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Tests of Covered Interest Rate Parity

RECENTLY there has been considerable interest in and investigations of whether the covered interest parity (CIP) holds. At the microeconomic level, CIP is important because is it a direct consequence of covered interest arbitrage. Its failure to hold would suggest 1) that markets are inefficient in the sense that traders do not take advantage of known profit opportunities, 2) that legal restrictions and regulations, such as capital controls, exist or 3) that costs have been unaccounted for, such as individual borrowing constraints or differences in political risks across countries.[1]

At the aggregate level, CIP is important because it implies that interest rates and spot and forward exchange rates are related in a particular way. Indeed, this relationship is frequently imposed in open-economy macroeconomic models. Finding that the relationship among these variables implied by CIP does not hold would leave their relationship uncertain.[2]

Generally, there have been two types of empirical investigations of CIP. The first are designed to determine whether markets are efficient in the sense that all known profit opportunities are arbitraged.[3] These tests investigate whether the actual forward premium deviates from that implied by CIP by more than the transaction costs using the most efficient arbitrage. The issues are whether the forward premia ever exceed estimates of the transaction costs and, if they do, whether they persist. The

[1]In a sense, there are no tests of covered interest arbitrage. It is axiomatic! If tests revealed that CIP was violated so that known riskless profit opportunities were being ignored for long periods of time, such results would undoubtedly be explained in various ways, such as alleging that relevant costs were ignored.

[2]If CIP does not hold, it does not necessarily mean that there is no other exact linear relationship among these variables or their subsets. It only means that the nature of the relationship would be uncertain.

The policy implications of CIP may be especially important for small open economies where the U.S. interest rate can effectively be taken as exogenous. If CIP holds, attempts by such countries' policymakers to move their domestic interest rates will immediately get translated into their exchange rates and vice versa. This is particularly true if the forward rate is an efficient predictor of the future spot rate. Even if this is not the case [for example, see Chrystal and Thornton (1988)], both forward and spot rates would likely be affected since they tend to move together. Furthermore, if CIP holds, such economies may be influenced more by external events, such as changes in U.S. monetary policy, than if CIP does not hold. See Dufey and Giddy (1978) and Kubarych (1983) for a discussion of some of the policy implications.

[3]For example, see Deardorff (1979), Callier (1981), Bahmani-Oskooee and Das (1985) and Clinton (1988).

evidence is that frequent violations of CIP occur, but do not persist.[4]

The second tests are designed to examine whether CIP holds on average.[5] Specifically, they test whether domestic and foreign interest rates and spot and forward exchange rates respond in a way consistent with CIP to economic news that affects each market individually.

This article provides a generic representation of the latter tests and shows that, under appropriate conditions, similar tests can be performed that do not require testing the markets' response to particular sets of information. In so doing, this article extends empirical investigations to a larger set of countries and over a longer time period.[6]

DOES CIP HOLD ON AVERAGE?

CIP is a direct consequence of covered interest arbitrage.[7] In the absence of transaction costs, the CIP condition requires that

(1) $\ln(1+i_t) - \ln(1+i_t^*) - \ln F_t + \ln S_t = 0,$

where i^* and i are the foreign and U.S. interest rates, respectively, and F_t and S_t are the forward and spot foreign exchange rates (dollars per unit of foreign currency), respectively.[8] The maturity of the U.S. and foreign assets and the forward contract are identical. Moreover, foreign and U.S. securities are assumed to be identical except for the currency in which future payments are denominated.

The Markets' Reactions to Economic News

Equation 1 asserts that a particular linear combination of these variables is zero in the absence of transaction costs. Other linear combinations of the variables need not equal zero. Tests of CIP that rely on the markets' reactions to economic news or events make use of the fact that the particular linear combination of asset prices implied by CIP is zero. To see this, assume that U.S. and foreign interest rates and the spot and forward exchange rates can be represented by the following equations:

(2) $\Delta\ln(1+i_t) = a_1 + b_1 n_t,$

(3) $\Delta\ln(1+i_t^*) = a_2 + b_2 n_t,$

(4) $\Delta\ln F_t = a_3 + b_3 n_t,$ and

(5) $\Delta\ln S_t = a_4 + b_4 n_t,$

where n_t denotes the new information that becomes available in the interval over which the t^{th} observation is made. Each asset may respond differently to the same news.

Investigations of CIP rely on testing the markets' responses to specific information by identifying a particular component of n_t and by making an assumption about the stochastic properties of the rest. One approach is to estimate the equations

(6) $\Delta\ln(1+i_t) = a_1 + d_1 I_t + e_{1t},$

(7) $\Delta\ln(1+i_t^*) = a_2 + d_2 I_t + e_{2t},$

(8) $\Delta\ln F_t = a_3 + d_3 I_t + e_{3t},$ and

(9) $\Delta\ln S_t = a_4 + d_4 I_t + e_{4t},$

where I_t denotes specific information that becomes available during the period in which the t^{th} observation is made, and $e_{it} = (b_i e_t)$ denotes an individual market's response to all other information made available during the in-

[4]Much of this literature shows that the difference between the actual forward premium and that implied by CIP often falls outside of the neutral band given by transaction costs, e.g., see Bahmani-Oskooee and Das (1985) and Clinton (1988). For example, Clinton finds "that while the longest sequence of profitable trading opportunities is five observations [days], the most common run does not extend beyond a single observation. Thus, in general, profit opportunities appear to be both small and short-lived, even though they are not rare." See Clinton (1988), p. 367. He suggests, however, that it is unlikely that the quality of the data will ever be sufficient to provide a rigorous test of market efficiency, i.e., that there are no unexploited profit opportunities.

