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INTEREST RATE CHANGES, INFLATIONARY EXPECTATIONS, AND EXCHANGE-RATE OVERSHOOTING: THE DOLLAR-DM RATE

by

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I. Introduction and Overview

There has been considerable interest in the relationships among interest rates, exchange rates, and inflationary expectations. Many exchange market analysts focus heavily on the effects of international interest-rate differentials in influencing the ups and downs of currencies. Generally such discussions assume that an interest rate increase will cause a currency to appreciate, i.e., its exchange-rate to fall, and recent theoretical analysis due especially to Rudiger Dornbusch,[1] has shown that in a Keynesian world such exchange rate fluctuations may be substantially magnified, lending exchange rate changes in the short run to substantially overshoot longer run equilibrium levels. Many commentators have argued that this has been a major explanation of the observed volatility of key exchange rates under floating rates, particularly the $-DM rate and in an influential paper, Jeffrey Feankel has found empirical support for this view.[2]

It is important to recognize that such scenarios are directly counter to the implications of the monetary models of exchange rates, which have also received a great deal of popular attention and empirical support. In these models, interest rate increases are mirrored by currency depreciation rather than appreciation.

While both of these approaches have been provided with published empirical support, a number of other studies have failed to find strong simple relationships of either sign between interest rate and exchange rate changes.[3] In this paper we discuss some of the major theoretical issues involved in analyzing the relationships between interest rates and exchange rates and present further empirical evidence that neither the monetarist nor Keynesian's explanation is fully satisfactory.

The reason is not hard to find. Whether an interest rate increase relative to those abroad should be expected to be accomapnied by an appreciation or a depreciation of the currency depends crucially on whether the change in the nominal interest rate represents primarily a change in the expecated real rate of interest due for example to the liquidity effects of a tightening of monetary policy, or whether it is primarily the result of a change in inflationary expectations. In the former (Keynesian) case which is assumed in many market commentaries, we would indeed expect the currency to appreciate, while in the latter case, emphasized in many monetarist models, we would expect higher interest rates to be accompanied by a falling currency.

The empirical evidence suggests that both explanations have been important in explaining short term interest rate movements in recent years and thus that neither provides a simple dominant explanation of the relationship between interest rates and exchange rates. The monetarists have certainly been correct that inflationary expectations have often played a major role in determining interest-rate changes and that we cannot safely assume that high nominal interest rates mean tight monetary policy, but on the other hand we have also had fluctuations in short term interest rates which cannot plausibly be explained in terms of changing inflationary expectations. The long duration of periods of negative real short term interest rates on an ex post basis in many industrial countries during the 1970's is clearly incompatible with the assumptions of reasonable processes of expectations formation and a positive (much less constant) real rate of return on short term assets such as was prevalent during the 1950's and 1960's.[3]

Attempting to identify between expectations of real and inflationary components of interest-rate changes is quite important not only for exchange rate forecasting but also for analysis of the empirical importance of various hypotheses about the causes of the high degree of exchange-rate volatility which has been experienced during the current period of floating. Even with respect to real interest-rate changes, however, there may be considerable variability in the relationships between interest-rate and exchange-rate changes. In the following section the basic outline of Rudiger Dornbusch's influential analysis of exchange-rate overshooting is presented and several complicating factors such as less than infinite capital mobility, and the effects of uncertainty are considered. In subsequent sections, the effects of changes in inflationary expectations on interest-rate, exchange-rate relationships are discussed and the difference is emphasized between changes in the expected trend rate of changes of exchange rates and changes in the base or initial equilibrium exchange rate from which the expected trend originates. Changes in inflationary expectations will only affect the former in a simple quantity theory world, but resulting effects on velocity and uncertainty may have a substantial impact on the latter. In the last section the recent effort by Jeffrey Frankel to model the exchange rate effects of both the real and inflationary expectations components of nominal interest rate changes is discussed and the need to extend the analysis to take into account the term structure of inflationary expectations is emphasized.[4] Appendices A and B extend and critique the Frankel analysis and present new empirical results.

II. The Effects of Real Interest-Rate Changes

A great deal of attention has been focused on the recent model presented by Rudiger Dornbusch in which the exchange-rate responses to unanticipated money supply changes will overshoot the resulting change in the long run equilibrium rate because of the combination of high international capital mobility and more rapid adjustment in foreign exchange and domestic financial markets than in goods markets. In traditional macroeconometric models, an unanticipated one shot increase in the money supply will lead to a temporary fall in the real short term interest rate. However, if capital is perfectly mobile internationally, then there can be no difference in interest rates internationally unless they are exactly offset by expected changes in exchange rates. Thus if interest rates fell at home relative to abroad, the home currency would have to depreciate immediately sufficiently below its long run equilibrium value so that it would be expected to appreciate back toward this long run equilibrium value at a rate equal to the interest-rate differential. The initial overshooting would be greater, the larger was the change in the interest differential and the longer the differential was expected to be maintained.

Estimates of the relationships between changes in interest rate differentials and exchange-rate movements have been used to calculate the magnitude of such exchange-rate overshooting. However, the accuracy of such estimates of exchange rate overshooting are critically dependent upon the adequacy of the specification of the estimating equations being used. If in fact the cause of the interest rate change has not been correctly identified, then we would expect econometric estimates to be quite unstable over time periods in which the relative importance of causes of interest-rate differentials differed and we could have little confidence in the results of overshooting estimates of any one particular regression.

This will be true even when changes in inflationary expectations play no role in the changes in nominal interest rate differentials. As is illustrated in Figure 1A in a Dornbusch type model the amount of overshooting in response to a decline in interest rates is a function of how long the resulting interest differential is expected to persist, but the expected duration of the differential (specifically the rate at which the differential is expected to close) may vary considerably depending on the cause of the interest rate change, Dornbusch's original analysis considers an unanticipated one shot change in the money supply. In this case the amount of the initial interest rate decline would be a function of the interest elasticity of the demand for money and the expected duration of the differential would depend on the speed with which the domestic economy adjusted to work off this unexpected increase in liquidity. These adjustment speeds may differ considerably from one economy to another. In particular in models which emphasize direct feedback from exchange rate changes to domestic prices (this is not considered in the original Dornbusch paper, but is in a latter paper by Dornbusch and Krugman[5]) it is often argued that adjustments will take place more rapidly in more open economies. Where adjustment speeds did differ significantly from one economy to another, it could make an important difference in which economy the interest rate change occurred.

