, yet our tests have shown them to be not only biased in that they systematically fail to predict the magnitude of change, but more often than not the correct direction of change too. Moreover, this bias is in the same direction as, and usually bigger than, that observed in the forward rate which may reasonably expect to contain some element of market premium".

At an earlier stage in this whole exercise, I had been unable to provide any plausible interpretation for the finding that market surveys and forecasts generally gave results that were further divorced from the historical random walk process than is the forward exchange rate. I now think that this provides the capstone to the hypothesis here that the forward rate is driven from the current spot rate by those betting on 'fundamentals'. There is little incentive for those paid to forecast the future to confess that it cannot be done, so they are unlikely to put much weight on the random walk view. Moreover those who actually place money on such a random walk basis will usually see themselves as unable to take, or simply not taking, any view of the future, rather than consciously reckoning that the best forecast of the future rate will be the same as the present. Thus any sample of market expectations, or collection of forecasts, will find that a disproportionate number of random walk operators will be in the 'Don't Know' or 'Nil Return' category.

So, such a survey sample will include an excessively large number of those prepared to forecast, (and perchance to bet), on the basis of 'fundamentals'. Thus it is actually an implication of this hypothesis that such surveys, forecasts, etc. should differ from current rate levels by more than the forward rate. This is necessary in order to achieve market balance between the two groups, each operating on a different, but equally valid and rational, information base.

F. Conclusions

In my view speculation is not only strictly limited in total, but is also likely to have an often unpredictable and wayward effect, since it is based on differing data sets, notably random walk expectations, fundamental analysis and even technical market analysis, such as Chartism. And who are we to deny the validity of at least the first two, if not all three of these?

Let me conclude by reminding you of the four main puzzling phenomena that appear to exist in the forex market.

(1) Whereas the spot exchange rate follows an approximate random-walk path over short periods, one week to three months, the forward exchange rate diverges systematically from this (historically predicted) path, and contains no predictive power whatsoever.

(2) Surveys of market opinion, and forecasts, regularly tend to diverge <u>even more</u> from the historical random walk path.

(3) In the medium term there appear to be major misalignments, from some fundamental PPP.

(4) In the short run, however, my assessment of the empirical evidence indicates that the reaction of exchange rates to 'news', notably of interest rate changes, is an under-reaction, rather than an over-reaction.

I would like to think that I have provided at least a promising, partial hypothesis for items 1 and 2, as resulting from the interaction of those speculating on the basis of differing information sets, notably fundamentalists and random walkers.

It may be that this same approach can also go some way to explain some of the major misalignments of recent years. At least I believe that it is consonant with market ancedotes about what actually happened. In my Appendix on actual market behaviour, I stressed that bankers, and other with open spot positions, being naturally uncertain of their own, and of

their economic advisers', judgments would insist on closing out loss-making positions quickly. Assume then an initial balance in the market, with the weight of commercial orders, random-walk operators and 'fundamentalists' establishing the current value of spot and forward exchange rates. If, then, the currency of the country with the higher interest rate should appreciate, contrary to the fundamentalists' open position, the latter will want to close out their losing position, being uncertain both of the timing and even basic validity of their forecast. But in so doing, the 'tired bears' will exacerbate the initial upwards move. Moreover, if some sequence of chance events, e.g. changes in oil prices, flights of capital from Latin America, has the effect of causing a series of losses to 'fundamentalists', confidence, always fragile, in the validity of their short-term forecasting ability will be weakened, so that the flow of speculative funds advanced on such grounds may well decline. During the period 1981-85, company and bank treasurers may well have given increasing weight to random walk views and less to fundamentalist' forecasts since the latter proved so often fallible. Per contra, once the fundamentals really did take hold, at long last, in the UK in 1976 and after 1981, in the USA from early 1985, there would be losses made from taking a random walk view. The forward rate would become more dominated by the successful 'fundamentalists'.

All this suggests that we may be able to make more use of survey data-- which you will recall, I believe to be dominated by fundamentalists -- to examine behaviour and to set up and run testable hypotheses in this field. Mark Taylor and I hope to start some further work on this, once we can assemble a satisfactory data set. I must also note that, after I had independently arrived at this view, my attention was drawn to the paper'Explaining the Demand for Dollars: International Rates of Return and the Expectations of Chartists and Fundamentalists', by Frankel and Froot, University of California, Berkeley, Working Paper No. 8603, now published in The Marcus Wallenburg Papers on International Finance, vol, no 1, (1986) which sets out virtually an identical model, in considerably greater detail and richness. I strongly recommend that paper.

I have left until last my claim, based purely on empirical observations of varying quality, that markets tend to under, rather than over, react to news. My division between fundamentalists and random walkers will not help, since the fundamentalists should, as in the theory, over-react in the short run. I fear that I too will have to fall back on the view that there are many, outside of the immediate market, who take time to assimilate and act on news, and that these, together with some smoothing interventions by the authorities, may serve to inject some slight persistence into short-term market prices. In view of existing complaints about the extent of short-run market volatility, a system which actually involved jump over-reactions would be even more uncomfortable. It may well be that the economic system has devised a number of buffering devices, besides government intervention, that dampen such jump responses. I have elsewhere emphasized the role of money as a buffer-stock. All this remains rather a thin explanation, but I have none better, especially at the end of what has been already an excessively long lecture.

Table 1

Election days, % Δ spot rate from t-1 to t+1

3rd May 1979	+ 0.43%
9th June 1983	+ 0.17%

Budget days, A % Δ spot rate from t-1 to t
B % Δ spot rate from t-1 to t+1

	A	B
12 June 1979	+1.09	+1.69
26 March 1980	+0.23	-0.71
10 March 1981	+0.65	+0.18
9 March 1982	-1.24	-0.77
15 March 1983	+0.30	-0.13
13 March 1984	+1.13	+1.00
19 March 1985	+2.68	+3.99
18 March 1986	+0.85	+1.02