[5]To date, this work has relied exclusively on investigating markets' responses to money announcements. See Roley (1987), Husted and Kitchen (1985) and Tandon and Urich (1987).

[6]Roley (1987) considers Japan and only the Gensaki rate, while Husted and Kitchen (1985) use data for Canada and Germany. Roley's data covers the period from October 6, 1977, through May 30, 1985, while Husted and Kitchen's data covers the period from February 8, 1980, through August 27, 1982.

[7]Deardorff (1979) shows that covered interest arbitrage requires that the forward rate deviate from that implied by CIP by no more than $|t + t^* + t_s + t_f|$, where t, t^*, t_s and t_f are the transaction costs (proportional to the size of the transaction) in the United States and foreign securities markets and the spot and forward foreign exchange markets, respectively. He also shows that the "neutral band" is narrower than this if "one-way" arbitrage is considered. This band has been further narrowed by Callier (1981), Bahmani-Oskooee and Das (1985) and Clinton (1988).

[8]$\Delta\ln F_t$ and $\Delta\ln S_t$ are weighted by an annualizing factor equal to 12 divided by the number of months in the forward contract.

terval, e_t.[9] Estimating this equation system involves the additional assumption that $E(e_t)=0$. Equations 6-9 are estimated and the restrictions $d_1 - d_2 - d_3 + d_4 = a_1 - a_2 - a_3 + a_4 = 0$ are tested. If CIP holds, the intercept and slope coefficients of equations 6-9 will satisfy the particular homogenous linear restriction implied by CIP.

An asymptotically equivalent test can be performed by estimating the equation

$$(10)\ \Delta\ln(1+i_t) - \Delta\ln(1+i_t^*) - \Delta\ln F_t + \Delta\ln S_t = a + dI_t + f_t,$$

and testing the hypothesis that $a = d = 0$. In this form, the error term, $f_t = e_{1t} - e_{2t} - e_{3t} + e_{4t}$, vanishes under the null hypothesis that the markets respond to the new information in a way consistent with CIP, that is, $b_1 - b_2 - b_3 + b_4 = 0$. A more satisfactory interpretation of f_t, therefore, comes from recalling that equation 1 holds identically only in the absence of transaction costs, so that f_t represents the change in the log of these costs.[10]

Another interpretation of f_t stems from the fact that the observations used to examine CIP generally are not taken at the same time. To illustrate the effect of this, assume that observations on U.S. and foreign interest rates are taken at 3 a.m. EST, while the observations on the spot and forward exchange rates are taken at 11 a.m. EST. The change in interest rates is measured from 3 a.m. before the release of the specific information to 3 a.m. after the information is released. The change in the exchange rates is defined similarly. Under these assumptions, changes in the interest and exchange rates reflect information that is common to both, as well as the information unique to each. For example, changes in the interest rates will reflect the markets' reaction to information between 3 a.m. and 11 a.m., but this information will not necessarily be reflected in the change in the exchange rates. Likewise, changes in the exchange rates reflect the markets' reaction to information from 3 a.m. to 11 a.m. the next day, but this information will not be reflected in the changes in the interest rates. Consequently, the error term of equation 10 comes potentially from differences in the information in the asset prices due to non-synchronous data, as well as from changes in the log of transaction costs.[11] It could not come from the common information because, as we have already noted, this component of the error term vanishes under the null hypothesis.[12]

Tests of the Linear Restrictions Implied by CIP

A comparison of equations 6-9 and equation 10 reveals another interesting aspect of these tests. The hypothesis that $a = 0$ is a test that the linear combination implied by CIP, but not accounted for by I_t, is zero. If CIP holds, this will be true at all times, not simply when the

[9]This specification assumes that there is no idiosyncratic information that affects one market but not the others. It is difficult to see how such idiosyncratic information could exist in the reduced-form equations 6-9, or how such an assumption could hold under the null hypothesis. For a model that looks at the implications of non-synchronous trading using the assumption of idiosyncratic information, see Lo and MacKinlay (1989).

[10]If transaction costs vary symmetrically around a non-zero mean, the change in the log of transactions costs will not vary symmetrically around zero. This stems directly from the concavity of the log function. This means that if the distribution of transactions cost is symmetric, the distribution of the log of the change in the transaction costs will be asymmetric.

[11]Since the markets may eventually respond to all information, the non-synchronous data implies that changes in asset prices taken at different periods of time will be serially correlated. In terms of equations 6-9, this means that the error terms will be cross-sectionally autocorrelated. In terms of equation 10, this implies that f_t will be serially correlated. Indeed, when equation 10 was estimated using all of the daily data, this was the case. The results reported in this paper are for estimates of equation 10 only on days when the specific information was available. Not surprisingly, in nearly all cases, these error terms were serially independent.