Other causes of changes in real interest rates must also be taken into account; the expected duration of changes in interest rates associated with cyclical upturns and downturns may differ from episode to episode and from those associated with changes in monetary policy. The story could be repeated with other causes for shifts in the demand for money, some of which might be expected to be quite temporary and others of quite long duration. Indeed there is certainly the possibility of shifts in real interest rates which are expected to be permanent. In models such as Dornbusch's which assume infinite capital mobility, i.e., perfect asset substitutability, such a permanent change in the expected real rate of interest could not occur, as it would require infinite initial overshooting. Where less than perfectly elastic capital mobility is assumed, it becomes possible for expected rates of return on financial instruments in different countries to differ. Overshooting could still occur, but it would be less than in the infinite capital mobility models.

There appears to be considerable range of opinion today about how high international capital mobility is. Those who have started with null hypotheses of rational expectations and the capital and pricing models have tended to assume highly integrated financial markets and have tended to take the absence of findings of significant risk premiums in forward rates in most studies to date as strong evidence for the perfect substitutability hypothesis. On the other hand, those who have adopted more traditional approaches have tended to view international capital mobility as significant, but considerably less than perfectly elastic, and this view is supported by the numerous econometric studies of the interest sensitivity of international capital flows which have been carried out in this tradition.

This question of the actual degree of capital mobility facing different countries and the implications for the magnitude of interest rate induced exchange rate overshooting needs a good deal more analysis, as does recognition that the exchange rate path following the initial overshooting is unlikely to remain undisturbed over the time period of the expected closing of the interest differential. The current interest differential is known with certainty, while there may be considerable variance to expectations of the future price path. With risk aversion this would suggest that the initial overshooting and consequent mean expected rate of appreciation would have to be greater than that indicated in the perfect certainty version of Dornbusch's analysis.[6]

The amount of initial overshooting would presumably be greater, the greater was the amount of uncertainty about future exchange rate shocks and the less the extent to which the exchange rate risk resulting from such shocks could be diversified away at zero or low costs. Under the assumption that the probability distribution of expected exchange rate paths becomes broader the further in the time horizon in question, the longer expected duration of the interest differential would increase the initial overshooting by more than proportionately in relation to the perfect certainty effects.

Thus consideration of less than infinitely elastic capital mobility and uncertainty about exchange-rate disturbances have opposing influences on the expected degree of interest rate related overshooting. Given that the interest cum expected appreciation sensitivity of capital flows is likely to vary over different ranges and the amount of exchange rate uncertainty can vary tremendously from one period to another, we should not be surprised to find estimates of exchange rate overshooting coefficients which differ quite a bit from one period to another, as well as from one pair of countries to another.

III. Changes in Inflationary Expectations in a Simple Quantity Theory World

The likelihood of unstable empirical relationships between interest-rate and exchange-rate changes is increased still further when one considers that nominal interest-rate changes are often the result of changes in inflationary expectations rather than expected real rates of interest. Suppose, for example, that the cause of an interest-rate decline is a decline in the expected rates of long run monetary growth and inflation. Then in a simple quantity theory world, as is illustrated in Figure 1B there would be no immediate impact of the interest rate changes on exchange rates.[7] This change in inflationary expectations would change the expected equilibrium trend of the nominal exchange rate by an amount equal to the change in the expected rate of inflation, but there would be no change in the base, i.e., the current equilibrium rate to which this trend is applied.[8] In such a world where this was the only type of disturbance, there would be zero coefficient for the regression of short run changes in exchange rates on changes in interest rates (assuming no initial trend), but a coefficient of plus one on the regression of the interest differential $(r_h - r_f)$ on the rate of currency appreciation or depreciation (a coefficient of minus one on the rate of exchange rate change $(\dot{e})$).

In a world composed of both types of disturbances a simple regression of $\Delta(r_h - r_f)$ on Δe would bias downward estimates of the amount of overshooting in response to unanticipated temporary changes in the rate of monetary growth.

It is important to note that the explanations of the dramatic and sizeable fall of the dollar during 1977-78 which focused on changes in the inflationary outlook are not consistent with such a simple quantity theory world. It is quite true that this fall of the dollar did coincide with an increase in expectations of U.S. inflation relative to that abroad, but such a shift in expected inflation rate differential could not plausibly have been more than four or five percent (and was in fact probably a good bit less than this). As noted above, in a simple quantity theory world this shift in inflationary expectations would change interest rates and the trend of exchange rates by an equal amount, but would have no effects on the current short run equilibrium exchange rates. While the worsening of inflationary expectations in the U.S. in 1977-78 undoubtedly played a role in the fall of the dollar over this period, the size of the decline over this period cannot be explained on simple quantity theory grounds.

IV. Inflationary Expectations and Velocity Effects

In more sophisticated models, however, changes in inflationary expectations may have sizeable immediate effects on exchange rates. One mechanism noted in the recent exchange rate analysis by Frankel[9] is through the effects of inflation on velocity and the demand for real cash balances where the interest elasticity of the demand for money is non-zero. Expectations of higher rates of inflation increase the expected "tax" on interest bearing money imbalances (and those which bear fixed rates of interest). The resulting incentives to economize on real cash balances results in a one short increase in the price level because of the resulting increase in velocity. Under the ceteris paribus assumption of no permanent real shocks, purchasing power parity will hold in the long run and the resulting increase in domestic prices because of the one shot increase in velocity will lead to a one shot increase in the domestic price level and a corresponding change in the level of the equilibrium exchange rate path.

In an efficient foreign exchange market, the exchange rate would change immediately by the full amount of the one shot velocity effect plus any overshooting which might occur even though it might take some time for domestic prices to fully adjust. Thus just as with the Dornbusch overshooting case of temporary unanticipated monetary expansions, there could be a sizeable initial change in the real exchange rate. But unlike the Dornbusch case, there would be no exchange rate overshooting.

The initial deviation from PPP would be closed entirely through domestic prices rather than exchange rate adjustments (for this discussion I assume no independent feedback from exchange rate changes to domestic prices).

Jeffrey Frankel in a recent study estimates this one shot effect of changed inflationary expectations to be quite large, with one percent interest in the U.S.-German long run inflation differential leading to a depreciation of the dollar against the mark of the order of six percent. Preliminary work by Hooper and Morton on an effective exchange rate measure of the dollar finds results of the same order of magnitude. If these estimates are in the correct ballpark then explanations of the fall of the dollar which place a major emphasis in the worsening of inflationary expectations in the U.S. begin to take on a good deal more plausibility (although there could still be a role for the influences of changed expectations about equilibrium real exchange rates because of changed expectations about economic growth rates and current account balances).

