Preliminary
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Exchange Rates and "News": A Multi-Currency Approach

By

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Abstract

In this paper a multi-currency model is used to investigate the relationship between spot exchange rates, forward rates, market efficiency and new information. It is shown that in a world with more than two countries the error term in the standard market efficiency tests will be correlated across rates. It is also shown that the exchange rate can be expressed as a function of factors known in advance, which are captured by the forward rate determined in the previous period, and "news". The empirical results presented in the paper tend to support the model's implications.

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One of the main characteristics of the recent experience with floating exchange rates has been the poor performance of forward rates as predictors of future spot rates. A large number of studies have empirically analyzed this problem, casting doubts on the efficiency of foreign exchange markets. Most of these studies have been based on single-currency tests and have regressed, using ordinary least squares, the spot exchange rate on the one-period lagged forward rate. According to the efficiency hypothesis, if the exchange rate market uses all available information, in these regressions the constant should not differ from zero, the coefficient of the lagged forward rate should not be significantly different from one, and the error term should be white noise. The results obtained, however, have not produced conclusive evidence in favor of exchange rate market efficiency. On the contrary, in a number of cases efficiency has been rejected.[1/]

It has recently been suggested that exchange rate movements basically respond to new information that is made available to economic agents in every period. In particular, it has been postulated that the market forecasting error -- or difference between the spot rate and the forward rate determined in the previous period -- can be explained by the fact that the spot rate has captured "news" that was not available when the forward rate was determined. This proposition has recently been empirically investigated by a number of studies, with different degrees of success.[2/]

In this paper a multi-currency approach is used to investigate the relationship between spot rates, forward rates, market efficiency and new information. It is shown that in a world with more than two countries, the error terms in the standard market efficiency tests will be correlated across rates. This means that the error covariance matrix across rates contains important information that can be exploited in the empirical tests of market efficiency.

The model developed in this paper also shows that the exchange rate can be expressed as a function of factors known in advance -- which are captured by the forward rate determined in the previous period -- and "news" regarding changes in domestic and foreign quantities of money, real incomes and real interest rates. These implications of the model are empirically analyzed for the case of the Pound/dollar, French Franc/dollar, DM/dollar and Lira/dollar rates, using a simultaneous equations procedure that incorporates the information contained in the covariance structure across rates. The plan of the paper is as follows: in Section 2 a three-country model of exchange rate determination is derived. In Section 3 empirical results regarding market efficiency and new information, using the multi-currency approach, are presented. Finally, Section 4 contains some concluding remarks.

I. Exchange Rates and New Information in a Multi-Currency Setting

In this section a simple model of exchange rate determination in a three-country world is presented. The model assumes that the economic structure is similar in the three countries, and investigates the process of determination of the two independent exchange rates in this world. The model is presented in equations (1) through (10), where countries have been indexed from A to C. The analysis will focus on the determination of the exchange rates between currencies B and A and currencies C and A.

$$i_t^j - i_t^A = f_t^{jA} - s_t^{jA} \quad , \quad j = B,C \tag{1}$$

$$E_t(s_{t+1}^{jA}) = f_t^{jA} \quad , \quad j = B,C \tag{2}$$

$$d_t^{jA} = s_t^{jA} - p_t^j + p_t^A \quad , \quad j = B,C \tag{3}$$

$$d_t^{jA} = \gamma^j d_{t-1}^{jA} + x_t^{jA} \quad , \quad j = B,C \tag{4}$$

$$i_t^k = r_t^k + E_t(p_{t+1}^k - p_t^k), \quad k = A,B,C \tag{5}$$

$$r_t^k = \rho^k + w_t^k \quad , \quad k = A,B,C \tag{6}$$

$$m_t^{dk} - p_t^k = a^k y_t^k - b^k i_t^k \quad , \quad k = A,B,C \tag{7}$$

$$m_t^k = m_{t-1}^k + \lambda^k + v_t^k + n_t^k - n_{t-1}^k, \quad k = A,B,C \tag{8}$$

$$y_t^k = y_o^k + g^k t + u_t^k \quad , \quad k = A,B,C \tag{9}$$

$$s_t^{BC} = s_t^{BA} - s_t^{CA} \tag{10}$$

where s_t^{jA} is the natural logarithm of the spot rate between currency j (=B,C) and currency A, and f_t^{jA} is the log of the forward rate between j and A. d_t^{jA} is defined, in equation (3), as deviations from purchasing-power-parity (PPP) between currencies j and A. i_t^k is the nominal interest rate on one-period bonds denominated in country k's (k=A,B,C) currency; p_t^k is the log of country k's (k=A,B,C) price level; r_t^k is the real interest rate in country k, and is assumed to be equal to a constant term (ρ^k) plus a random element (w_t^k); m_t is the log of the nominal quantity of money in country k; and y_t^k is the log of real output in country k. On the other hand, w_t^k, v_t^k, n_t^k and u_t^k are independent, serially uncorrelated random shocks with zero mean and constant variances.