[12]For simplicity, let $\Delta i_t = \Delta\ln(1+i_t^*) - \Delta\ln(1+i_t^*)$ and $\Delta R_t = \Delta\ln F_t - \Delta\ln S_t$, so that CIP implies that $\Delta i_t - \Delta R_t = 0$, under the simplifying assumption of zero transaction costs. Now let $\Delta i_t = \alpha_0 + \alpha_1 SI_t + \delta_0\varepsilon_t + \delta_0\eta_t$ and $\Delta R_t = \beta_0 + \beta_1 I_t + \delta_1\varepsilon_t + \delta_1\omega_t$. Here, ε_t denotes the information not contained in I_t that is reflected in both interest rates and exchange rates. η_t denotes the information reflected in Δi_t that is not reflected in ΔR_t and ω_t denotes the information reflected in ΔR_t that cannot be reflected in Δi_t. Since there is little justification to do otherwise, it is assumed that Δi_t responds the same to ε_t and η_t; likewise, the response of ΔR_t is the same for ε_t and ω_t. Note that if the response of these markets to information is consistent with CIP, i.e., $(\alpha_0 - \beta_0) = (\alpha_1 - \beta_1) = (\delta_0 - \delta_1) = 0$, $\Delta i_t - \Delta R_t$ differs from zero by $\delta_0\eta_t - \delta_1\omega_t$, the response to the non-synchronous information. [Estimation requires a normalization; however, this does not affect the conclusion].

Roley (1987), p. 65, asserts that, "when testing whether the responses of these variables to a specific piece of new information are inconsistent with covered interest parity, the exact alignment of the data is not necessary." The above illustration demonstrates that this is not necessarily the case. The error term of equation 10 and, hence, the precision with which the parameters can be estimated is clearly dependent on the degree to which the data are synchronous.

markets react to specific information. Tests of CIP using the markets' response to specific information generally are performed using data only for days when the information is released; however, evidence on CIP can be obtained directly from the changes in these four asset prices even if information that the markets respond to is not identified or is not available.

Rejecting the hypothesis that this linear combination of changes in asset prices is zero is strong evidence against CIP. A failure to reject the null hypothesis is not strong evidence in favor of it, however, because the same could be true for other linear combinations of these asset prices. If asset prices follow a random walk without drift, the same could be true for any linear combination of the change in these asset prices, not simply for the linear combination implied by CIP. Consequently, stronger evidence consistent with CIP would be obtained if the null hypothesis is not rejected for the linear combination implied by CIP, but is rejected for other linear combinations.

EMPIRICAL EVIDENCE

Tests of CIP using the markets' response to specific information have relied exclusively on their response to money announcements. In this section, the broader test outlined above is applied to daily data for the period from October 5, 1979, to September 14, 1988. Tests of CIP using the markets' response to information in the form of money announcements also are undertaken. The reported tests using money announcements are only for days on which there was an announcement.

The data used in this study are one-, three-, six- and twelve-month Eurocurrency rates for the United States (U.S.), United Kingdom (U.K.), Canada (CA), Germany (GR), Switzerland (SW), France (FR) and Japan (JA), the corresponding forward exchange rates and the spot exchange rates. Anticipated changes in M1 are the median forecasts from the Money Market Services survey, and the forecast error is the difference between the forecasted change and the change in first-announced M1. The interest rates are reported as of 3 a.m. EST and the exchange rates are reported as of 11 a.m. EST. The interest rates are bid rates from the Bank of International Settlements.[13] The exchange rates are the average of bid and ask rates from the London foreign exchange market.

The test of CIP using money announcements involves estimating the equation

$$(11)\quad \Delta\ln(1+i_t) - \Delta\ln(1+i_t^*) - \Delta\ln F_t + \Delta\ln S_t = a + d_1 UM_t + d_2 ME_t + e_t.$$

Both anticipated money, ME, and unanticipated money, UM, are included because, as a number of researchers found, these asset prices responded in a statistically significant way to both anticipated and unanticipated changes in the money stock.[14] The finding that the individual markets respond significantly to ME is, itself, frequently taken as evidence that the markets are informationally inefficient.[15] For the purpose of testing for CIP, however, the only relevant issues are whether the markets respond to ME and whether the responses net out in a way consistent with CIP.

It has been common to estimate equations like 6-9 or equation 11 over different subsamples to see if the markets' response to money announcements changes in response to changes in the Federal Reserve's operating procedure.[16] Since the interest here is only in testing for CIP, however, there is no need to split this sample for this purpose: the difference in magnitude of the market's response is unimportant.

It is important to split the sample for another reason, however: the null hypothesis that $d_1 = d_2 = 0$ will not be rejected either if the markets do not respond to money announcements or if

[13]The interest rates are from the BIS data tape at the Board of Governors of the Federal Reserve System. These are bid rates taken from several markets. The Money Market Service survey data through 1986 were provided by Graig Hakkio.

[14]For example, this is true of Tandon and Urich (1987), Husted and Kitchen (1985) and Belongia and Sheehan (1987). Deaves, Melino and Pesando (1987), however, show that the significance of expected money on U.S. interest rates is due to a few outliers, while Belongia, Hafer and Sheehan (1986) have shown that the response of U.S. interest rates to anticipated money is very sensitive to the sample period. In any event, the presence or absence of ME from equation 10 is likely to have little bearing on the test because ME and UM are nearly orthogonal. Furthermore, while the evidence on the importance of ME may be weak, the cost in terms of lost efficiency for including it is small.

[15]While this type of test is generally valid, there are some important limitations. For a discussion of these, see Pesaran (1987), especially chapter 8.

[16]In October 1982, the Fed switched from a nonborrowed-reserves to a borrowed-reserves operating procedure. See Thornton (1988a) for a discussion of the borrowed-reserves operating procedure.