£/$ SPOT RATE, CLOSING RATE, MARCH 1985

DATE	RATE	% CHANGE	ABSOLUTE % CHANGE
1	1.0725		
4	1.0685	-0.3737	0.3737
5	1.0555	-1.2241	1.2241
6	1.0725	1.5977	1.5977
7	1.0665	-0.5610	0.5610
8	1.0665	0.0000	0.0000
11	1.0890	2.0877	2.0877
12	1.0890	0.0000	0.0000
13	1.0860	-0.2759	0.2759
14	1.0805	-0.5077	0.5077
15	1.0840	0.3234	0.3234
18	1.1065	2.0543	2.0543
19	1.1365	2.6750	2.6750
20	1.1515	1.3112	1.3112
21	1.1880	3.1203	3.1203
22	1.1735	-1.2280	1.2280
25	1.1715	-0.1706	0.1706
26	1.1825	0.9346	0.9346
27	1.2390	4.6665	4.6665
28	1.2280	-0.8918	0.8918
29	1.2375	0.7706	0.7706
		TOTAL	24.7741
		AVERAGE	1.2387

Table 2

Data Sets

	Source	Exchange Rate	Tenor of Interest Rate	Frequency of Observation	Sample Period	Number of Observations
A	Bank of England	£/$	3 month	Weekly	1977:14-1985:47	450
B	Bank of England	£/$	1 month	Weekly	1977:14-1985:47	450
C	OECD	DM/$	3 month	Monthly	1974:1-1986:6	150
D	OECD	SwFr/$	3 month	Monthly	1974:1-1986:6	150
E	Harris Bank	DM/$	1 month	Weekly	1974:1-1980:52	364
F	Harris Bank	SwFr/$	1 month	Weekly	1974:1-1980:52	364
G	Baring Bros *	SwFr/$	1 month	Daily	1981:1:6-1986:9:14	1443
H	Baring Bros *	Y/$	1 month	Daily	1981:1:6-1986:9:14	1443
I	Baring Bros *	DM/$	1 month	Daily	1981:1:6-1986:9:23	1450

* In this data set, observations of the spot rate and the two euro-deposit rates were collected near the market opening at the same moment each day, and estimates of the forward rate on that day were then constructed using the covered interest parity arbitrage condition.

Table 3

Comparison of Spot and Forward Rates as
Predictors of Future Spot Rate

Equation 1 $\text{Spot}_{t+1} = a + b\ \text{Spot}_t$ (all in log form)

Equation 2 $\text{Spot}_{t+1} = a + b\ \text{Forward}_t$ (all in log form)

	a			b				
Data Set	Coefficient	SE	t	Coefficient	SE	t	R^{-2}	DW
A1	.01	.04	0.21	0.973	.07	13.5	.91	0.11
2	-.02	.05	-0.32	0.966	.08	12.3	.90	0.10
B1	.002	.01	0.19	0.993	.02	50.7	.978	0.43
2	.004	.01	0.32	0.991	.02	48.4	.976	0.41
C1	-.07	.05	-1.37	0.920	.055	16.6	.851	0.62
2	-.08	.05	-1.77	0.908	.056	16.1	.847	0.60
D1	-.07	.04	-1.93	0.898	.043	21.1	.865	0.58
2	-.10	.03	-2.93	0.874	.042	21.0	.864	0.56
E1	-.02	.02	-1.13	0.972	.020	49.5	.9683	0.41
2	-.03	.02	-1.79	0.962	.020	48.3	.9680	0.40
F1	-.01	.01	-0.97	0.973	.016	59.2	.9792	0.41
2	-.03	.01	-1.89	0.962	.017	58.1	.9789	0.39
G1	-.12	.08	-1.47	0.837	.113	7.4	.678	1.20
2	-.13	.08	-1.59	0.832	.113	7.4	.675	1.18
H1	-1.70	1.32	-1.29	0.685	.243	2.82	.426	1.54
2	-1.71	1.33	-1.29	0.685	.244	2.81	.424	1.53
I1	-0.13	.04	-3.08	0.861	.049	17.7	.795	0.79
2	-0.14	.04	-3.26	0.856	.049	17.6	.794	0.79

In all the data sets there is a higher frequency of observation than of the maturity of the instruments, i.e. there are overlapping observations. The econometric problems that this entails can be met by an apporpriate adjustment to the OLS coverieance matrix, following the technique developed by Hansen, 'Large Sample Properties of Generalised Method of Moments Estimators', Econometrica (1982), and this has been done in all cases.

Table 4

Equation: $Spot_{t+n} - Spot_t = a + b\,(Forward_t - Spot_t)$ (all in log form)

Hypothesis a = o b = 1

	a			b				
Data Set	Coefficient	SE	t	Coefficient	SE	t	R^{-2}	DW
A	-.001	0.27	-.004	7.90	42.2	0.19	-.002	3.86
B	-.00002	0.0003	-.04	-0.05	0.29	-0.17	-.002	3.47
C	.0092	0.005	1.92	-0.98	0.51	-1.94	-.003	3.41
D	.002	0.007	.25	-0.09	0.32	-0.22	-.1007	3.37
E	-.0002	0.003	-.07	0.04	0.71	0.06	-.003	3.56
F	.005	0.003	1.54	-0.93	0.55	-1.71	-.001	3.58
G	-1291.1	1337.2	-0.97	255192	271514	0.94	-.001	3.91
H	1211.0	1157.0	1.05	-1322596	300608	-1.07	-.001	3.91
I	-879.6	961.9	-0.91	254359	285831	0.88	-.001	3.91

Table 5

Equation Log Spot $_{t+1}$ = a + b_1 Log Forward $_t$ + b_2 Interest Differential

(Interest Differential = $\frac{\text{Interest rate, domestic - Interest rate, foreign}}{\text{1,0 + interest rate domestic}}$)

Hypothesis $b_1 > b$ Log Spot, equation 1, Table 3

$b_2 > 0$

		a Coefficient	b_1 Coefficient	(b) Table 3 Equation 1	b_2 Coefficient	t	R^{-2}	Table 3 Equation 1	DW
Data Set	A	-0,0006	0,982+	(0,973)	4,90	3,75	0,93	(0,91)	0,15
	B	-0,003	0,999+	(0,993)	4,51	4,30	0,980	(0,978)	0,49
	C	-0,04	0,939°	(0,920)	2,31	1,55	0,851	(0,851)	0,66
	D	0,05	0,958+	(0,898)	2,83	1,47	0,868	(0,865)	0,64
	E	-0,007	0,980°	(0,972)	2,70	1,72	0,969	(0,968)	0,42
	F	0,01	0,994+	(0,973)	3,14	2,23	0,9794	(0,9792)	0,42
	G	-0,08	0,857°	(0,837)	5,65	2,00	0,685	(0,678)	1,25
	H	-1,72	0,680*°	(0,685)*	4,37	1,32	0,430	(0,426)	1,55
	I	-0,11	0,874×	(0,861)	4,18	1,34	0,797	(0,795)	0,81

\+ less than one standard deviation from 1,00

° less than two standard deviation from 1,00

× more than two standard deviation from 1,00

* rejects hypothesis

Appendix A.