Estimates of this magnitude seem quite on the high side, however, in terms of the various estimates of the interest elasticity of the demand for money. Note also that if the interest elasticities of the demand for money differs significantly across countries, as appears to be the case, then we should look separately at the expected rate of inflation in each country, rather than just at the expected differential.[11]

V. Uncertainty Effects of Higher Rates of Inflation

There is, however, an additional rationale for why a change in the expected rate of inflation may have a quite large immediate impact on the exchange rate. There is a growing body of evidence that higher rates of inflation tend to be more variable and less predictable.[12] As has been emphasized by Richard Sweeney[13] increased uncertainty about price level developments makes a country a less attractive place for investment and can lead to a sizeable decline in the equilibrium foreign exchange value of a country's currency. If the increased uncertainty effects which are likely to accompany higher rates of inflation are taken into account, then short run exchange rate effects of changes in inflationary expectations of the size estimated by Frankel, or even larger, begin to become quite plausible. Initial attempts by Der Hovanessian and Makin to include risk proxies in exchange rate equations have not found strong results, but this seems likely to be due as much or more to the difficulties in empirical estimation of short run exchange rate models as to the possible relative unimportance of risk considerations in exchange rate determination.[14]

VI. The Frankel Model and the Term Structure of Inflationary Expectations

While the need to distinguish between the real and inflationary components of interset-rate changes has become widely acknowledged at the time of this writing, we are aware of only two published studies which attempt to take this distinction directly into account in empirical research. These are the recent papers by Dornbusch and Frankel[15]. These studies include both short and long term interest differentials in a monetary approach model for the dollar-D mark exchange rate. Frankel hypothesizes that changes in the long run interest-rate differential reflect changes in inflationary expectations (he also tries several other proxies), while changes in the short-term interest differential in excess of changes in long run inflationary expectations reflect changes in real interest rates. In his published estimates he finds empirical support for his hypothesis of a positive coefficient of the long run interest differential on the exchange rate (i.e., increases in domestic long term rates are due primarily to changes in inflationary expectations and are associated with currency depreciation), while holding long run interest differentials constant, he finds a negative coefficient for changes in the short term interest differential, indicating that these are predominantly changes in real rates so that short term interest rate increases lead to currency appreciation. Thus he argues that his theory is a significant improvement over the initial simple monetarist models which assumed that changes in short term interest rates were positively associated with exchange rate changes and the simple Keynesian-Dornbusch model which abstracted from inflationary expectations. Consistent with his theory, Frankel uses the coefficients on his short term interest-rate differential holding constant the proxies for long run inflationary expectations to derive elements of the magnitude of short run exchange-rate overshooting and the coefficients of the long run interest rate differential as a proxy for inflationary expectations to derive estimates of the one shot effect of changes in the long run expected inflation rate differential on the level of the exchange rate.

There is a serious question whether we can place much confidence in these estimates, however, because of severe instability of the coefficients. The results reported by Dornbusch using the same type of question but a somewhat different time period are quite different, with the coefficients on the short-term interest rate differential frequently being positive rather than negative. Further evidence of the instability of coefficient estimates in these types of models resulting both from differences in time periods and econometric techniques is presented in Appendix A. Later work by Frankel, himself, has also found considerable instability.[16]

VII. The Term Structure of Inflation Rate Expectations

Another potentially important source of the instability of these types of estimates results from the failure to take into account that there can be quite sizeable shifts in the term structure of inflationary expectations. In periods of prolonged low inflation we have become accustomed to a term structure with short term interest rates lying below long term rates. On the other hand, in the recent periods of very high inflation we have very frequently observed just the reverse, with short term rates rising far above long term rates. While the variability in short term rates has undoubtedly at times reflected sizeable shifts in short term expected real interest rates, it has also often reflected changes in expectations about near term inflation say over the next three months or even a year to two which differ considerably from changes in expectations of the average rate of inflation over the next 10 or 20 years. Casual observation suggests that a good bit of the variations in short term nominal interest rates in recent years has been due to changes in expectations about the cause of inflation over the next few months or years which are associated with much less change about expectations of longer run rates of inflation. Thus one can have a sizeable change in short trerm relative to long term interest rates without there being any change in expected real interest rates.

Even under the assumption that the long run real rate of interest is constant, one cannot take changes in long term interest rates as a good indicator of changes in short run inflationary expectations. We need to also attempt to break down the change in short term interest differentials into expected real and short term inflationary expectations components. An initial effort along these lines using several simple proxies for short-run inflationary expectations has been undertaken by Khan. (See Appendix B) While the empirical results using these proxies have yielded only mixed results, given the large observed shifts in the term structure of interest rates, it would seem that this may reflect more the difficulties of obtaining good estimates of expectations than it does the lack of importance of the term structure of inflationary expectations.