Table 1
General Tests for CIP; October 5, 1979, through September 14, 1988

Country	One Month			Three Month			Six Month			Twelve Month		
	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
CA	−.00	−.27	−.39	.02	−.45	−.46	.01	−.45	−.52	.01	−.20	−.41
SW	.02	−.12	−.01	.01	−.34	−.03	.02	−.32	−.06	.00	−.32	−.09
GR	.05	−.26	−.18	.03	−.42	−.21	.04	−.46	−.24	.05	−.46	−.28
FR	.01	−.10	−1.23	.00	−.23	−1.26	−.00	−.29	−1.30	.00	−.28	−1.31
UK	−.01	−.21	−.77	−.02	−.37	−.79	.00	−.38	−.82	−.00	−.32	−.84
JA	.03	−.21	1.57	.00	−.27	1.56	.01	−.40	1.55	.00	−.01	.10

T_1: $\Delta \ln (1+i_t) - \Delta \ln (1+i_t^*) - \Delta \ln F_t + \Delta \ln S_t = 0$

T_2: $\Delta \ln (1+i_t) + \Delta \ln (1+i_t^*) + \Delta \ln F_t - \Delta \ln S_t = 0$

T_3: $\Delta \ln (1+i_t) + \Delta \ln (1+i_t^*) + \Delta \ln F_t + \Delta \ln S_t = 0$

their response is consistent with CIP on average.

It is well-documented that the markets, especially U.S. interest rates, responded in a statistically significant way to unanticipated changes in the money stock through the early part of 1984. Their response after early 1984 is more problematic, however. Consequently, the period was divided into two subperiods: October 5, 1979, to January 29, 1984, and January 30, 1984, to September 14, 1988.[17] Equations in the form of 6-9 were estimated for both periods, and both anticipated and unanticipated changes in the money stock had a statistically significant effect only during the first subperiod.[18] Consequently, estimates of equation 11 are presented only for the period ending in 1984. Results for the more general test are presented for the entire period.

THE RESULTS

Table 1 reports t-statistics for tests of various linear combinations of changes in U.S. and foreign interest rates and spot and forward exchange rates, including the linear combination implied by CIP. The t-statistic for the linear combination implied by CIP is denoted T_1; t-statistics for two other linear combinations of the changes in these asset prices are denoted T_2 and T_3. The alternative linear combinations are interesting because T_2 is the t-statistic for a test of a linear combination of changes in these asset prices that is correlated with that implied by CIP, while T_3 is the t-statistic for a test of a linear combination that is orthogonal to that implied by CIP.[19] Consequently, if the null hypothesis that CIP holds cannot be rejected, it would not be surprising to find that $T_3 > T_2 > T_1$.

[17]For example, Dwyer and Hafer (1989) found that essentially there was no statistically significant response of U.S. interest rates to money announcements after July 1984. More importantly, estimates of equations of the form of 6-9 found no statistically significant response to either anticipated or unanticipated changes in the money stock during the second subperiod.

[18]Estimates of equations like 6-9 for the first subperiod indicate that the markets frequently responded significantly to anticipated changes in the money stock. This was the case for U.S. and Canadian interest rates at all maturities, except the 12-month maturity for Canada, and is generally true for both the forward and spot exchange rates. It is not true for other foreign interest rates, with the exception of the one-month Euroyen rate.

[19]Let R_1, R_2 and R_3 denote the three restrictions on the vector of changes in asset prices that correspond with T_1, T_2 and T_3, respectively, e.g., $R_1 = (1, -1, -1, 1)$. Then the correlation between R_1 and R_2 is −.50, while R_1 and R_3 are uncorrelated.

In every instance, the t-statistics for the test of CIP are extremely small, suggesting that CIP holds on average over the sample period. While supportive of CIP, the fact that the null hypothesis cannot be rejected is not compelling evidence because the same could be true of other linear combinations of these variables. Tests of other linear combinations produce t-statistics that are considerably larger than those for that implied by CIP, although in no case was the null hypothesis rejected. In the majority of cases, however, $T_3 > T_2$.

Tests of the Response to Specific Information

Estimates of equation 11 along with the t-statistics for tests of linear combinations of the changes in these variables for the period from October 5, 1979, through January 29, 1984, are presented in table 2.[20] Two F-statistics are reported. F_1 is a test that all of the coefficients are zero. F_2 is a test that the two slope coefficients are zero.

There were four instances in which the coefficient on unanticipated changes in money was statistically significant at the 5 percent level and three instances in which the null hypothesis that both slope coefficients are zero is rejected. In no instance was the coefficient of anticipated money alone significant at the 5 percent level.

The occasional statistically significant response to unanticipated changes in the money supply is odd given the general lack of such responses. Even more surprising, one of these occurs at a maturity of six months while the other three occur at a maturity of 12 months, despite the fact there was no statistically significant response at shorter maturities.[21] This fact along with the extremely low adjusted R-squares leaves open the possibility that the statistically significant responses are due to the influence of a relatively few observations.[22]

Scatter plots of the dependent variable and unanticipated changes in the money stock for the four instances in which the coefficient on UM was statistically significant are presented in figures 1-4. In the case of the six-month maturity for Japan shown in figure 1, it appears that two extreme observations (see arrows) could account for the significant positive coefficient on UM. The same two observations appear as extreme observations for the 12-month maturity for Japan in figure 2. To see if the results for Japan are sensitive to these observations, they were deleted and the equation was re-estimated. In both instances the coefficient on UM was no longer statistically significant at the 5 percent level.[23]

The remaining scatter plots reveal no similarly dramatic outliers. They do indicate what the low adjusted R-squares suggest: a relatively weak relationship between the dependent variable and unanticipated changes in the money stock.[24] Given the spherical nature of the scatter plots and the extremely low adjusted R-squares, these results do not represent a serious challenge to the null hypothesis that CIP holds on average.