Equation (1) is the interest arbitrage condition, and indicates that asset holders will be indifferent between holding bonds denominated in domestic or foreign currency as long as the interest rate differential is equal to the forward discount.[3/] Equation (2) introduces the simplifying assumption of risk-neutral agents, which is made for convenience. If, alternatively, risk-averse agents are assumed, equation (2) could be modified by adding a risk premium term to f_t.[4/] Equation (3) defines deviations from PPP. Equation (4) introduces the simplifying assumption that short-run deviations from PPP follow an autoregressive process of order one ($\gamma<1$). There is some empirical support provided by the work of Frenkel (1981a, 1981b) for this characterization of d_t during the recent floating period.[5/] The error term x_t^{jA} in equation (4) is related to the random shocks w_t^j and w_t^A in equation (6). The reason for this is that since interest arbitrage is assumed to hold continuously (equation [1]), all shocks cannot be independent in this model. In particular, it is easy to show that x_t^{jA} will be a linear function of temporary real interest rates differentials ($w_t^A - w_t^j$).[6/] Equation (5) is the traditional Fisher equation for the domestic and foreign interest rates respectively, where $E_t(z)$ is the expected value of z conditional on all information available up to period t.[7/] Equation (6), on the other hand, indicates that in each country the real interest rate is equal to a constant element (ρ^k)

plus a serially uncorrelated random term (w_t^k). Equation (7) depicts the demand for money equations in each country; while equation (8) represents the money supply processes. According to this equation, in every moment in time the rate of growth of money will diverge from its long-run rate of growth (λ^k) both by a permanent shock (v_t^k) and a temporary shock (n_t^k). Equation (9) depicts the process of real income. In order to simplify the exposition, it has been assumed that in each country real income evolves according to a random walk with trend, where the random element (u_t^k) is independently distributed from all other shocks in the model.[8/] Finally, equation (10) is the triangular arbitrage condition, and points out that only two of the three exchange rates in this world are independent.

The solution of this model can be used to find expressions for the spot exchange rates s_t^{BA} and s_t^{CA} as functions of the forward rates determined in the previous period (f_{t-1}^{BA} and f_{t-1}^{CA}) and the relevant random shocks. Assuming that the information set in period t includes the model and the past and current values of all relevant variables, and using the undetermined coefficients technique to solve difference equations, the following expressions that relate the forward rates to the future spot rates are obtained (see the Appendix for further details):[9/]

$$s_{t+1}^{BA} = f_t^{BA} + [v_{t+1}^B + (\frac{1}{1+b^B})\, n_{t+1}^B - (\frac{b^B(1-\gamma^B)-(1-b^B)}{(1+b^B)(1-\gamma^B)})w_{t+1}^B$$

$$- (\frac{a^B}{1+b^B})\, u_{t+1}^B - v_{t+1}^A - (\frac{1}{1+b^A})\, n_{t+1}^A$$

$$+ (\frac{b^A(1-\gamma^B)-(1-b^A)}{(1+b^A)(1-\gamma^B)})w_{t+1}^A + (\frac{a^A}{1+b^A})\, u_{t+1}^A] \tag{11}$$

and

$$s_{t+1}^{CA} = f_t^{CA} + [v_{t+1}^C + (\frac{1}{1+b^C})\, n_{t+1}^C - (\frac{b^C(1-\gamma^C)-(1-b^C)}{(1+b^C)(1-\gamma^C)})\, w_{t+1}^C$$

$$- (\frac{a^C}{1+b^C})\, u_{t+1}^C - v_{t+1}^A - (\frac{1}{1+b^A})\, n_{t+1}^A$$

$$+ (\frac{b^A(1-\gamma^C)-(1-b^A)}{(1+b^A)(1-\gamma^C)})\, w_{t+1}^A + (\frac{a^A}{1+b^A})\, u_{t+1}^A] \qquad (12)$$