As reported earlier in the main text, I have examined a second set of data for evidence on the validity of the 'overshooting' model. This involved an attempt to examine the response of exchange rates to 'news', in this case 'news' of administered interest rate changes. One of the difficulties in analysing the inter-relationship between exchange rates and interest rates is that there are strong simultaneous two-way inter-connections. An advantage, however, of having worked at the Bank of England is that one can appreciate how official, administrative decisions do lead to certain occasions when there is a predominantly uni-directional sequence of causation from such administrative decisions to market realignments. In particular, decisions to alter official operations in such a way as to provoke a change in clearing bank base rates in this country represent a relatively clear-cut example of a chain of events leading from official decision to interest rate change to exchange market realignment. It was, indeed, the practical experience of several of these events not resulting in the kind of jump response that one might have expected from the change in interest rates that first led me to give more weight to the hypothesis that the forward rate is primarily a slack variable.

The authorities' actions can be, and often are, anticipated in advance. It is only the unanticipated element in their actions that should drive free, uncontrolled financial markets. What I assume in this next exercise is that prior anticipations of future official actions, along with other rational expectations, have been already incorporated into the price, and yield, of financial instruments at the close of business on the previous working day. Thus I take the change in UK market interest rates between the previous close and the end of the day on which the actions were taken, that led to the base rate being changed, as representing the effect of the unanticipated, or 'news' element of such events. Official actions, in turn, are themselves undertaken in response to prior developments, but the length and form of the decision making process is such that the official action on day t is generally predetermined by events on previous days, and is rarely influenced by market developments on

day t itself. Moreover the actions, for example the change in the Bank's market dealing stance, generally occur quite early in the morning, since the authorities wish to avoid a false trading market. Of course, other events also occur on days when base rates are changed, but that latter change is generally the major UK market news on the day involved; and I have already argued that the official decision is generally effectively pre-determined early on the day involved, and thus unrelated, or orthogonal, to the rest of the day's news flow.

I have, therefore, taken the change between the previous close (day t-1) and the close on the day (day t) of the announcement in four sets of UK interest rate 1 and 3 month euro-£, and 1 and 3 month UK Treasury Bill rates, as representing my proxy for an unanticipated, exogenous change in UK monetary conditions. I should, perhaps, add that many of the changes in base rates had been well predicted by the market, particularly the seemingly reluctant ½% declines in base rates in periods of improving confidence, (and indeed some had been overpredicted, so that the sign of the change in market interest rates was not always the same as the sign of the announced change in base rates)*, but there were a number of key occasions when the one day jump in interest rates made it clear that the market had been taken largely by surprise. The data set include all 50 occasions of announced changes in base rates between March 1981 and April 1986.

Given price stickiness, an unanticipated rise in nominal interest rates implies a short-term rise in real rates. Moreover, the high first-order correlation in short-term interest rates, again approximating to a random

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* Thus, in the sample of 50 changes in base rates, there were some ten occasions when the one and three month interest rates moved (very slightly) in the opposite direction to the announced change in base rates (in every case, when these were reduced by ½%) on the day of the announcement itself, (as measured by the change from close t-1 to close t).

walk, should make a rational investor predict that such higher levels would persist. On such grounds, any adherent of the sticky price overshooting model ought to expect forward exchange rates to rise following an unanticipated increase in interest rates, and the spot rate to show a 'jump' overshoot. That did not happen in the cases covered by this data set.

What I had myself expected that my event study would reveal would be a rise in spot rates, as interest rates were increased, but no significant change in forward rates, since these, I hypothesized, would fall relatively to spot rates, since they would simply adjust passively to accommodate covered interest parity.

In the event I found no significant response of either spot rates, or forward rates, to the unanticipated element in the change in interest rates, see Table 8, equations 1 and 2. The variation in the exchange rates, both spot and forward, was comparatively large on these days, and the interest rate changes, despite the fact that some were large and, on this assumption unanticipated, explain effectively none of the exchange fluctuations. Note, however, that, although the relationship between interest rate movements and the forward rate is as tenuous as with the spot rate, the coefficient on the change in interest rates is regularly more negative. This is consistent with the maintenance of covered interest parity, in the sense that a rise in UK interest rates, relative to US rates, ought to drive the forward rate down relative to the spot rate. When I tested this directly, in equation 3, relating the change in the forward/spot premium to changes in UK interest rates, and also in the UK-US interest rate differential, the results were much more encouraging, in the sense that the change over the day in the UK interest rates and in the UK-US interest differential, did in most cases have a significant effect on the change over the day in the spot-forward premium, except in those cases when the 3 month TB rates were used.

I also explored certain variants, for example whether the effects on the exchange rate of such (unanticipated) interest rate changes might have been lagged, whether the pattern of response might have been disturbed by a few outlying observations. Thus I regressed the change in the exchange rate from

t-1 to t+1, and again from t-1 to t+5 against the (unanticipated) change in interest rates from t-1 to t. Whereas rather more of the signs on the b coefficient then take on the expected positive sign, the variance of the outcomes also, not surprisingly, increases, so the response remains uncompromisingly insignificant. Next, I excluded from the sample the six most extreme examples of large (unanticipated) upwards changes in interest rates on the grounds that these were usually associated with exchange rate crises, and that market reactions may have been atypical in such circumstances. But the same tests on the restricted sample showed exactly the same pattern of an absence of any systematic relationship between changes in exchange rate levels and interest changes, but a clear relationship between changes in spot/forward premia and in interest rates.

So a study of these events not only provides no support at all for the overshooting hypothesis, but actually leaves one with a contrary puzzle, why did exchange rates apparently respond so little to (unanticipated) changes in official actions? My tentative suggestion is that the market believes that the authorities possess private information. A more restrictive action, than expected, may then be taken by the market to reveal that the authorities' private information is discouraging. If so, it provides a possible rationale for the authorities' penchant for large, discrete upwards jumps in interest rates at times of falling confidence. Since the very fact of a rise has an adverse informational impact, the rise has to be large enough to overcome that effect if it is to provide encouragement for inward capital flows and support for the exchange rate.