Tests of linear combinations of changes in these variables reported in table 2 are similar to those for the entire period reported in table 1. The major difference is the T_3 statistic is significant at the 5 percent level for Germany, France and the United Kingdom for all maturities.[25] This provides strong evidence that CIP holds on average during the period. This finding is consistent with that of Clinton (1988) who found that, even though there were numerous instances when deviations from interest rate parity were larger than those implied solely by transactions costs, no profitable arbitrage opportunities exist on average.

Unlike Roley (1987) who rejected CIP for Japan, these results suggest that it holds for the

[20]France devalued its currency three times during this period, causing excessively large movements in the Eurofranc rate. These observations were deleted from tests involving money announcements for France. They were October 5, 1981, June 14, 1982, and March 21, 1983.

[21]Most of the empirical evidence suggests that the response of U.S. interest rates to money announcements is the strongest at the short-term maturities. For example, see Dwyer and Hafer (1989) and Hafer and Sheehan (1989).

[22]Thornton (1988b, 1989) has shown that some of the reported statistically significant responses of U.S. interest rates, exchange rates and stock prices to unanticipated changes in the money stock are due to relatively few observations.

[23]The observations are March 7, 1980, and June 10, 1983. The t-statistics for the coefficient on UM are 0.97 and 1.69 for the six- and twelve-month maturities, respectively.

[24]Given the results reported here, there is little reason to perform formal statistical tests for the stability of the coefficients. In any event, such tests likely will be of low power given the low adjusted R-squares for these equations.

[25]Separate tests indicate that many of these asset prices do not follow a random walk.

Table 2

The Markets' Reaction to Money Announcements: October 5, 1979 - January 27, 1984

	Estimates of Equation 7							Test of Linear Combinations		
Maturity/ Country	Constant[1]	UM[1]	ME[1]	SEE[1]	R^2	F_1	F_2	T_1	T_2	T_3
ONE MONTH										
CA	−.103*	−.022	.030	0.394	.016	6.69*	2.87	−.03	−.19	−.82
	(3.78)	(1.86)	(1.67)							
SW	−.103*	.006	.022	0.642	−.006	1.85	0.33	.04	−.14	−1.37
	(2.34)	(0.29)	(0.73)							
GR	−.029	.004	.026	0.478	−.002	0.62	0.75	.06	−.20	−2.12*
	(0.81)	(0.21)	(1.12)							
FR	.457*	−.019	−.007	3.155	−.009	1.54	0.02	.01	−.08	−3.09*
	(2.11)	(0.19)	(0.04)							
UK	.026	.016	.023	0.603	−.002	0.84	0.80	.03	−.16	−2.08*
	(0.62)	(0.88)	(0.83)							
JA	−.125	.019	.011	0.970	−.007	1.22	0.25	.05	−.19	−.23
	(1.86)	(0.65)	(0.24)							
THREE MONTH										
CA	−.022	−.010	.019	0.230	.012	2.06	2.39	−.03	−.33	−.91
	(1.36)	(1.38)	(1.81)							
SW	.022	−.001	.001	0.266	−.009	0.52	0.01	.01	−.32	−1.42
	(1.21)	(0.10)	(0.05)							
GR	−.017	−.001	.007	0.212	−.007	0.52	0.27	.01	−.31	−2.20*
	(1.13)	(0.11)	(0.73)							
FR	.065	.002	.009	0.943	−.009	0.41	0.03	.02	−.19	−3.16*
	(1.00)	(0.06)	(0.21)							
UK	−.009	−.012	.001	0.230	.005	1.25	1.52	−.05	−.29	−2.14*
	(0.59)	(1.74)	(0.11)							
JA	−.031	.010	−.001	0.354	−.005	0.79	0.47	.01	−.20	−.25
	(1.29)	(0.97)	(0.05)							
SIX MONTH										
CA	−.031*	.001	.007	0.213	−.007	1.54	0.28	−.03	−.34	−.99
	(2.14)	(0.21)	(0.69)							
SW	−.026	.006	−.004	0.305	−.007	0.68	0.26	.04	−.34	−1.48
	(1.22)	(0.67)	(0.30)							
GR	−.036*	.003	.010	0.192	−.001	2.62	0.86	.03	−.35	−2.33*
	(2.73)	(0.47)	(1.18)							
FR	.056	−.001	−.032	0.584	−.003	0.93	0.72	.01	−.25	−3.26*
	(1.40)	(0.07)	(1.19)							
UK	−.040*	−.000	.000	0.221	−.009	2.45	0.00	−.06	−.31	−2.23*
	(2.63)	(0.07)	(0.02)							

Table 2 (Continued)

The Markets' Reaction to Money Announcements: October 5, 1979 - January 27, 1984

	Estimates of Equation 7							Test of Linear Combinations		
Maturity/ Country	Constant[1]	UM[1]	ME[1]	SEE[1]	R^2	F_1	F_2	T_1	T_2	T_3
JA	−.050*	.021*	−.024	0.337	.019	3.86*	3.12*	.00	−.32	−.29
	(2.18)	(2.08)	(1.56)							
TWELVE MONTH										
CA	−.043*	.004	.004	0.220	−.006	2.77*	0.30	.01	−.28	−.91
	(2.87)	(0.59)	(0.45)							
SW	.014	.006	−.007	0.288	−.006	0.39	0.35	.00	−.27	−1.49
	(0.69)	(0.68)	(0.54)							
GR	−.021	.011*	−.005	0.174	.010	2.33	2.12	.04	−.31	−2.38*
	(1.75)	(2.02)	(0.56)							
FR	.003	.026*	−.019	0.364	.019	2.16	3.22*	.02	−.23	−3.21*
	(0.10)	(2.36)	(1.15)							
UK	−.032*	.000	−.003	0.230	.009	1.56	0.03	−.04	−.25	−2.24*
	(2.03)	(0.05)	(0.24)							
JA	−.073*	.029*	−.021	0.377	.023	5.08*	3.58*	.01	−.27	−.31
	(2.83)	(2.49)	(1.20)							

[1]Actual coefficient is 10^{-2} times the reported coefficient.