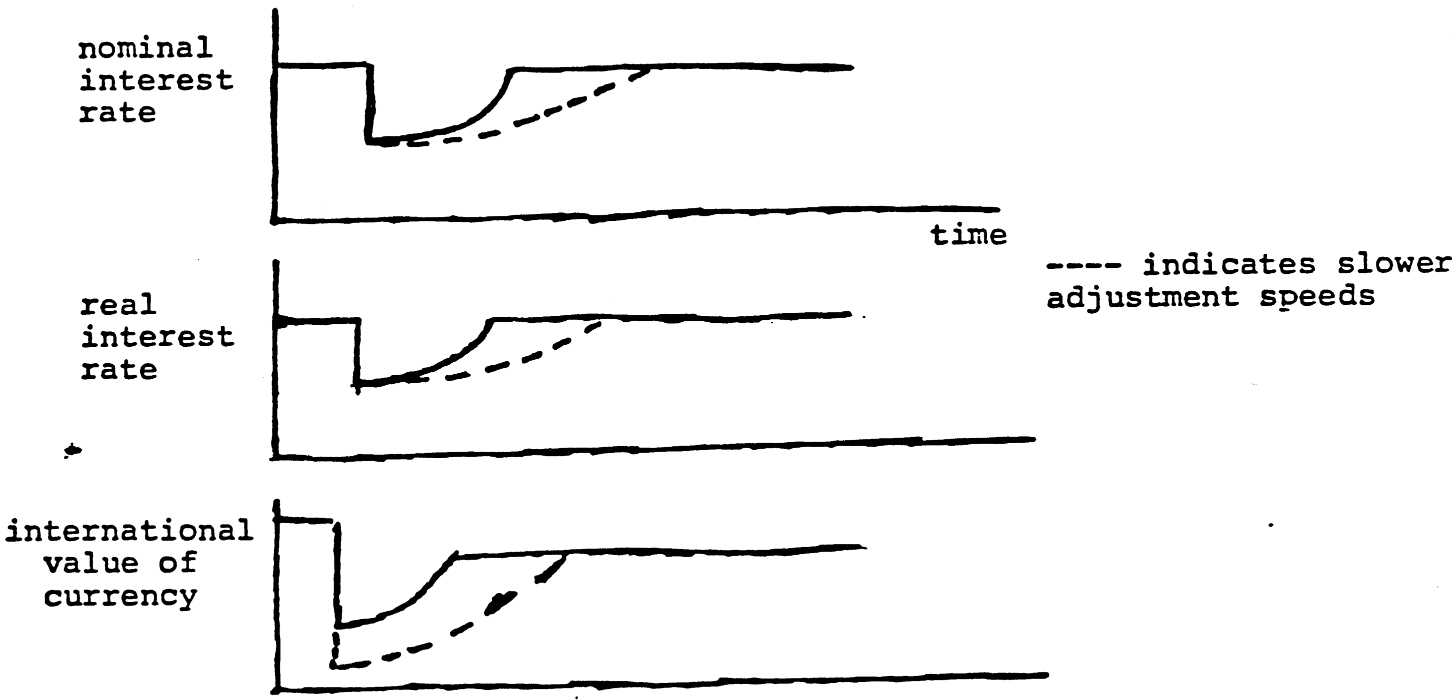
VII. Concluding Remarks

We have learned quite a bit in recent years about the complexities of the possible relationships between interest rates and exchange rates. Unfortunately as yet, we have been much less successful in identifying stable empirical relationships. We have, however, amassed a good deal of negative knowledge. This at least provides the useful function of warning us to be wary of assuming that particular views of these relationships such as that higher interest rates will strengthen the dollar will almost always hold. In this case, recognition of our ignorance is itself a sign of progress.

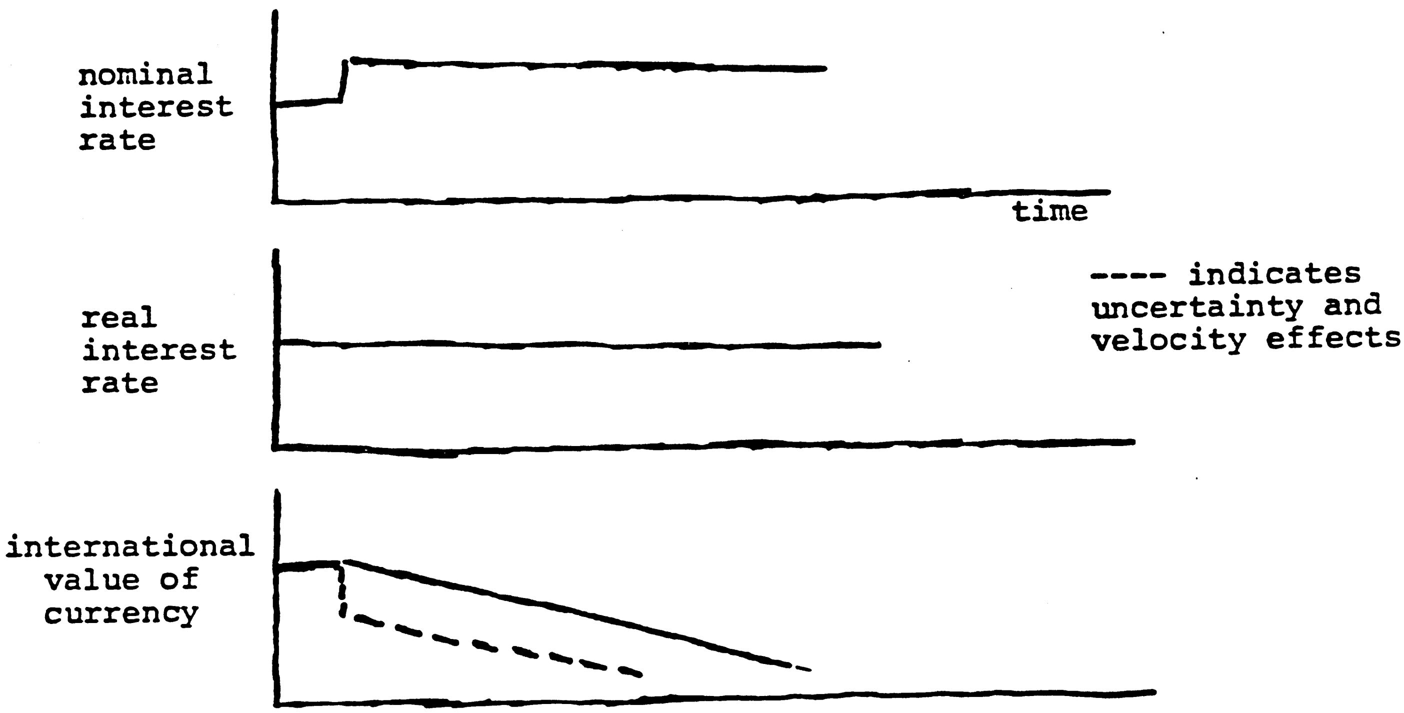
Figure 1

RELATIONSHIPS AMONG INTEREST RATES, EXCHANGE RATES, AND MONEY SUPPLY CHANGE

A. Unanticipated One Shot Monetary Expansion in a Keynesian Model



B. Change in the Rate of Monetary Expansion in a Quantity Theory Model



Footnotes

[1] See Rudiger Dornbusch, "Expectations and Exchange Rate Dynamics," Journal of Political Economy, vol. 84, no. 6 (December 1976), pp. 1161-1176.

[2] See Jeffrey Frankel, "On the Mark, The Theory of Floating Exchange Rates Based Upon Real Interest Differentials," American Economic Review, vol. 69, no. 4 (September 1979), pp. 610-622.