Table 6

Equation 1 % change $Spot_t$ - $Spot_{t-1}$ = a + b (Interest $rate_t$ - Interest $rate_{t-1}$)

Equation 2 % change $Forward_t$ - $Forward_{t-1}$ = a + b (Interest $rate_t$ - Interest $rate_{t-1}$)

Equation 3 $Premium_t$ - $Premium_{t-1}$ = a + b (Interest $rate_t$ - Interest $rate_{t-1}$)

Premium = Forward - Spot, (absolute levels).

Hypotheses: a = o; b > 0 Equations 1 & 2; b<0 Equation 3

Alternative Interest Rate Sets

A Euro-£ 1 month rate ; used with 1 month forward rate

B Euro-£ 3 month rate ; used with 3 month forward rate

C UKTB 1 month rate ; used with 1 month forward rate

D UKTB 3 month rate ; used with 3 month forward rate

E Euro-£/Euro-$ 1 month differential ; used with 1 month forward rate

F Euro-£/Euro-$ 3 month differential ; used with 3 month forward rate

G UKTB/USTB 1 month differential ; used with 1 month forward rate

H UKTB/USTB 3 month differential ; used with 3 month forward rate

Equation 1

Data set of interest rates	a		b			
	Coefficient	t value	Coefficient	t value	R^{-2}	DW
A	,038	0,33	-,13	-0,55	-,01	1,91
B	,047	0,42	-,30	-1,16	,001	1,85
C	,041	0,36	-,14	-0,61	-,01	1,91
D	,037	0,33	-,21	-0,87	-,005	1,89
E	-,008	-0,07	,24	1,17	,007	1,87
F	,001	0,09	,16	0,59	-,01	1,91
G	-,002	-0,02	,14	0,61	-,01	1,90
H	,02	0,21	,01	0,05	-,02	1,92

Table 6 (Continued)

Equation 2

Data set of interest rates	a coefficient	t value	b coefficient	t value	R^{-2}	DW
A	.033	0.29	-.21	-0.90	-.004	1.90
B	.053	0.49	-.44	-1.76	.04	1.99
C	.04	0.31	-.21	-0.90	-.004	1.90
D	.04	0.34	-.28	-1.18	.008	2.07
E	-.01	-0.09	.16	0.77	-.009	1.87
F	.023	0.21	-.04	-0.15	-.02	2.08
G	-.003	-0.02	.07	0.32	-.02	1.89
H	.024	0.22	-.06	-0.27	-.02	2.08

Equation 3

Data set of interest rates	a coefficient	t value	b coefficient	t value	R^{-2}	DW
A	-.008	-1.08	-0.10	-6.92	.49	2.17
B	.005	0.18	-0.17	-2.50	.10	2.20
C	-.008	-1.06	-0.08	-5.04	.33	2.03
D	-.002	-0.07	-0.09	-1.37	.020	2.31
E	-.003	-0.58	-0.11	-13.6	.79	1.82
F	.017	0.64	-0.26	-4.16	.25	2.01
G	-.002	-0.21	-0.09	-5.39	.36	1.91
H	-.000	-0.03	-0.11	-1.71	.04	2.38

Appendix B

This appendix reports some additional statistical tests to support the assertion that, for the data bases examined above, the (log) spot exchange rate follows a random walk with zero drift.

An appropriate test for a random walk is the Dickey-Fuller test. This is constructed as follows.

Consider the regression

$$(\log spot_{t+1} - \log spot_t) = a + b \log spot_t + u_t \quad (1)$$

If the exchange rate follows a random walk, we should have b= 0. Rearranging (1):

$$\log spot_{t+1} = a + (1 + b) \log spot_t + u_t$$

So that, if the exchange rate follows a stationary first-order auto-regression, we should have $b < 0$.

The Dickey-Fuller test then amounts to estimating an equation of the form (1) and the testing

$$Ho: b = 0$$

The Dickey-Fuller statistic is then the standard 't-ratio' for b. However, under the null hypothesis $Spot_t$ will have a theoretically infinite variance, so that the Dickey-Fuller statistic will not have a t-distribution. However, Fuller (Introduction to Statistical Time Series, 1976, John Wiley) has published a table of critical values generated by Monte Carlo Methods.

Note that it may be the case that the exchange rate follows a higher-order auto-regressive process (perhaps with a unit root). Evidence of this

should however be apparent as serial correlation in the residuals from (1).

Table 7 lists computed Dickey-Fuller statistics for the logarithm of the spot exchange rate for each of the data sets examined. Given that the critical value of the 5% level is approximately - 2.88, for most cases the null hypothesis of a random walk cannot be rejected. Moreover, the values of the Ljung-Box Statistic in each case suggests that a first-order auto-regressive process in each case adequately characterises the data. Only for the Barings data set, which uses daily data, can the random walk hypothesis be rejected.

These tests are not designed, however, to discriminate between random walks with and without drift. However, if we accept the random walk hypothesis, we can easliy test for zero drift by regressing the change in the (log) exchange rate onto a constant and testing the estimated parameter against zero. In this case, the t-ratio will have its usual interpretation. In Table 8, we report the estimated drift parameter and its t-ratio for each of the data sets. Only in one case (Harris Bank SwFr/$) do we appear able to reject the null hypothesis of zero drift.

As noted above, with very large data sets we will generally find a rejection for <u>any</u> departure from the null hypothesis, even if it is of no practical significance whatsoever (resulting, say, from, tiny approximations in construction of the data). Some allowance for this phenomenon can be made

from a Bayesian perspective, by computing the posterior odds ratio of the null to the alternative hypothesis. In the standard regression model with the posterior odds ratio set to one, Zellner and Siow* have shown the posterior odds ratio to be approximately

$$\lambda = \left\{\frac{\pi(T-2)}{2}\right\}^{1/2}\left\{1+\frac{t^2}{T-2}\right\}^{-(T-3)/2}$$

where T is the sample size and t is the t-ratio for the null hypothesis of a zero parameter. Given that the Harris data set contains 364 observations, and if we agree that the null hypothesis should be rejected when the posterior odds ratio is below unity, the critical t-value for data set F in Table 2 is 2.53: the null hypothesis of zero drift cannot be rejected.

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* Zellner, A and Siow, A, (1980), 'Posterior Odds Ratios for Selected Regresssion Hypotheses,' Trabajos De Estadistica, vol 31, pp 585-603.