* Indicates statistical significance at the 5 percent level.

T_1: $\Delta \ln (1+i_t) - \Delta \ln (1+i_t^*) - \Delta \ln F_t + \Delta \ln S_t = 0$

T_2: $\Delta \ln (1+i_t) + \Delta \ln (1+i_t^*) + \Delta \ln F_t - \Delta \ln S_t = 0$

T_3: $\Delta \ln (1+i_t) + \Delta \ln (1+i_t^*) + \Delta \ln F_t + \Delta \ln S_t = 0$

Euroyen rate. Roley used the Gensaki rate and attributed his failure to support CIP to capital controls. Since the Eurocurrency rates used here are not affected by capital controls, the results are not inconsistent with Roley's. Together, however, they suggest that there should be relatively weak substitutability between the Euroyen and Gensaki rates.

Conflicting Results for the T_1 Statistics and the Estimated Intercept Coefficients

The T_1 statistics reported in table 2 are much smaller than the t-statistics for the intercept terms, some of which were significant at the 5 percent level.[26] One explanation for this, which

[26]Equation 11 was also estimated using all of the daily data, not simply for days when there was a money announcement. Not surprisingly, the t-statistics for the intercept terms were not much different from the t-statistics for the linear combination of these asset prices implied by CIP reported in table 2.