[3] For survey articles which conclude that there is substantial empirical support for the monetary approach to exchange rates, see John Bilson, "Recent Developments in Monetary Models of Exchange Rate Determination," I.M.F. Staff Papers, Vol. 26, No. 2 (June, 1979), pp. 201-223 and Michael Musa, "Empirical Regularities in the Behavior of Exchange Rates" in Karl Brunner and Allan Meltzer (eds.), Policies for Employment, Prices, and Exchange Rates, Carnegie-Rochester Conference Series on Public Policy, Vol. II, Amsterdam: North-Holland, 1979, pp. 9-57. For a more recent survey which finds considerably less systematic empirical support for short run monetary models, see Waseem Khan and Thomas D. Willett, "Empirical Evidence on the Monetary Approach to Exchange Rates," Claremont Working Paper, 1982. Specifically on the instability of estimates of the relationships between interest rates and exchange rates, see, for example, Ira J. Kaylin, Charles Pigott, Richard J. Sweeney, and Thomas D. Willett, "Annexes, The Effect of Interest-Rate Changes on Exchange Rates During the Current Float," in Carl H. Stern, et. al. (eds.), Eurocurrencies and the International Monetary System (Washington, D.C.: American Enterprise Institute, 1976), pp. 223-234, and Bruce Brittain, "Tests of Theories of Exchange Rate Determination," Journal of Finance, vol. 32 (May 1977), pp. 519-529, and Rudiger Dornbusch, "Monetary Policy Under Exchange Rate Flexibility," in Managed Exchange Rate Flexibility: The Recent Experience, Federal Reserve Bank of Boston Conference Series, No. 20, 1978, pp. 90-122.

[4] This point has been emphasized in David Howard, "The Real Rate of Interest in International Financial Markets," International Finance Discussion Papers, No. 136, Board of Governors of the Federal Reserve, April 1979. A recent study by E. Fama, "Short-Term Interest Rates as Predictors of Inflation," American Economic Review, vol. 65 (June 1975), pp. 269-282, did proport to find evidence consistent with the hypothesis of rational

expectations and a constant real short-term interest rate in the U.S., but this study has been subjected to severe criticism. See Charles Nelson and William Schwert, "On Testing the Hypothesis That the Real Rate of Interest is Constant," American Economic Review, vol. 69 (June 1977), pp. 478-486; John Carlson, "Short-Term Interest Rate as Predictors of Inflation: Comment," American Economic Review, vol. 67 (June 1977), pp. 469-475; John Elliot, "Measuring the Expected Real Rate of Interest: An Explanation of Macroeconomic Alternatives," American Economic Review, vol. 67 (June 1977), pp. 429-444.

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[5]See Rudiger Dornbusch and Paul Krugman, "Flexible Exchange Rates in the Short-Run," Brookings Papers on Economic Activity, no. 3 (1976), pp. 537-575.

[6]On this point, see Susan Schadler, "Sources of Exchange Rate Variability, Theory and Empirical Evidence," IMF Staff Papers, vol. 24 (July 1977), pp. 253-296.

[7]For simplicity, this analysis assumes that changes in inflationary expectations leave real rates of interest unchanged. It has often been argued that in reality real balance effects and (at least short run) elasticities of wages with respect to expected inflation of less than one will cause higher expected rates of inflation to lower the real interest rate, while Michael Darby, "The Financial and Tax Effects of Monetary Policy on Interest Rates," Economic Inquiry, vol. 13, no. 2 (June 1975), pp. 266-276, has pointed out that if after tax real rates of return are to remain constant, nominal rates will have to rise by more than the increase in expected inflation. (He suggests that this tax factor is on the order of 1/3.) For a more recent analysis, that includes the effects of taxes on short-term interest rates, see Maurice Levi and John Makin, "Anticipated Inflation and Interest Rates: Further Interpretation of Findings on the Fisher Equations," American Economic Review vol. 68 (December 1979), pp. 801-812. For an application to an open economy, see John Makin, "Anticipated Inflation and Interest Rates in an Open Economy," Journal of Money, Credit and Banking, vol. 10 (August 1978), pp. 275-289.

[8]This point has bsen emphasized by Peter Isard, "Factors Determining Exchange Rates: The Role of Relative Price Levels, Balances of Payments, Interest Rates and Risk," International Finance Discussion Papers No. 156, Board of Governors of the Federal Reserve, April 1980.

[9]See Jeffrey Frankel, "On the Mark," op. cit.

[10]See Peter Hooper and John Morton, "Fluctuations in the Dollar: A Model of Nominal and Real Exchange Rate Determination," International Finance Discussion Papers, No. 168, Board of Governors of the Federal Reserve (October 1980).

[11]On this point, see James Rasulo and D. Sykes Wilford, "Estimating Monetary Models of Balance of Payments and Exchange Rates: A Bias," Southern Economic Journal, vol. 47, no. 1 (July 1980), pp. 136 - 146.

[12]See, for example, Deborah Frohman, Leroy O. Laney, and Thomas D. Willett, "Uncertainty Costs of Inflation," Voice of the Federal Reserve Bank of Dallas (July 1981), pp. 1-9, and references cited there.

[13]See Richard J. Sweeney, "Risk, Inflation, and Exchange Rates," in the Proceedings of the West Coast Academic/Federal Reserve Economic Research Seminar, Federal Reserve Bank of San Francisco (May 1979), pp. 142-161.

[14]See Aida Der Hovanessian, Risk and the Foreign Exchange Market, unpublished Ph.D. Dissertation (1981), Claremont Graduate School; John Makin, "Exchange Rate Behavior Under Full Monetary Equilibrium: An Empirical Analysis," National Bureau of Economic Research Working Paper No. 647 (March 1981); and Appendix A.

[15]See Rudiger Dornbusch, "Monetary Policy Under Exchange Rate Flexibility," in Managed Exchange Rate Flexibility: The Recent Experience, Federal Reserve Bank of Boston Conference Series No. 20 (1978), pp. 90-122, and Jeffrey Frankel, "On The Mark," op. cit.

[16]See also Jeffrey Frankel, "On the Mark: A Response to Various Comments," mimeo, Department of Economics, University of California at Berkeley, (April 1981); and "On the Mark: Reply," American Economic Review, Vol. 71, No. 3 (December 1981), pp. 1075-1082.

APPENDIX A

The Frankel Model

Critique and Further Evidence

The well known recent empirical study by Jeffrey Frankel[1] examined the behavior of the mark/dollar exchange rate during July 1974 to February 1978. In constructing his empirical model Frankel combined the two well-known variants of the monetary approach, i.e., the flexible-price and sticky-price versions, into a single equation and concluded that his model provides sufficient evidence of interest rate induced exchange rate overshooting.