Table 7

Dickey-Fuller Statistics for Log Exchange Rates*

Data Set	Dickey-Fuller Statistics	Q(K)
A/B	- 0.52	Q(63) = 54.66 (0.76)
C	- 1.55	Q(36) = 27.82 (0.83)
D	- 2.17	Q(36) = 25.11 (0.91)
E	- 1.79	Q(60) = 66.25 (0.27)
F	- 1.59	Q(60) = 57.69 (0.56)
G	- 8.98	Q(80) = 87.73 (0.26)
H	-16.10	Q(80) = 93.11 (0.15)
I	- 5.64	Q(80) = 88.91 (0.23)

* The null hypothesis is that the exchange rate follows a random walk, with rejections for (absolutely) large, negative Dickey-Fuller Statistics. Approximate critical value at the 5% Significance level (from Fuller op.cit.) is - 2.88. Q(k) is the Ljung-Box Stastistic and is asymptotically chi-square with k degrees of freedom under the null hypothesis of white noise residuals (marginal significance level in parentheses).

Table 8

Testing for Zero drift

Data Set	Estimated drift	t-ratio
A/B	-0.0004	-0.50
C	0.001	0.57
D	0.004	1.26
E	0.001	1.80
F	0.002	2.34
G	0.81×10^{-6}	0.54×10^{-3}
H	0.0002	0.07
I	-0.0002	-0.19

Appendix C

One advantage of examining whether covered interest parity, CIP, holds in one's data sets is that it also provides an opportunity to check the accuracy of the underlying data sets. If the data set does not accord with covered interest parity pretty closely over any period, then either there are faults in the basic data, or the conditions under which the data were calculated incorporate various constraints on transactions, such as exchange control, or there are perceived differential risks, that make further tests on the inherent relationships between these variables more than a little hazardous. Thus the basic test for covered interest parity doubles as a valuable test on the accuracy and reliability of the data set itself. We should mention, en passant, that some of the data sets, initially examined by us, showed marked divergences from covered interest parity, sufficiently so that we felt that it could be unwise to use them until the reasons for such divergence could be properly established.

The results of the equation that we ran, to test for covered interest parity are reported in Table 9. You will note that, even for the series that we accepted as conforming reasonably closely to such parity, the hypotheses of a zero constant and a coefficient of exactly unity on the interest differential are rejected in several cases.

In particular, the Bank of England data series not only have coefficients significantly different from the predicted values of 0 and 1, but also the residuals exhibit considerable auto-correlation, as evidenced by the low Durbin-Watson ratio. Thus, except in cases such as the Barings data, where covered interest parity holds by construction, even in the best time series there are various faults and errors, as a result of which covered interest parity holds only as a close approximation, not exactly, as it should in reality.

[Table 9]

A null hypothesis will, however, never be <u>exactly</u> true - for example these data will suffer from averaging over bid-ask spreads and other

approximations. A problem with standard statistical inference is that with very long data sets (as here), the null hypothesis may often be rejected even for deviations from it which are of no practical significance (see, for example, E. Leamer, Specification Searches, John Wiley, 1978).

Table 9

Test of Covered Interest Parity

Equation:

$$\frac{\text{Spot-Forward}}{\text{Spot}} = a + b \left(\frac{\text{Interest Rate, domestic} - \text{Interest Rate Foreign}}{1.0 + \text{Interest Rate, domestic}} \right)$$

Hypothesis, $a = 0$, $b = 1$

		a		b			
		Coefficient	SE	Coefficient	SE	R^{-2}	DW
Data Set	A	.0004	.00008	1.06	.011	0.95	0.23
	B	.00006	.00004	1.07	.016	0.90	0.53
	C	.0003	.0004	1.03	.034	0.86	1.95
	D	-.0020	.0008	0.87	.049	0.68	2.15
	E	-.0001	.0002	1.11	.044	0.64	1.03
	F	-.0001	.0002	1.05	.033	0.74	1.34
	G	NA					
	H	NA					
	I	NA					

Appendix D

Where are the Speculators?

Can it be rational for speculators not to seize on better-than-fair gambles? The answer to that is that people, and even bankers, are risk averse and that the risks from such speculation are large compared with the minor gains from betting on a tendency for the exchange rate to approximate to a random walk. Thus Froot and Frankel in their working paper (1986) on 'Interpreting Tests of Forward Discount Bias using Survey Data on Exchange Rate Expectations', note that in their data set, "The magnitude of expost exchange rate changes dwarfs that of the forward discount".[o]

In his essay on 'The Theory of Risk Aversion',* Arrow writes, "Consider an individual faced with a random income Y and offered the alternative of a certain income, Yo. A risk averter would be willing to accept a value of Yo less than the mean value, E(Y), of the random income; the difference may be thought of as an insurance premium. In particular, choose Yo so that the individual is just indifferent between Yo and the random income Y, and let,

$$\pi = E(Y) - Yo$$

Then if the distribution is sufficiently concentrated (technically if the third absolute central moment is sufficiently small compared with the variance), Pratt shows that,

$\pi = \frac{1}{2}\sigma^2 R_A(Yo)$ + terms of higher order, where σ^2 is the variance of Y", and R_A the coefficient of absolute risk aversion. "A similar interpretation can be offered for the relative risk aversion".

We can reformulate that expression, as follows:-
where $R_A(YO) = \frac{2\pi}{\sigma^2}$, the agent will be indifferent whether to gamble, or not. Now, we can use our data base easily to calculate $\frac{2\pi}{\sigma^2}$. quite easily.

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o A considerably revised version of this paper was subsequently published under the title 'Using Survey Data to Test Standard PropositionsRegarding Exchange Rate Expectations'. The American Economic Review, vol 77,(March 1987)

* Chapter 3, pages 90-120, from Essays in the Theory of Risk-Bearing,(Chicago 1971)

The earlier empirical work in the paper suggested that, in at least some of our data samples, the spot exchange rate approximated closely to a random walk, whereas the forward rate, by itself, was a biassed predictor of this. Accordingly, in such cases, the annualized profit that could be expected to obtain at any time from betting that the spot rate would continue to be a random walk is simply the interest differential between the two countries involved. Meanwhile, the variance of the outcome of this bet is equally just the expected variance of the exchange rate itself over the same maturity period (e.g. 3 month, or 1 month), expressed in terms of the same dimension, e.g. in annualized % terms.