According to equations (11) and (12), the future spot rates will differ from the forward rates determined in the current period by the terms in square brackets. These expressions in brackets summarize the effect of "news" about unanticipated (as of t) changes in money, real income and real interest rates on the spot exchange rates. In particular, equations (11) and (12) indicate that "news" can help explain the market forecasting error, or divergence between s_{t+1}^{jA} and f_t^{jA}. According to (11) and (12), "news" about a permanent increase in the domestic quantity of money (v_{t+1}^j) will have a positive effect (over and above the market forecast) on the spot rate in period t+1. News about a temporary increase of the quantity of money at home (n_{t+1}^j) will also have a positive effect on the exchange rate over and above the rate forecast in the previous period. However, this effect will be less than proportional, since agents know, under the assumption of full current information, the temporary nature of this shock. Equations (11) and (12) indicate that "news" about unexpected changes in the real interest rate can have either a positive or negative effect on the forecasting error. Finally, according to equations (11) and (12) "news" about unexpected increases in real income will have negative effects on the forecasting error. The opposite effects are true with respect to "news" regarding the behavior of foreign money, real income and real interest rate.

It is interesting to note that equations (11) and (12) suggest that the exchange rate forecasting error is affected by a more general set of "news" than what has been considered in previous work (i.e., Dornbusch, 1980, Frenkel, 1981a). An important feature of equations (11) and (12) is that the terms in square brackets provide an explicit representation of the error term in the traditional exchange-rate market efficiency equations. Usually the efficiency hypothesis has been tested by fitting the following expression (see Frenkel, 1981a, Frenkel and Razin, 1980, and Levich, 1979):

$$s_{t+1}^{jk} = \alpha_o^j + \alpha_1^j \; f_t^{jk} + \varepsilon_{t+1}^{jk} \tag{13}$$

where under the efficiency hypothesis $\alpha_o^j = 0$, $\alpha_1^j = 1$ and ε_{t+1} is a white noise process. According to equations (11) and (12), ε_{t+1} will be a linear function of a set of terms that reflect "news" about relevant domestic and foreign variables (v_{t+1}^j, u_{t+1}^j, n_{t+1}^j, w_{t+1}^j, v_{t+1}^A, u_{t+1}^A, n_{t+1}^A and w_{t+1}^A). Furthermore, equations (11) and (12) point out that these error terms (ε_{t+1}^{jk}) will be correlated across rates, since they have the following term in common:

$$\left\{v_{t+1}^A + \left(\frac{1}{1+b^B}\right) n_{t+1}^A + \left(\frac{a^A}{1+b^A}\right) u_{t+1}^A\right\} \tag{14}$$

This means that the covariance matrix across currencies includes valuable information that can be exploited in the econometric testing of market efficiency hypotheses. In particular, the information included in this covariance matrix can be used by estimating (13) <u>simultaneously</u> for a number of currencies using Zellner's (1962) seemingly unrelated regressions procedure. In our three-country world, this covariance matrix will be equal to $\Sigma \otimes I$, where

$$\Sigma = \begin{bmatrix} \sigma_{BB} & \sigma_{BC} \\ \sigma_{CB} & \sigma_{CC} \end{bmatrix} \tag{15}$$

and [10]

$$\sigma_{jj} = [\sigma^2_{jv} + (\frac{1}{1+b^j})^2 \sigma^2_{jn} + [\frac{b^j(1-\gamma^j)-(1-b^j)}{(1+b^j)(1-\gamma^j)}]^2 \sigma^2_{jw}$$

$$+ (\frac{a^j}{1+b^j})^2 \sigma^2_{ju} + \sigma^2_{Av} + (\frac{1}{1+b^A})^2 \sigma^2_{An}$$

$$+ [\frac{b^A(1-\gamma^j)-(1-b^A)}{(1+b^A)(1-\gamma^j)}]^2 \sigma^2_{Aw} + (\frac{a^A}{1+b^A})^2 \sigma^2_{Au}] \text{ for } j = B,C \qquad (16)$$

and

$$\sigma_{\substack{ij \\ i \neq j}} = [\sigma^2_{Av} + (\frac{1}{1+b^A})^2 \sigma^2_{An} + (\frac{a^A}{1+b^A})^2 \sigma^2_{Au}] \text{ for } i,j = B,C \qquad (17)$$

where σ^2_{kv}, for example, refers to the variance of the random shock v in country k.