In our recent research on the Frankel model, we found that the model is extremely sensitive to econometric techniques, time periods and data sources used. Any change in these factors substantially undercuts Frankel's original conclusions with respect to exchange rate overshooting.[2,3]

More specifically, to correct for first order serial correlation Frankel employs the Cochrane-Orcutt (CORC) iterative process as is normally done. But as Sargan[4] has demonstrated, this may not be the most efficient method of removing first order serial correlation among the residuals. The CORC iterative process consists essentially of the minimizing of a quadratic function at each step for a certain value of rho, the serial correlation coefficient. The desired value of rho is achieved where the standard error of the regression is a minimum. Since this quadratic function is a bounded decreasing function, the sequence of values of rho necessarily converges to a limit which may be one of the many local minima available. Hence, the desired value of rho may not be achieved, and the estimated coefficients would be inefficient and possibly inconsistent.

To avoid these problems, an alternative method, the Hildreth-Lu (HILU) grid search technique could be employed. The HILU technique specifies a grid of values for rho whereby an iteration is performed at each value of rho. The final value selected for rho is that where the standard error of the regression is a minimum. Application of the HILU technique to the Frankel model yielded significantly different results, which as shown in Table II are quite poor as seen in the reduced magnitude and significance of the estimated coefficients. For example, in equation (3) the relative money supply coefficient is insignificantly different than zero and the relative real income variable, though statistically significant is highly reduced in magnitude and quite different from the income elasticity estimates reported by domestic money demand studies. Furthermore, the insignificance of the interest differential coefficient suggests that there has been no incidence of interest rate induced exchange rate overshooting.

Note that the higher value of rho obtained by using the HILU technique is accompanied by a lower standard error of the regression and a higher Durbin-Watson statistic when compared to those obtained by employing the CORC method, thus indicating maximum elimination of first order residual autocorrelation. A value of rho greater than unity implies non-stationarity in the residuals but does not qualitatively affect the above conclusions.

The results of the Frankel model fared even worse when the sample period was extended to January 1974 - December 1979. As shown in Table II, equations (7, 8, 9) both the magnitude and statistical significance of all estimated coefficients are lower than those reported by Frankel, in particular the evidence on the interest differential coefficient is very weak and indicates no exchange rate overshooting whatsoever.

In addition, the Frankel model is highly susceptible to changes in data sources. In particular, when data from the IMF's International Financial Statistics tape was employed the results for both the original and the extended time periods differed significantly than those obtained by using data from the original sources. These results are reproduced in equations (4, 5, 6, 10, 11,12) in Table II. Note, for example that in the equations corrected for serial correlation, the inflation differential coefficients are insignificantly different than zero and carry the incorrect (negative) sign. The interest differential coefficients indicate Keynesian liquidity effects for the July 1974 - February 1978 period and inflationary effects for the January 1974 - December 1979 period. However, the results remain statistically insignificant in both cases. Evidence on the real income coefficient for both periods is quite similar to that obtained by using data from the original sources. But note that the estimated coefficients are not statistically significant and also are substantially lower than estimates reported in the domestic money demand studies. Estimates on the money supply coefficients that are derived by using the IFS data are substantially lower in magnitude and significance than those derived by employing data from the original sources, particularly in the July 1974 - February 1978 sample period. The reader would note once again the advantages of using the HILU technique to correct for serial correlation.

Furthermore, in an attempt to modify the Frankel model, risk variables were introduced into the empirical specification as additional explanatory variables. The results, as shown in Table II, equations (7, 8, 9) suggest two possible effects of the risk factor. One relates to exchange rate appreciation caused by an increase in inflation adjusted real returns. As Makin[5] has lately shown, a rise in inflation volatility causes risk-averse investors to seek a risk premium as compensation for uncertainty in the purchasing power of their financial assets over commodities. The resulting increase in real interest rates attracts foreign capital and causes the exchange rate to appreciate. This argument may find some support in the results of equations (7) and (8). Secondly, as is well known, inflation augmented risk which tends to lower real returns reduces the relative attractiveness of a country for investment purposes, thereby reducing the demand for its money and hence, generating an exchange rate depreciation. The results in equation (9) tend to be supportive of the latter argument.

In summary, we do not find Frankel's conclusion regarding interest rate induced overshooting in the DM/$ exchange rate to hold generally. Further evidence on this issue is provided in Appendix B. Our results also indicate that Frankel's model is highly sensitive to its empirical characteristics, which include data sources, sample periods and econometric techniques. Any change in these factors yields substantial changes in the depreciation and overshooting aspects of the exchange rate.

TABLE II

THE FRANKEL STICKY-PRICE MODEL

Results Of Changes In Econometric Techniques, Sample Period
And Data Sources, And The Effect Of Risk Variables

Est. Tech.	Const.	$\ln(e_{t-1})$	$\ln(m/m^*)$	$\ln(y/y^*)$	$(r-r^*)$	$(\pi-\pi^*)$	$(\sigma-\sigma^*)$	R^2	S.E.	D.W.	RHO
July 1974 to Feb. 1978											
1) OLS	-3.33*		0.87*	-0.72*	-0.34	27.13*		.79	.0285	.95	--
	(0.12)		(0.20)	(0.19)	(2.04)	(2.59)					
2) CORC	-3.80*		0.37	-0.33	-0.37	7.29		.90	.0184	1.38	.96
	(0.22)		(0.33)	(0.19)	(1.01)	(4.38)					
3) HILU	-3.37*		0.49	-0.41*	-0.45	4.42		.92	.0121	1.56	1.05
	(0.20)		(0.29)	(0.17)	(0.95)	(3.95)					
4) OLS	0.87*		0.028	-0.587*	-8.239*	20.891*		.55	.0459	0.61	--
	(0.02)		(0.025)	(0.248)	(2.840)	(3.264)					
5) CORC	0.57*		0.008	-0.447	-0.316	-7.257		.87	.0245	1.88	.98
	(0.16)		(0.009)	(0.227)	(1.572)	(6.811)					
6) HILU	1.067*		0.009	-0.522*	-0.408	-11.066		.88	.0236	2.11	1.05
	(0.081)		(0.009)	(0.212)	(1.456)	(6.187)					
Jan. 1974 to Dec. 1979											
7) OLS	-3.62*		0.064*	0.424	10.150*	9.74*		.70	.0581	.42	--
	(0.06)		(0.026)	(0.383)	(2.36)	(3.75)					
8) CORC	-4.09*		0.009	-0.295	0.638	0.372		.98	.0203	1.54	.98
	(0.11)		(0.007)	(0.160)	(0.683)	(3.130)					
9) HILU	-11.50		0.019	-0.281	0.629	0.061		.98	.0184	1.62	1.00
	(11.20)		(0.173)	(0.159)	(0.674)	(3.121)					