As noted by Froot and Frankel, the variance of the exchange rate changes dominates the size of the interest differential, i.e. the forward discount. We have estimated the variance of exchange rate changes over the whole period 1977:15 to 1985:47 for the £/$ exchange rate over 3 month periods, and assuming this to be constant, estimated the value of $\frac{2\pi}{\sigma^2}$, as the (3 month) interest differential varies over time. The estimates for the 1st and 26th week of each of these years are given in Table 10. It should be noted, however, that ARCH tests reveal the existence of auto-correlation in the time series for the variance, and Mark Taylor and I intend to produce a technically superior version of this Table in future work.

For a number of reasons it has proven generally simpler and easier in the literature to make estimates of relative risk aversion, and to work with this concept rather than that of absolute risk aversion. In his paper on "The Marginal Valuation of Income",*Nick Stern concluded that models of consumer demand, and of optimum savings and taxation, provided estimates of the elasticity of the marginal utility of income concentrated around 2 (P249), and we shall use that value as our estimate of relative risk aversion.

Before we can revert to the Pratt/Arrow formula to work out when it would repay an individual to speculate on the random walk characteristic of the spot exchange rate, we need one further piece of evidence, which concerns the actual transactions costs of so doing. If there were no transactions costs at all, so that each individual could undertake a speculation involving a miniscule

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*From Studies in Modern Economic Analysis, eds.M.J.Artus and A.R.Nobay (Blackwells 1977), pages 209-57

proportion of his wealth, then it would be worth putting some tiny fraction of one's wealth on an outcome with a positive expected mean return, however risk averse the punter, and however high the relative risk aversion. We live, however, in a world with positive transactions costs. The cheapest way to speculate on the foreign exchange market for relatively small sums is to use the futures market. Table 11 reports the minimum size, and costs, of dealing in futures, as given to me by a London dealer. Note that the initial margin that has to be deposited will normally be non-interest bearing, at least for small, occasional players, if not necessarily for all those operating in the market.

For the time being, the only feature of these dealing arrangements that I want to use is the figure for the minimum contract, £25,000. The speculator is signing a futures deal for a minimum value of £25,000, even if he actually initially puts up a smaller sum - (and for the much larger forward deals the speculator would not need to put up any initial money, so long as he was credit-worthy). Anyhow, we can now use the Pratt/Arrow formula to ask the question, "What would an individual's wealth have to be to make it worthwhile for that speculator to bet on the future spot rate following a random walk, given a minimum contract of £25,000, a coefficient of relative risk aversion of 2, and the values of $\frac{2\pi}{\sigma^2}$ exhibited in Table 10.

Taking the highest value in Table 10 of $\frac{2\pi}{\sigma^2}$ of .097 gives me a resulting estimate that the individual's requisite wealth should have been about £500,000 (half a million pounds) to make the minimum sized gamble worthwhile, and that for most of the period the lowest wealth necessary to tempt a normally risk averse individual into this risky arena would be in excess of a million pounds.

Such attempted calculations are, however, <u>extremely</u> approximate, and by and large. They may <u>underestimate</u> the incentive to speculate, in that the appropriate variance to use is not the variance from the individual gamble, but the addition to the variance faced by the agent in his <u>overall</u> position as a result of taking the gamble, and that may be significantly less, particularly if there are some potential co-variances between unanticipated changes in exchange rates and unanticipated changes in future price levels that may be

exploited, a possibility raised by Hansen and Hodrick (1983).* Moreover, of course, the majority of speculative positions will be adopted by those who believe, rightly or wrongly, that they have information on the future movement of spot exchange rates that is different from, and superior to, the random walk hypothesis.

On the other hand, in these calculations we have taken no specific account of the various other transactions costs of speculation, and, as already indicated, particularly for individuals, they can be large on relatively small futures and forward deals. Moreover, the Pratt/Arrow formula that we have been using requires the third absolute central moment to be small compared with the variance, and that condition is surely violated in the foreign exchange market. It can be easily demonstrated that the forex data series are markedly leptokurtic. Thus the risks facing speculators are actually considerably worse than the above calculations, based on the mean and variance of the outcome, already suggest.

Theory allows rational, utility maximising, agents to refuse to gamble, even when the expected outcome is better than fair, if the risks are sufficiently high. There is so much fuzziness and uncertainty in these calculations that, certainly at present, one cannot state with any confidence how sizeable the set of agents will be who would find such a gamble worthwhile, though certainly it is not an empty set. If, however, one does ask practitioners with direct market experience how large this set is, one will receive the answer, as I have recently, that the number of individuals, with the combination of wealth, risk aversion, knowledge and tastes willing and able to take (speculative) positions in forex markets is tiny, in relation to overall market size, with extremely limited market influence.

So, the combination, of riskiness, minimum economical size of contract and transactions costs more generally, prevents individuals from being able to exert much speculative influence on the forward exchange rate. How about non-bank corporate customers? Not only is the wealth of corporations vastly greater, but economies of scale mean that the effective transactions costs, e.g. of forward deals, becomes pared to the bone. Indeed, the only overt cost of

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*'Risk Averse Speculation in the Forward Foreign Exchange Market: An Econometric Analysis of Linear Models', in J.A.Frenkel,ed. Exchange Rates and International Macroeconomics(Chicago 1983), also see Hodrick, R.J. and Saivastava S, 'An Investigation of Risk and Return in Forward Foreign Exchange', Journal of International Money and Finance,vol.3,(1984), and 'The Covariation of Risk Premiums and Expected Future Spot Rates, Journal of International Money and Finance,(1986)

forward deals for large corporates resides in the spread between the bid and ask price, and, for large enough deals, this will not be any greater than charged in inter-bank deals. Any such forward transaction between bank and corporate customer, however, involves a credit risk. Thus a corporate which gets relatively deeply involved in forward deals will find that his other credit lines with that bank will get trimmed back.