Figure 1
Scatter Plot For Japan: Six-Month Maturity

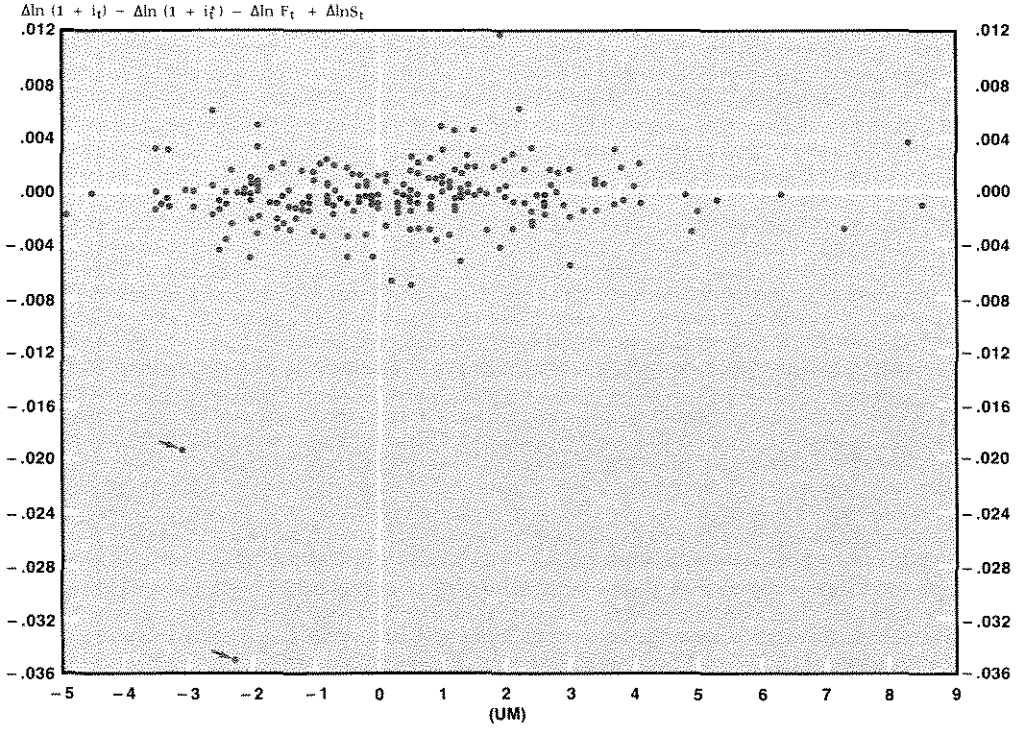


Figure 2
Scatter Plot For Japan: 12-Month Maturity

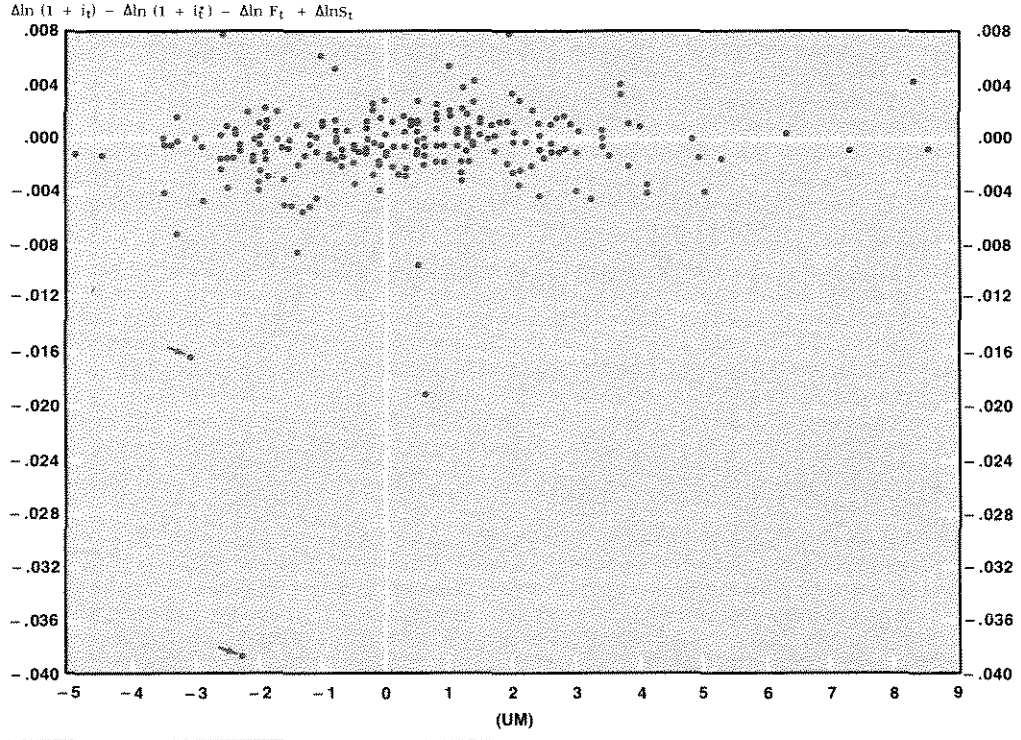


Figure 3
Scatter Plot For Germany: 12-Month Maturity

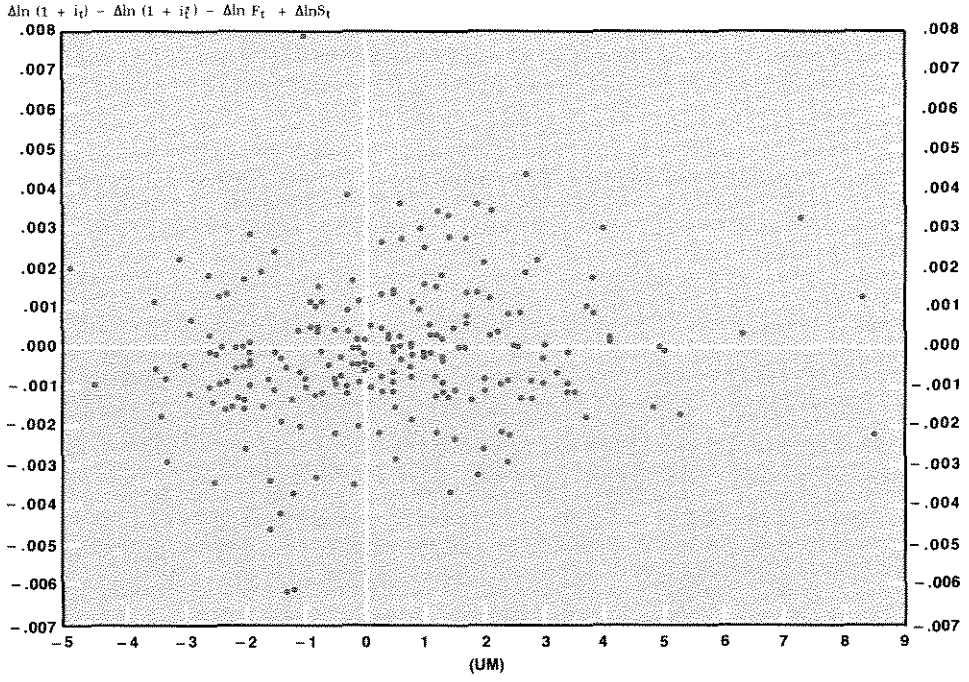
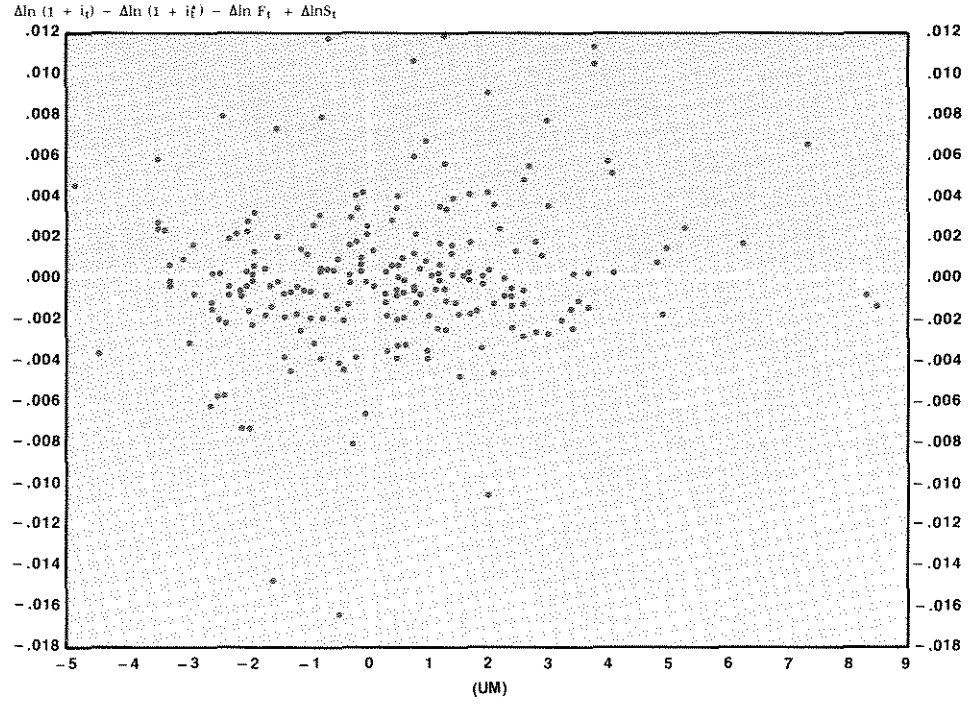