Summarizing, the multi-currency model derived in this section yields two important conclusions: First, the exchange rate market forecasting error $(s^j_{t+1} - f^j_t)$ can be expressed as a function of unanticipated (as of t+1) changes in domestic and foreign quantities of money, real income and real interest rate. Second, in a multi-currency setting the error terms from the standard exchange-rate market efficiency tests will be correlated across currencies. This implies that the error-covariance matrix across currencies contains valuable information that can be exploited in tests of exchange rates market efficiency. These implications of the model can be extended to the case of an n-currency world. In this case, there will be n-1 independent exchange rates, and the covariance matrix (15) will have an (n-1) x (n-1) dimension.

II. Empirical Results

In this section, the implications of the model derived in Section I are empirically tested using monthly data for the Pound/Dollar, DM/Dollar, French Franc/Dollar and Italian Lira/Dollar rates for the period July 1973-September 1979. Even though all the tests are performed expressing the exchange rates in terms of the U.S. dollar, the results will be similar if a different currency is used as the reference currency. The reason for this is that in this case (where five countries are considered), due to the triangular arbitrage condition there will only be four independent exchange rates. Once these rates are known, all other exchange rates can be derived using equations of the type of (10). As suggested in the preceding section, the estimation was performed using Zellner's seemingly unrelated regressions procedure (SURE).

The following versions of the exchange-rate market efficiency equations were estimated using SURE:

$$s_{t+1}^{j\ US} = \alpha_o^j + \alpha_1^j\ f_t^{j\ US} + \varepsilon_{t+1}^j \tag{13}$$

$$s_{t+1}^{j\ US} = \beta_o^j + \beta_1^j\ f_t^{j\ US} + [\gamma_o(v_{t+1}^j - v_{t+1}^{US}) + \gamma_1(u_{t+1}^j - u_{t+1}^{US}) + \gamma_2(w_{t+1}^j - w_{t+1}^{US})] + w_{t+1}^j \tag{18}$$

where j refers to the Pound, DM, French Franc and Lira. Equation (13) is the standard exchange rate market efficiency equation, and has been estimated by Frenkel (1980, 1981a), Frankel (1980) and Frenkel and Clements (1980), among others. Equation (18), on the other hand, is a modified version of equations (11) and (12) derived in Section 2 from the multi-currencies exchange rates model, and explicitly points out the role of unanticipated changes in money, real income and real interest rate differentials in the process of exchange rate determination. The main differences between (18) and (11) are: (a) in (18) only one type of monetary shock is considered (a permanent shock), and (b) in (18) the structural coefficients for the domestic country and the U.S. have been restricted to be equal. Due to this simplification, the term $(v^j_{t+1} - v^{US}_{t+1})$, for example, should be interpreted as the unanticipated (as of t) increase in money differentials between country j and the U.S. In the empirical analysis, unanticipated changes in money, real income and real interest rates were constructed as innovations from three-month autoregressions of these variables. In ease case the residuals were checked in order to make sure that they were white noise.

In Table 1 the results obtained from the estimation of equation (13) using both OLS and SURE are presented. As may be seen, when the multi-currency procedure (SURE) is used, the precision of the estimates improves significantly.[9/] In particular, while when OLS are used the market efficiency hypothesis is rejected for the Franc/Dollar and the Lira/Dollar rates, when SURE is used it is only marginally rejected for the Lira/Dollar rate.

Table 2, on the other hand, contains multi-currency (SURE) estimates of equation (18). In this case, the hypothesis $\beta_o=0$ and $\beta_1=1.0$ cannot be rejected at the conventional levels for the Pound/Dollar, French Franc/Dollar and DM/Dollar rates, and is only marginally rejected for the Lira/Dollar. With respect to the role of "news", the coefficients for unanticipated money growth differentials are significantly positive, as expected, for the Franc/Dollar and DM/Dollar rates. These results suggest that, for these currencies, a 10% unanticipated increase in the money differential will generate a <u>depreciation</u> of the domestic currency of approximately 3.5% over and above what was expected in the previous period.