TABLE II
(continued)

THE FRANKEL STICKY-PRICE MODEL

Results Of Changes In Econometric Techniques, Sample Period And Data Sources, And The Effect Of Risk Variables

Est. Tech.	Const.	$\ln(e_{t-1})$	$\ln(m/m^*)$	$\ln(y/y^*)$	$(r-r^*)$	$(\pi-\pi^*)$	$(\sigma-\sigma^*)$	R^2	S.E.	D.W.	RHO
10) OLS	0.90* (0.03)		0.002 (0.045)	0.490 (0.363)	10.952 (3.027)	9.513* (4.331)		.63	.0844	.31	--
11) CORC	0.55* (0.14)		0.005 (0.012)	-0.194 (0.240)	1.072 (1.278)	-4.073 (5.665)		.95	.0311	2.39	.98
12) HILU	0.51* (0.17)		0.004 (0.012)	-0.173 (0.236)	1.172 (1.252)	-2.281 (5.478)		.95	.0300	2.10	1.00
13) HILU	-0.22 (0.21)	0.960* (0.049)	-0.103 (0.088)	-0.074 (0.145)	0.123 (0.308)		-11.038 (7.262)	.96	.022	1.94	.20
14) HILU	-0.20 (0.22)	0.967* (0.050)	-0.098 (0.091)	-0.073 (0.149)	0.017 (0.283)		-1.431 (2.752)	.96	.022	1.94	.22
15) HILU	-0.23 (0.23)	0.962* (0.052)	-0.118 (0.096)	-0.084 (0.153)	0.008 (0.267)		0.470 (0.627)	.97	.022	1.96	.28

NOTES:
- i) Parenthesized figures are standard errors.
- ii) An asterisk on each variable indicates a foreign country variable. An asterisk on each estimated coefficient indicates statistical significance at the 5% level.
- iii) The dependent variable in all equations is $\ln e_t = \ln(DM/\$)$ spot exchange rate.
- iv) S.E. is the standard error of the regression, D.W. the Durbin-Watson statistic and RHO the serial correlation coefficient.
- v) All equations were estimated with data from the Federal Reserve Bulletin, Economic Report of the President, World Financial Markets of Morgan Guarranty Trust and the Deutsche Bundesbank monthly reports, with the exception of equations (4, 5, 6, 10, 11 and 12) that were estimated with data from the IMF's International Financial Statistics
- vi) $(\sigma-\sigma^*)$ represents the risk differential. The following proxies for risk were used in equations (13, 14 and 15), respectively: a three-month moving variance of CPI inflation, the lagged three-month moving variance of CPI inflation, and Foster's measure of risk (see Aida Der Hovanessian, "Risk in the Foreign Exchange Market").

Footnotes

[1]Jeffrey Frankel, "On the Mark," American Economic Review, Vol. 69, No. 4 (September 1979), pp. 610-621.

[2]For a more detailed discussion of data, sample period and estimation technique problems in the Frankel model, See Waseem Khan, "Interest Rates and Exchange Rates; Techniques and Methodology: A Critique and Some Evidence," Claremont Working Paper (February 1981), and The Monetary Approach to Exchange Rates: Theory and Empirical Evidence (unpublished Ph.D. dissertation, Claremont Graduate School, 1981). Frankel also finds that his model does not hold up well when it is applied to later data. See Frankel, "On the Mark: Reply," American Economic Review, Vol. 71, No. 3 (December, 1981), pp. 1075-1082.

[3]See Aida Der Hovanessian, Risk in the Foreign Exchange Market, (unpublished Ph.D. dissertation, Claremont Graduate School, 1981).

[4]See J. D. Sargan, "Wages and Prices in the United Kingdom: A Study in Econometric Methodology," in P. E. Hart, et. al., Econometric Analysis for National Economic Planning (London: Butterworth, 1964), pp. 25-63.

[5]The inflation-induced increase in real interest rates and the resulting exchange rate appreciation is explained in detail in John H. Makin, "Exchange Rate Behavior Under Full Monetary Equilibrium: An Empirical Analysis," National Bureau of Economic Research Working Paper No. 647 (March 1981).

APPENDIX B

Interest Rates, Inflationary Expectations, And Exchange Rates

In order to investigate the effects of changes in the real and nominal components of short-term interest rates on changes in the exchange rate, five different proxies for inflationary expectations were constructed. These proxies included the following:

a) Inflationary expectations over the next three months were assumed to equal those experienced over the last three months,

b) The inflationary expectations over the next three months were assumed to equal those experienced over the last three months, plus the difference between that and the three month rate preceeding it,

c) Inflationary expectations assumed to prevail over the next three months were derived by using the method specified by Mullineaux,[1]

d) Inflationary expectations assumed to hold over the next three months were derived by using an ARIMA model as specified by Howard,[2]

e) The Livingston[3] six-month and twelve-month ahead inflation forecasts were used by adjusting (i) by Carlson's[4] method, and (ii) by taking the average of all survey respondents in each period.

These proxies for inflationary expectations were then used to derive the real components of short-term nominal interest rates and subsequently both were used in the Frankel-model. To increase the generality of the analysis the model was estimated for the DM/$ and the £/$ exchange rates over various periods (see notes to Table III). These results are reproduced in equations (1) through (8) and (10) through (17) in Table III. As is evident the results are poor. For example, none of the relative money supply coefficients are significantly close to their hypothesized (in the monetary approach) value of unity. The real income coefficients though maintain their correct signs (negative according to the monetary approach) are statistically significant only in a handful of cases. But almost all of them are very low in magnitude, significantly lower than the income elasticity estimates reported in the domestic money demand studies. Evidence on the real interest differential coefficients indicates a mixture of liquidity and inflationary effects where only the latter are statistically significant and that, too, in the £/$ case. The absence of significantly negative real interest differential coefficients indicate no evidence of overshooting for either of the exchange rates. The inflationary expectations proxies, though all maintain their correct (positive) signs, are statistically significant in only half the cases. Since the estimated coefficients are quite low in magnitude (at least compared to what Frankel had reported) we refrain from drawing significant conclusions.

None of the proxies for inflationary expectations employed in the Frankel-model yielded results as hypothesized by Frankel.[5] This analysis suggests the lack of a good measure of inflationary expectations. Since the proxies used above are those commonly employed in the domestic inflation predictions literature, our results are indicative of this problem in a more general context.