Nevertheless, my discussions with senior bankers involved in the foreign exchange market in London suggested that only a small proportion of corporates, at most 4/5% of large corporate customers, were prepared to take outright speculative positions in forward markets, (as compared with a much larger proportion who used the forward market for hedging). In some large part this was due to a feeling by corporate treasurers that they were not in a position, with regard to comparative information and perceived role, where they should take up purely speculative positions. Even when treasurers did not feel such inhibition themselves, there was a considerable incentive to take a speculative position in another way. Borrowing money in country X, transferring the funds through the spot market to currency Y, and investing in country Y, effectively achieves exactly the same result (given that covered interest parity rules, as it does) as undertaking a forward purchase of Ys currency, in short a 'synthetic forward'. In practice, the choice of the distribution of a (multi-national) firm's assets and liabilities around the world in the light of prospective interest rates and exchange rates is perceived as a legitimate function for any corporate treasurer; whereas the adoption of an outright speculative position in forwards is, still, seen commonly as inappropriate gambling with company funds. So, there is a considerable incentive for corporates to back their speculative views with synthetic forward positions, involving switches of asset/liabilities and spot transactions, not direct forward deals. Indeed, the psychological stigma of the forward market - as inappropriate speculation - is such that I know of several cases where institutions, notably those run by cautious trustees, will prefer to undertake synthetic forwards to hedge an existing exposure, rather than make a forward deal, even if the latter is slightly cheaper and easier to manage. Thus some pension, or other charitable, funds with large $ holdings will on occasion prefer to hedge their $/£ currency risk by borrowing $s,

buying £ spot, and investing the funds in the UK, rather than have a forward contract on their books.

Moreover, perhaps in part because of the ease of undertaking 'synthetic' forward, rather than actual, forward deals, the forward market is relatively thin beyond six months and for broken dates (i.e. for dates that are not exactly N months hence, n = 1 - 12). This means that corporates may find 'synthetic' forward positions both easier to manage, e.g. to close out, on a day by day basis, and as cheap, in terms of transactions costs, to arrange as a straight forward position. Whatever the reason, however, my direct, qualitative information from those closely involved in the London foreign exchange market is that the proportion of corporate customers who will take speculative positions in forward markets is small (less than 5%), and that the extent and effect of such activity on the forward market is also strictly limited. On the other hand the proportion of corporate treasurers who will be prepared to take up a 'synthetic' forward position, of some limited size, is vastly greater.

At this stage, however, one is usually faced with the response that it is not the non-bank agents, but the banks themselves who are supposed to provide the speculation requisite to drive the forward rate into line with the expected spot rate. After all, they have much larger wealth and expertise, and face much lower transaction costs than outside agents. Thus McKinnon in the paper, 'Floating Foreign Exchange Rates 1973-74' (1976), already quoted, stated, (page 84)

> "Perhaps implicit in the traditional theory of flexible rates, the commercial banks were the natural candidates for the role of stabilizing speculators".

McKinnon believed that banks' ability to undertake this role was constrained by official regulations. Thus,

> "Governments and central banks have now pressed commercial banks to balance their net position in foreign exchange. Hence commercial banks are

restricted - and perhaps correctly so - from taking speculative positions".

My own enquiries of commercial banks in London do not suggest that they find the Bank of England's guidelines on open positions unduly restrictive. Rather they stressed the limits that they voluntarily adopt themselves for their own internal prudential purposes. Indeed, given the opportunity that banks now have to transfer positions from financial centre to financial centre, whereas a Central Bank can generally only monitor close of business positions, the Bank's guidelines have to be regarded as largely voluntarily accepted. The Bank sees them, perhaps, as representing helpful guidance for banks' own internal prudential control, than as providing a serious constraint to banks whose senior management had decided consciously to take on a large speculative position; though the adoption of this latter course by responsible senior management would be, I believe, extremely rare.

Anyhow I decided, as part of this study, to send an early version of this paper to a number of banks involved in the London forex market, and followed this up with a number of interviews, and further correspondence, which indicated a common pattern of behaviour.

Let us begin with the manner in which such banks operate in the forward market. Except in banks with extremely small dealing rooms, the forward dealer (desk) will be physically separate from the spot trader (desk). When a customer contracts an outright forward deal, say to buy forward $ from the bank, the bank's forward dealer will then automatically, as a matter of course, cover that by buying spot $s from the bank's spot desk. Consequently, any outright forward position in the bank is immediately transformed into a swap position, i.e. selling $s forward and buying spot, or vice versa. The forward dealer then has to make a decision, to let that swap position stand, or to close it out by a reverse swap, i.e. in this case by buying $s forward and selling $s spot. That will depend on the forward trader's view of future interest differentials. The crucial features are:-

(1) the forward dealer's position is always transformed into a swap position,

(2) the dealer's decision on that position becomes a speculation about future relative interest rate movements, not about currency movements at all.*

The spot traders, usually one for each main bilateral exchange rate, (e.g. £/$, Dm/S, SwFr/$, etc.,), are the key operators in the bank's forex business. Each trader will be set prudential limits by his bank on his close-of-business open position, and a much larger intra-day position. The size of each trader's limits will depend in part on the bank's aggregate prudential limits, itself influenced by the Bank of England's guidelines, and in part by the trader's previous track-record in achieving trading profits by taking positions. The traders are each given a free hand by their bank to back their own individual views about the course of the currencies in which they are trading. The bank may have, often will have, a separate considered view about the likely development of certain currencies, but any position taken by the bank is adopted, monitored and accounted for separately, and the individual traders are not constrained to seek to maintain the same currency position (at the close of business each day) adopted by the bank, in a totally separate exercise. Indeed it can be quite common for the trading book and the bank's own position to be opposite.

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* This can cause communication difficulties. Bankers are so used to regarding forward operations as being essentially swaps based on views of interest rate adjustments that they are likely to respond to questions why they prefer to take positions (with respect to expected currency fluctuations) in the spot rather than in the forward market by referring to the lesser volatility (of relative interest rates) in the forward (swap) market than of (exchange rates in) the spot market.

The individual spot trader's position will at any time quite largely reflect the balance of outside buy/sell orders that he has received. As a market maker, quoting bid/offer prices (for which he will be good, i.e. stand ready to transact, up to the normal market size of deal), his open position depends in part on the stochastic order flow. Nevertheless, and particularly in the efficient, low transactions cost, spot foreign exchange market, the trader can extremely rapidly adjust his own book by dealing in the interbank market. When a trader's open position changes, he has the choice of running his position, or reversing it; and he is equally able to initiate taking a position.

What is clear is that there is an enormous volume of short-term intra-day adjustment of spot traders' positions. The ratio of the amount of turnover in the foreign exchange market in London, with average daily turnover of $90 billion, (see the Bank of Englands' Press Notice of August 20, 1986), to the size of the U.K.'s current account and estimated capital flows through London has often been remarked. Bankers themselves often estimate that interbank deals are a large multiple (10, even 20 times) of those for non-bank customers. Much of this reflects the natural market adjustments that follow an initial outside order. What, however, is particularly interesting to an economist is the firmly maintained view that not only is short-term (largely intra-day) speculation prevalent, indeed very large in scale, but that it is also on balance profitable. Traders, so it is claimed, consistently make profits from their position-taking (and those who do not, get fired), over and above their return from straight dealing, owing to the bid/ask spread.