Table 1

EXCHANGE-RATES MARKET EFFICIENCY:
SINGLE CURRENCY AND MULTI-CURRENCY TESTS
(Monthly Data - June 1973/September 1979)

$$s_{t+F} \alpha_o + \alpha_1 f_t + \varepsilon_{t+1}$$

Rate	α_o	α_1	R^2	F	D.W.
a. - Single Currency Tests (OLS)					
Pound/Dollar	-.030 (.017)	.961 (.024)	.955	3.52	1.701
French Franc/ Dollar	-.457 (.170)	.853 (.055)	.758	7.67	2.093
DM/Dollar	.026 (.027)	.965 (.032)	.923	.78	1.938
Lira/Dollar	.301 (1.37)	.954 (.021)	.965	4.56	1.960
b. - Multi-Currency Tests (SURE)					
Pound/Dollar	-.029 (.014)	.964 (.020)	--	--	--
French Franc/ Dollar	-.155 (.104)	.951 (.034)	--	--	--
DM/Dollar	.029 (.018)	.961 (.021)	--	--	--
Lira/Dollar	.272 (.114)	.958 (.017)	--	--	--

Notes: Standard errors in parentheses.

F refers to the joint test for a=0 and b=1.0.

D.W. is the Durbin-Watson statistic.

Table 2

Exchange Rates and "News": Multi-Currency Tests
(Monthly Data - June 1973/September 1979)

$$s_{t+1} = \beta_o + \beta_1 f_t + [\gamma_o(v_{t+1} - v^{US}_{t+1}) + \gamma_1(u_{t+1} - u^{US}_{t+1}) + \gamma_2(w_{t+1} - w^{US}_{t+1})] + w_{t+1}$$

Rate	β_o	β_1	γ_o	γ_1	γ_2	D.W.
Pound/Dollar	-.024 (.014)	.970 (.020)	.103 (.154)	.006 (.002)	.007 (.018)	1.849
Franc/Dollar	-.155 (.113)	.951 (.037)	.359 (.142)	.182 (.123)	-.005 (.015)	1.889
DM/Dollar	.032 (.018)	.957 (.021)	.372 (.182)	.243 (.174)	.011 (.023)	2.092
Lira/Dollar	.248 (.119)	.962 (.018)	.084 (.190)	-.046 (.102)	-.022 (.010)	2.004

Notes: Standard errors in parentheses.

D.W. refers to the Durbin-Watson statistic from the first stage of the estimation.

Table 3

Exchange Rates and "News": Multi-Currency Restricted Estimates

$$s_{t+1} - f_t = [\gamma_o(v_{t+1} - v_{t+1}^{US}) + \gamma_1(u_{t+1} - u_{t+1}^{US}) + \gamma_2(w_{t+1} - w_{t+1}^{US})] + w_{t+1}$$

Rate	γ_o	γ_1	γ_2	D.W.
Pound/Dollar	.090 (.155)	.006 (.002)	.007 (.018)	1.849
Franc/Dollar	.371 (.132)	.133 (.112)	-.010 (.014)	2.248
DM/Dollar	.379 (.174)	.202 (.203)	.007 (.022)	1.907
Lira/Dollar	.047 (.182)	-.032 (.097)	-.021 (.009)	1.984

Notes: See Table 2.

Table 4

Exchange Rates and "News": The Role of Lagged Innovations

(Monthly Data - June 1973 - September 1979)

$$s_{t+1} = \beta_o + \beta_1 f_t + [\gamma_o (v_{t+1} - v_{t+1}^{US}) + \delta_o (v_t - v_t^{US}) + \gamma_1 (u_{t+1} - u_{t+1}^{US}) + \delta_1 (u_t - \mu_t^{US})$$

$$+ \gamma_2 (w_{t+1} - w_{t+1}^{US}) + \delta_2 (w_t - w_t^{US})] + \phi_{t+1}$$

Rate	β_o	β_1	γ_o	δ_o	γ_1	δ_1	γ_2	δ_2	D.W.
Pound/ Dollar	-.025 (.014)	.967 (.018)	.151 (.147)	.560 (.148)	.007 (.003)	.009 (.006)	.008 (.017)	.011 (.016)	1.924
Franc/ Dollar	-.128 (.118)	.960 (.038)	.356 (.146)	.241 (.149)	.113 (.139)	.003 (.130)	-.007 (.015)	-.019 (.075)	2.202
DM/ Dollar	.025 (.019)	.966 (.022)	.394 (.183)	.137 (.187)	.291 (.184)	-.350 (.185)	-.003 (.024)	-.013 (.024)	1.942
Lira/ Dollar	.259 (.118)	.960 (.018)	.071 (.193)	.431 (.202)	-.115 (.109)	.033 (.102)	-.022 (.010)	-.006 (.010)	2.000

<u>Notes</u>: See Table 2.