TABLE III

Proxies for Inflationary Expectations, Real Interest Rates and the Exchange Rate

(corrected for serial correlation)

	Const.	ln(m/m*)	ln(y/y*)	(r-r*)	(π-π*)	R^2	D.W.	S.E.	RHO
ln DM/$									
a_1	-4.91* (0.18)	-0.003 (0.172)	-0.272 (0.161)	0.871 (0.710)	1.943 (1.551)	.98	1.54	.021	1.00
b_2	-4.85* (0.18)	-0.026 (0.174)	-0.301* (0.150)	0.792 (0.680)	2.123 (1.430)	.98	1.54	.021	1.00
c_3	-4.98* (0.20)	-0.030 (0.178)	-0.371 (0.200)	0.980 (0.621)	2.450 (1.401)	.98	1.60	.020	1.00
d_4	-3.72* (0.61)	0.590 (0.410)	-0.692* (0.271)	-0.622 (0.420)	1.789* (0.812)	.91	1.65	.022	.95
e_5	-3.45* (0.82)	0.030 (0.540)	-0.223 (0.178)	1.213 (1.001)	4.013* (1.012)	.85	1.45	.051	-.31
f_6	-3.82 (0.73)	0.009 (0.290)	-0.298* (0.132)	1.411 (0.983)	4.230* (0.972)	.89	1.49	.047	-.16
g_7	-3.02* (0.61)	0.051 (0.211)	-0.392* (0.186)	1.351 (1.150)	4.123* (1.311)	.81	1.21	.056	-.16
h_8	-3.13* (0.60)	0.062 (0.216)	-0.387 (0.205)	1.721 (1.311)	4.119* (1.173)	.83	1.19	.051	-.28
i_9	-5.07* (0.18)	0.024 (0.172)	-0.270 (0.160)	0.710 (0.670)	0.261 (0.860)	.98	1.58	.081	1.00

TABLE III

Proxies for Inflationary Expectations, Real Interest Rates and the Exchange Rate

(corrected for serial correlation)

ln ¥/$	Const.	ln(m/m*)	ln(y/y*)	(r-r*)	(π-π*)	R^2	D.W.	S.E.	RHO
[a]10	-1.47 (1.95)	0.043 (0.175)	-0.187 (0.131)	2.571* (0.890)	3.541* (1.570)	.97	1.24	.021	1.00
[b]11	-2.19 (2.58)	0.041 (0.176)	-0.201 (0.130)	2.481* (0.880)	2.370* (1.151)	.97	1.22	.021	1.00
[c]12	-1.72 (1.60)	0.072 (0.136)	-0.201 (0.142)	2.713* (0.810)	3.732* (1.230)	.98	1.35	.021	1.00
[d]13	0.62 (0.42)	0.870 (0.910)	-0.651 (0.680)	0.135 (0.242)	0.771 (1.001)	.90	1.34	.022	1.00
[e]14	-0.75* (0.29)	0.052 (0.220)	-0.450 (0.231)	-0.981 (0.999)	1.820 (1.320)	.82	1.45	.065	.91
[f]15	-0.83* (0.20)	0.057 (0.131)	-0.430 (0.242)	-0.920 (1.310)	1.320 (1.022)	.87	1.65	.061	.97
[g]16	-0.85* (0.30)	0.411 (0.523)	-0.398* (0.148)	-0.320 (0.981)	1.977 (1.563)	.77	1.40	.073	.88
[h]17	-0.87* (0.30)	0.445 (0.511)	-0.372 (0.178)	-0.362 (0.822)	1.451 (0.890)	.73	1.37	.065	.86
[i]18	-3.16 (4.30)	0.064 (0.174)	-0.161 (0.130)	2.573* (0.871)	2.391* (0.870)	.97	1.25	.021	1.00

NOTES TO TABLE III

Parenthesized figures are standard errors. An asterisk on each variable indicates a foreign country variable; an asterisk on each figure indicates statistical significance at the 5% level. All equations are corrected for serial correlation using the Hildreth-Lu grid search technique. RHO is the coefficient of serial correlation; S.E. is the standard error of the regression and D.W. is the Durbin-Watson statistic. Due to data limitations equations (1, 2, 3, 9, 10, 11, 12 and 18) are estimated over January 1974-December 1979, while equations (4 and 13) are estimated over 1971:I - 1977:III, and equations (5, 6, 7, 8, 14, 15, 16 and 17) are estimated over 1972 - 1978. Inflation proxies used are:

a. The previous three month inflation rate is expected to prevail over the next three months;
b. The previous three month inflation rate plus the difference between that and the three month rate preceeding it is expected to prevail over the next three months;
c. The inflation rate was calculated by using the technique specified by Mullineaux;
d. The inflation rate was calculated by using an ARIMA model as demonstrated by Howard;
e. The Carlson-adjusted Livingston six month ahead inflation forecast;
f. The Carlson-adjusted Livingston twelve month ahead inflation forecast;
g. The average of the Livingston six month ahead inflation forecast;
h. The average of the Livingston twelve month ahead inflation forecast;
i. A three month moving average of the actual ex post CPI rate of inflation.

Data Sources: Federal Reserve Bulletin, Economics Report of the President; Deutsche Bundesbank monthly reports and Statistical Supplement; Economic Trends, H.M.S. Central Statistical Office.

FOOTNOTES

[1]See Donald Mullineaux, "Inflation Expectations and Money Growth in the United States," American Economic Review, vol. 70, no. 1 (March 1980), pp. 149-161.

[2]A detailed specification of the ARIMA model is given in David Howard, "The Real Rate of Interest on International Financial Markets," International Finance Discussion Paper No. 136 (April 1979).

[3]The Livingston six-month and twelve-month ahead forecast data was graciously provided by David Resler of the Federal Reserve Bank of St. Louis.

[4]This method is specified in John Carlson, "A Study of Price Forecasts," Annals of Economic and Social Measurement, Vol. 6 (Winter 1977), pp. 27-56.

[5]Jeffrey Frankel, "On the Mark," American Economic Review, Vol. 69, no. 4 (September 1979), pp. 610-621. In a following paper, "On the Mark: A Reply," American Economic Review, Vol. 71, No. 3 (December, 1981), pp. 1075-1082, Frankel uses a monthly moving average of CPI inflation over the past twelve months to proxy the expected rate of inflation. Although Frankel reports a significant result for this inflationary expectations proxy, our further work using this type of proxy did not find robust results.