It is only possible to make such consistent speculative profits, if you have better information. What informational advantages do these bank traders have, and who, in contrast, is the loser, getting a worse deal? Certainly such speculative activities are <u>not</u> based on any consideration of longer term economic fundamentals. There are various hypotheses. During certain periods in the past, certain bank traders had access to better public information, quicker, than other traders, (e.g. when only some trading desks had Telerate/Reuters screens), and could make money during the process of information dissemination, but, as the market becomes more efficient, that

source of trading profit has been reduced. A further source of informational advantage to the traders is their access to, and trained interpretation of, the information contained in the order flow. Examples are various. Some market actions may indicate Central Bank involvement. Each bank seeks to interpret the activity of other banks in the market; some have a reputation of being able to position themselves well in certain currencies, and their perceived operations may cause others to follow their lead. Each bank will also know what their own customer-enquiries and orders have been in the course of the day, and will try to deduce from that the positions of others in the market, and overall market developments as they unfold. Because they sit at the centre of the market, the traders can react very quickly and sensitively to incoming market information: presumably the losers, in a sense, are the outside customers, in that once they seek to react themselves to changing information, or even provide it themselves in the shape of making enquiries about terms for a large order,* the market will already have moved against them. Be that as it may, the extremely large-scale, very short-term speculative activity in this market by the individual traders is not well understood, or even much analysed, by economists. And to repeat, it is <u>not</u> based on a long-term future view of economic fundamentals.

Whereas the view taken by the bank's spot traders is inherently short-term, the bank itself may take a view on future currency movements that is more related to longer-term economic fundamentals. If it does wish to take such a view, it will, in every case that I have personally discussed, take a position in the spot market, <u>not</u> in the forward market. In a sense such a spot market position is a synthetic forward position also, since the bank must finance the short side and lend out the proceeds on the long side. In practice, however, since exchange rates are historically more subject to

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* An outside customer has less good information on terms than a market maker. If he asks around, he improves his own information on relative terms, but may turn the market as a whole marginally against himself.

unanticipated variation than are interest rates, speculation on interest rate relative movements is the province of the swap book held by the forward dealers, while the bank's open spot position is seen generally as a pure currency play, with little attention normally being given to interest rates.

Why do banks in London behave in this fashion, putting their speculative positions in the spot, rather than the forward, market? The spot market is a much broader, more liquid market; it is easier to close out a currency position exactly in the spot market than in the forward market where that might involve dealing in broken dates, i.e. not exactly in a multiple of n months; the bank's monitoring and control mechanisms are based on keeping the forward market as a swap market (speculating on relative interest differentials) and putting straight open (currency) positions, both for traders and for the bank, through the spot market.

The size of a bank's open spot position is limited by the extent of risk that the bank is prepared to accept, given its capital resources, and by the Bank of England's guide-lines. In general, banks appear to perceive such open positions as particularly risky, and seem much less willing to accept risks of currency fluctuation than to expose a maturity mis-match to interest rate risk. Accordingly, the size of banks' open positions is quite a small, often a very small, proportion of their capital. Even so, of course, the cumulative weight of all banks' aggregate positions could be extremely large. Perhaps just as important, a bank's open position is continuously monitored, and a position which has begun to make a loss will be very quickly closed out, in a matter of

a day or so. The adage that you should take your losses and run your profits* is firmly maintained. The reason given for closing out a losing position quickly is that bankers are realistic about their limited ability to predict the future path of exchange rates, and also concerned that the state of their own book may cloud their judgement. Thus, once a course of action has been initially decided, all subsequent information may be interpreted as justifying that initial judgment, even if that is not objectively so. Bankers feel that this syndrome is common, and a frequent cause of disaster. To guard against it, they will insist on closing out loss-making positions quickly, whatever the economic fundamentals may indicate.

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* In some cases initial profits from a successful open position will be employed to buy an option, which will ensure that the speculation cannot lose money, and allows the bank to run its position on a longer term basis with somewhat less day-to-day concern.

Table 10

Estimated values of , where is the interest differential ruling at any time and is the (assumed constant) variance of the spot exchange rate.

1977;26	.027
1978; 1	-.014
;26	.020
1979; 1	.012
;26	.046
1980; 1	.030
;26	.097
1981; 1	-.041
;26	-.079
1982; 1	.026
;26	-.046
1983; 1	.023
;26	.000
1984; 1	-.007
;26	-.035
1984; 1	-.007
;26	-.035
1985; 1	.020
;26	.063

N.B. The signs simply reflect the sign of the interest differential and indicate the expected profitable direction of speculation (on the assumption of random walk behaviour). The absolute value indicates the comparative return/risk of so doing.

Table 11

Sterling/Dollar Futures

1) London

- Contract Size = £25,000
- Min Dealing Size = 1 Contract
- Commission = Institutions = $1.20 a Round Trip
  Individuals = $40.10 a Round Trip
- Volume discount = Only offered to Institutions and is negotiable as is basic commission for Institutions.
- Size of spread = .01 (= $2.50)
- Margins = Initial Margin = $1.000 per Contract but fluctuates up to $2.000 with volatility. Individuals pay twice as much.
- Other Costs = If delivery is ever taken transfer charges would be incurred.

2) Chicago

- Contract Size = £25,000
- Min Dealing size = 1 Contract
- Commission = Similar to London for US based Institutions plus Individuals but high for UK Nationals dealing through US brokers.
- Discount for Volume = As London
- Size of Spread = .05 ($12.50)
- Margins = Initial Margin $1500 - again affected by volatility. Individuals double - margined as in London.
- Other Costs = As London.

For individuals wishing to deal in futures, it is much better to use the Chicago Market as the liquidity is far greater. However, institutions dealing in larger sizes can easily use either London or Chicago.

NB: Banks are extremely reluctant to quote Forwards to Individuals unless they are very wealthy and have deposits with them. Min Size = £25-50k - depending on the Bank
Costs = None apart from banking charges - as banks will alter their price to give themselves a margin - Customers rarely get market prices. Size of Spread = From .01 in short dates to 10 points in 1 year.