The coefficient for unanticipated changes in real income is only significant (and positive) for the case of the Pound/Dollar rate. The coefficient of unanticipated changes in real interest rates, on the other hand, is only significant for the Italian Lira/Dollar rate.

In order to focus the attention on the role of "news", equation (18) was also estimated under the restrictions $\beta_o=0$ and $\beta_1=1$. Table 3 contains the results obtained in this case. As might have been expected, the results are very similar to those reported in Table 2. The main finding is that for the Franc/Dollar and DM/Dollar, unanticipated changes in money differentials have a significantly positive effect on exchange rate market forecasting errors. Additionally, as before, the coefficient of $(w_{t+1}-w_{t+1}^{US})$ is significantly negative for the Lira/Dollar case.

A possible explanation why unanticipated changes of some of the exchange rate determinants do not appear to be significant in Tables 2 and 3 is that, in some countries, it may take people more than one month to find out the "news". The reason for this could be that there is a long lag before "announcements" about actual changes in these variables are made. If this is the case, lagged innovations of money, real income and real income could have an effect on the exchange rate forecasting error. However, it is important to note that according to the market efficiency hypothesis, once "news" has been incorporated into the exchange rates, past innovations should have no effect. The reason for this is, of course, that once incorporated into the exchange rate, past innovations are not "news" any more. In order to investigate the possible lag in "announcements", equation (18) was also estimated using contemporaneous and one-month lagged innovations of money, real income and real interest rate differentials. The SURE results obtained in this case are presented in Table 4. As expected, for the cases where the contemporaneous innovation was significant, lagged innovations are insignificantly different from zero. However, in the cases of the Pound/Dollar and Italian Lira/Dollar rates, lagged innovations of money differentials are significantly positive, indicating that in this case there might indeed be a fairly long "announcements" lag. Additionally, for the case of the DM/Dollar lagged innovations of real income are significantly negative, as expected.

III. Conclusions and Summary

This paper has made two points related to the empirical analysis of floating exchange rates. First, using a simple multi-currency model of exchange rate determination, it has been shown that the error terms in the standard exchange rates market efficiency equation are correlated across rates. This means that the error covariance matrix across rates includes information that can be exploited in the empirical analysis of exchange rate market efficiency. Secondly, the model indicates that the exchange rate can be expressed as a function of factors known in advance -- captured by the lagged forward rate -- and new information or "news". In particular, the model suggests that "news" about changes in domestic and foreign monies, real incomes and real interest rates have an effect on the exchange rate forecasting error.

These two propositions were tested using monthly data for the Pound/Dollar, French Franc/Dollar, DM/Dollar and Lira/Dollar rates for period July 1973 - September 1979. The analysis was performed using Zellner's seemingly unrelated regressions procedure. The results obtained show that when this multi-currency method is used the precision of the estimation in the standard exchange rate efficiency tests is greatly improved. Additionally, the empirical analysis provides some support to the asset-view of exchange rate determination that postulates that exchange rate movements basically respond to new information.

FOOTNOTES

1/ On the recent behavior of exchange rates see, for example, Artus and Young (1979), Dornbusch (1980), Frenkel (1981a), Frenkel and Mussa (1980), Isard (1981), Mussa (1979). On exchange rate market efficiency see Bilson (1981), Edwards (1981), Frenkel (1980), (1981a), Frenkel and Razin (1980), Hansen and Hodrick (1980, 1981), Kolhagen (1978) and Levich (1979).

2/ See, for example, Dornbusch (1978, 1980), Edwards (1981), Frenkel (1981) and Isard (1981).

3/ This assumes that there is perfect capital mobility, and that domestic and foreign bonds are perfect substitutes. We are abstracting, however, from the issue of political risk as discussed by Aliber (1973) and Dooley and Isard (1980).

4/ From an empirical point of view, this assumption means that efficiency tests based on this model will jointly test efficiency and the assumption of no-risk premium.

5/ Darby (1980), however, has found that deviations from PPP can be characterized by a random walk with a moving-average process added.

6/ In this paper it is assumed that real interest rates can temporarily differ across countries only due to unexpected shocks (w_t^j and w_t^A). The expected real interest rates, however, are assumed to be equated across countries (i.e., $E_{t-1}(r_t^j) = E_{t-1}(r_t^k)$). See Edwards (1981) for a detailed discussion. Darby (1980) also analyzes the porposition that deviations from PPP are related to temporary real interest rates differentials. See Frankel (1979) and Isard (1981) for models of exchange rate determination that are also based on real interest rates differentials.