Figure 4
Scatter Plot For France: 12-Month Maturity



is consistent with the frequent—though not persistent—violations of CIP using transaction cost data, is that shocks to the market in the form of money announcements are destabilizing, causing large deviations from CIP on these days.[27] If this is the case, deviations from CIP should be larger on money-announcement days. Consequently, not only will the means be larger, but the variance of the dependent variable in equation 11 should be larger on money-announcement days as well.[28]

Table 3 reports test of the equality of the variances of the dependent variable of equation 11 against the alternative that the variance is larger on money-announcement days. These tests are performed only for the period ending in 1984 because, as has been noted, the individual markets do not respond significantly to unanticipated changes in the money stock thereafter.

In general, the results are not consistent with the hypothesis that the variance is larger on money-announcement days. There are six instances in which the null hypothesis of the equality of the variances is rejected in favor of the alternative at the 5 percent significance level, but there are seven instances in which the variance of the dependent variable is significantly lower on money-announcement days.[29] Moreover, two of the former cases are for the six- and 12-month maturities for Japan. Since the previous results for these maturities were strongly influenced by these observations, they were deleted and the tests repeated. When this was done, the null hypothesis was no longer rejected in favor of the alternative in either case.[30] Consequently, the occasional significant intercept term and the occasional significantly larger variance on money-announcement days are not strong evidence against CIP holding on average.

Table 3
Tests of Equality of Variance

	Maturity			
Country	One Month	Three Month	Six Month	Twelve Month
CA	0.57	0.94	1.09	0.97
SW	0.19	0.70	1.58*	1.79*
GR	0.24	0.32	0.90	1.07
FR	2.76*	1.05	1.17	0.78
UK	0.47	0.52	0.97	1.31*
JA	1.02	0.16	1.80*	2.39*

*indicates statistical significance at the 5 percent level.

CONCLUSIONS AND IMPLICATIONS

Despite a few occasions in which there was a statistically significant response to unanticipated changes in the money stock, the results of tests of the markets' response to economic news are consistent generally with the hypothesis that CIP holds on average. In two of the four instances in which there was a significant response to unanticipated changes in the money stock, the results appeared to be due to the nature of the data and the sensitivity of least-squares to extreme observations. Also, the few instances in which the means of the dependent variable implied by CIP were significantly different from zero on money-announcement days do not constitute strong evidence against CIP.

[27]Another is that the difference in these results are due to the distributions of the dependent variable. Though not reported here, the distributions of the dependent variable have their probability mass more highly concentrated about the mean and have thicker tails than normally distributed random variables. Consequently, sample means vary considerably, even in what conventionally would be large samples. The evidence of this is obtained from tests derived from histograms constructed by dividing the interval from ± 2.33 standard deviations around the mean into 11 equal-length groups centered on the mean. The first and last group were open-ended, theoretically containing 1 percent of the sample in each. These histograms were created for all observations and for days when there were and were not money announcements for the first subperiod. In nearly all instances, the actual frequency in the first and last group exceeded—in many cases, greatly exceeded—the expected frequency. But even in those instances where this was not the case, the actual frequency in the first and last group exceeded the actual frequencies in the second and third and 11th and 12th groups. The null hypothesis of normality was rejected in every case at very low significance levels by formal chi-square goodness-of-fit tests.

[28]One way to conceptualize this is simply to note that there is an extra source of variation on money-announcement days. For an example, see Thornton (1988b).

[29]This may not be too surprising given the transaction-cost interpretation of the error term because Bahmani-Oskooee and Das (1985) report that their estimates of transaction costs were highly unstable.

[30]The F-statistics for the six- and 12-month maturities are 0.72 and 1.14, respectively. Indeed, for the six-month maturity, the variance is significantly smaller on money-announcement days.

This is so because the hypothesis that the mean of the dependent variable implied by CIP is zero was never rejected for larger samples using all of the daily observations.

There is no evidence that the data are consistently more variable on money-announcement days. Furthermore, the t-statistics for tests that linear combinations other than that implied by CIP were zero were much larger than those for that implied by CIP and, in several instances, the null hypothesis was rejected during part of the sample period. Hence, CIP appears to hold on average for these data.

There are several policy implications of the finding that, on average, an exact linear relationship exists between the U.S. and foreign interest rates and the spot and forward exchange rates. For example, if the U.S. interest rate is taken as exogenous, foreign central banks cannot independently and simultaneously control both their interest rates and their exchange rates. This means that small open economies are susceptible to exogenous changes in U.S. monetary policy. Finally, the results indicate the CIP assumption used in many theoretical models is appropriate, so long as it is not required to hold at every point in time. These results, however, do not provide evidence for the question of market efficiency which characterizes many discussions of CIP and covered interest arbitrage.

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