7/ These expressions do not consider the effects of income taxes on nominal interest rates. For a discussion of this issue, see Darby (1975).

8/ While this assumption greatly simplifies the exposition, it does not alter the results. See Edwards (1981).

9/ If it is assumed that there is incomplete current information, the solution of the model becomes more difficult. The reason is that -- as pointed out by Barro (1980) -- when incomplete information and an economy-wide capital market are assumed, these kinds of models do not have a closed form solution.

10/ Note that in deriving (17) we have made use of the assumption of independence of the different random shocks. If this assumption is relaxed, some covariance terms across shocks would be included in (17). The main conclusions, however, will not be affected.

11/ For data sources, see the Appendix. As expected, when the forward rate lagged by more than one period was added to these regressions, its coefficient was never significant. See Edwards (1981).

Appendix

1. Derivation of p_t^j, i_t^j, s_t^{jA} and f_t^{jA}

Assuming money market equilibrium in every country [i.e., equation (7) equals equation (8)], and assuming that the expected real rates of interest are equalized across acountries (i.e., $E_{t-1}(r_t^j) = E_{t-1}(r_t^k)$), it may be shown that the expressions for the equilibrium price level, interest rate and spot exchange rate will be of the following form (see Edwards (1981) for further details):

$$p_t^j = \pi_o + \pi_1 t + \pi_2 m_t^j + \pi_3 u_t^j + \pi_4 w_t^j + \pi_5 n_t^j \tag{A.1}$$

$$i_t^j = \gamma_o + \gamma_1 u_t^j + \gamma_2 w_t^j + \gamma_3 n_t^j \tag{A.2}$$

$$s_t^{jA} = \beta_o + \beta_1(m_t^j - m_t^A) + \beta_2 u_t^j + \beta_3 w_t^j + \beta_4 n_t^j + \beta_5 u_t^A + \beta_6 w_t^A + \beta_7 n_t^A \tag{A.3}$$

Rationality requires that:

$$\pi_o = [b^j(\rho^j - a^j g^j) - a^j y_o^j + b^j \lambda^j]; \qquad \pi_1 = -a^j g^j$$

$$\pi_2 = 1 \qquad ; \qquad \pi_3 = -a^j/(1+b^j)$$

$$\pi_4 = b^j/(1+b^j) \qquad ; \qquad \pi_5 = -b^j/(1+b^j)$$

and that:

$$\gamma_o = (\rho^j - a^j g^j + \lambda^j) \qquad ; \qquad \gamma_1 = a^j/(1+b^j)$$

$$\gamma_2 = 1/(1+b^j) \qquad ; \qquad \gamma_3 = -1/(1+b^j)$$

and that:

$$\beta_o = [b^j(\rho^j - a^j g^j) - a^j y_o^j + b^j \lambda^j - b^A(\rho^A - a^A g^A + \lambda^A) + a^A y_o^A]; \quad \beta_1 = 1$$

$$\beta_2 = -a^j/(1+b^j) \quad ; \quad \beta_3 = [b^j(1-\gamma^j)-(1-b^j)]/[(1+b^j)(1-\gamma^j)]$$

$$\beta_4 = -b^j/(1+b^j) \quad ; \quad \beta_5 = a^A/(1+b^A)$$

$$\beta_6 = [b^A(1-\gamma^j)-(1-b^A)]/[1+b^A)(1-\gamma^A)]; \quad \beta_7 = b^A/(1+b^A)$$

The expression for f_t^{jA} is computed by updating (A.3) for period t+1, and taking conditional expectations. Recalling from (8) that $E_t(m_{t+1}^j) = m_t^j + \lambda^j - n_t^j = m_{t+1}^j - v_{t+1}^j - n_{t+1}^j$, it is found that:

$$f_t^{jA} = \beta_o + m_{t+1}^j - v_{t+1}^j - n_{t+1}^j - m_{t+1}^A + v_{t+1}^A + n_{t+1}^A \tag{A.4}$$

Equations (11) and (12) from the text are then obtained by writing s^{jA} in (A.3) for period t+1, and subtracting (A.4).

2. Data Sources

1. Exchange Rates: All exchange rates (spot and forward) are bid prices obtained from the Weekly Review of the Harris Bank. All rates refer to the closest Friday to the end of the month. The forward rates are one month maturity.

2. Prices: For all countries the Consumer Price Index, as reported in line 64 of the International Financial Statistics, was used.

3. Money: Seasonally adjusted M1, as reported in line 34b of the IFS, was used for all countries.

4. Real Income: A seasonally adjusted index of Industrial Production, as reported in line 66c of the IFS, was used for all countries.

5. Interest Rates: Nominal interest rates are one month maturity Eurocurrency rates, as reported by the Weekly Review of the Harris Bank. Real interest rates are constructed as ex-post rates.

REFERENCES

Aliber, Robert Z., "The Interest Parity Theorem: A Reinterpretation," Journal of Political Economy, 81 (1973), 1451-59.

Artus, Jacques and Young, John, "Fixed and Flexible Exchange Rates: A Renewal of the Debate," National Bureau of Economic Research, Working Paper Series, No. 367, 1979.

Barro, Robert J., "A Capital Market in an Equilibrium Business Cycle Model," Econometrica, 48 (September 1980), 1393-1418.

Bilson, John F.O., "The 'Speculative Efficiency' Hypothesis," The Journal of Business (1981), 435-451.

Darby, Michael R., "The Financial and Tax Effects of Monetary Policy on Interest Rates," Economic Inquiry, 13 (1975), 266-76.

_____, "Does Purchasing Power Parity Work?," NBER Working Paper Series, No. 607 (December 1980).

Dooley, Michael P. and Isard, Peter, "Capital Controls, Political Risk, and Deviations from Interest-Rate Parity," Journal of Political Economy, 88 (1980), 370-384.

Dornbusch, Rudiger, "Exchange Rate Economics: Where Do We Stand?," Brookings Papers on Economic Activity, 10 (1980), 143-185.

Edwards, Sebastian, "Aspects of the Economics of Exchange Rates," unpublished Ph.D. Dissertation, The University of Chicago, 1981.

Frankel, Jeffrey A., "On the Mark," American Economic Review, 69 (1979), 610-622.

Frenkel, Jacob A., "Exchange Rates, Prices and Money: Lessons from the 1920's," American Economic Review, 70 (1980), 235-242.

_______, "Flexible Exchange Rates, Prices and the Role of "News": Lessons from the 1970's," Journal of Political Economy, 89 (1981a), 665-705.

_______, "The Collapse of PPP in the 1970's," European Economic Review, 16 (1981b), 145-165.

Frenkel, Jacob A. and Kenneth Clements, "Exchange Rates in the 1920's: A Monetary Approach," in Development in an Inflationary World, edited by M. June Flanders and Assaf Razin (New York: Academic Press) 1981, 283-318.

Frenkel, Jacob A. and Mussa, Michael, "Efficiency of Foreign Exchange Markets and Measures of Turbulence," American Economic Review, 70 (1980), 374-81.

Frenkel, Jacob A. and Razin, Assaf, "Stochastic Prices and Tests of Efficiency of Forecasting Exchange Markets," Economic Letters, 6 (1980), 165-170.

Genberg, Hans, "Effects of Central Bank Intervention in the Foreign Exchange Market," IMF Staff Papers, 28 (1981), 451-476.

Hansen, Lars Peter and Hodrick, Robert J., "Forward Exchange Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis," Journal of Political Economy, 88 (1980), 829-853.

_____, "Risk Averse Speculation in the Forward Exchange Market: An Econometric Analysis," paper presented to the NBER Conference on Exchange Rates and International Macroeconomics, Cambridge, Mass. (November 1981).

Isard, Peter, "An Accounting Framework and Some Issues for Modelling Exchange Rates," paper presented to the NBER Conference on Exchange Rates and International Macroeconomics, Cambridge, Mass. (November 1981).

Kolhagen, Steven W., The Behavior of Foreign Exchange Markets: A Critical Survey of the Empirical Literature (New York: New York University Press) 1978.

Levich, Richard M., "The Efficiency of Markets for Foreign Exchange," in International Economic Policy: Theory and Evidence, edited by Rudiger Dornbusch and Jacob A. Frenkel (Baltimore: Johns Hopkins University Press, 1979).

Mussa, Michael L., "The Exchange Rate, the Balance of Payments and Monetary and Fiscal Policy Under a Regime of Controlled Floating," Scandinavian Journal of Economics, 78 (May 1976), 229-48.

_____, "A Model of Exchange Rate Dynamics," Journal of Political Economy, 90 (1982), 74-104.