The Pricing Relationship of Eurodollar Futures and Eurodollar Deposit Rates

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INTRODUCTION

Price discovery is one of the major contributions of futures markets to economic activity.[1] Many studies [Bessler and Covey (1991); Khoury and Yourougou (1991); MacDonald and Hein (1989); Oellermann, Brorsen, and Farris (1989); Herbst, McCormack, and West (1987); Fama and French (1987); French (1986); Garbade and Silber (1983a), among others] have analyzed the price discovery function of various futures markets. Their results generally support the view that the futures market provides useful information to forecast spot market price movement.

This article examines the pricing relationship of Eurodollar futures and Eurodollar time deposit rates for the period 1983–1990. In particular, the price discovery function of the Eurodollar futures market is tested. The analysis is of interest for several reasons. First, economic theory asserts that forces tend to keep a pair of economic series together over time. Futures and cash market prices are good examples of such an economic time series. One would expect that a predictive relationship may exist between these two markets.

Futures and spot prices have been shown to be nonstationary [e.g., Goldenberg (1989); Doukas and Rahman (1987); and Schwert (1987)]. Thus, many prior studies use the first difference of the futures prices or other measures, such as the difference between futures and spot prices, to account for nonstationarity in regression or vector autoregressive (VAR) models. For testing the relationship between nonstationary variables, the more appropriate analysis is the cointegration methodology because the VAR model is misspecified [Engle and Granger (1987); Granger (1986)]. In fact, Granger (1986) suggests that futures and cash prices are cointegrated. A recent study by Bessler and Covey (1991) uses the cointegration method to analyze the U.S. cattle futures and cash markets.

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[1]Other important functions of the futures market include risk transfer (via hedging) and aribitrage (that corrects mispricing behaviors in both futures and cash markets).

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Second, since the Eurodollar futures contract was introduced in 1981, spreading between it and the Treasury bill (T-bill) futures contract has become increasingly popular.[2] Many studies [e.g., MacDonald and Hein (1989); Kawaller and Koch (1984)] have analyzed the pricing of T-bill futures market. Eurodollar futures have come to dominate the short-term interest rate market and greatly exceed the T-bill contract in volume and open interest. An apparent lack of research in this futures market motivates this study.

Finally, although there are hedging strategies to manage interest rate risk for multinational firms whose cost of capital is interest rate sensitive, and for financial institutions whose profits depend on successful gap and spread management [Melton and Pukula (1984)], it is important for both practitioners and researchers to understand these Eurodollar interest rate markets to anticipate the interest rate movement.

The pricing relationship between the Eurodollar futures and Eurodollar deposit rates are tested for the existence of cointegration. Engle and Granger (1987) have shown that if a set of variables are cointegrated then there exists an error correction representation and vice versa, which means there must be Granger-causality in at least one direction. It follows that VAR models for variables in differences lead to misspecification if the variables are cointegrated. An error correction model (ECM) is estimated to account for cointegration between the two interest rate series. The model should provide robust results for testing the pricing relationship of these two markets.

RESEARCH METHODOLOGY

The specific model employed in this study is fully developed in Granger (1986) and Engle and Granger (1987). Consider two time series, Y_t and X_t, that are nonstationary. To achieve stationarity, the two variables need to be differenced. It is generally true that any linear combination of the two time series is also nonstationary. However, if Y_t and X_t are cointegrated, then there exists a constant A, such that

$$z_t = Y_t - AX_t \tag{1}$$

is stationary. The constant A is called the cointegrating parameter that links the two time series together. Furthermore, the relationship

$$Y_t = AX_t \tag{2}$$

is considered a long-run or "equilibrium" relationship, suggested by economic theory. Thus, the relationship in (1) measures the extent to which the system X_t and Y_t is out of equilibrium, and provides the basis for the error correction model.

Before testing two time series for cointegration, however, it is important to ensure that they are both nonstationary with the same order. Thus, a standard unit root test is applied to both interest rate series as follows:

$$\Delta Y_t = b_0 + b_1 Y_{t-1} + b_2 \Delta Y_{t-1} + b_3 \Delta Y_{t-2} + e_t \tag{3}$$

where $\Delta Y_t = Y_t - Y_{t-1}$; the b_i's are constant parameters; and e_t is a white-noise disturbance. If autoregressive representation of Y_t has a unit root (i.e., is integrated of order one), the t-ratio for b_1 should be consistent with the hypothesis b_1=0. Because conventional t-tables are inappropriate for this hypothesis test, the results of Dickey

[2]For more information regarding the spreading relationship of the Eurodollar with the T-bill market, see Schwarz, Hill, and Schneeweis (1986) and Kolb (1991). An analysis of the spread position may shed light on the forecasting performance of the Eurodollar futures market.

and Fuller (1979) and the tabulated distribution in Fuller (1976, p. 373) are applied to interpret the t-ratio.

Assuming that each series has the same number of unit roots, the cointegration test can commence using an ordinary least squares (OLS) regression in the following form:

$$Y_t = c + \alpha X_t + u_t \tag{4}$$

where α is the estimator for the equilibrium parameter, A; c is the intercept [this constant term is included as a generalized case suggested by Granger (1986)]; and u_t is the disturbance term.

The disturbance terms provided by the cointegration regression (u_t) in eq. (4) provide a means for developing the preferred augmented Dickey–Fuller (ADF) test.[3] Using the residuals from eq. (4), the ADF requires estimation of the following model:

$$\Delta u_t = \phi_1 u_{t-1} + \Sigma_{i=1 \text{ to } n} b_i \, \Delta u_{t-i} + e_t \tag{5}$$

where ϕ and b_i are the estimated parameters and e_t is the error term. The number of lags (n) chosen in eq. (5) should be sufficient to ensure that the error term, e_t, is white noise. The test for cointegration involves the significance of the estimated ϕ coefficient. If the ADF t-statistic on the ϕ coefficient is less than the critical value, the u_t residuals from the cointegration regression are stationary. Then X and Y are cointegrated.

If cointegration exists between the two time series, an error correction model can be used to estimate their relationship [Engle and Granger (1987); Granger (1986)]. The error correction model can be expressed as:

$$\Delta Y_t = \alpha_0 + \beta_0 z_{t-1} + \Sigma_{i=1 \text{ to } n} \beta_i \, \Delta Y_{t-i} + \Sigma_{j=1 \text{ to } m} \tau_j \, \Delta X_{t-j} + v_t \tag{6}$$

where z_{t-1} is the error correction term [$z_{t-1} = Y_{t-1} - \alpha X_{t-1}$; α being the estimated coefficient from the cointegration regression (4)], n and m are the optimal number of lags for the lagged dependent and independent variables, respectively, and v_t is error term.

The results of eq. (6) provide a test of the relationship between changes in the Eurodollar deposit rate (Y_t) and lagged changes in the Eurodollar futures rate (X_t). This equation enables one to test whether the futures price is able to forecast the future spot price. If the futures market performs the price discovery function properly, the futures rates would be expected to have significant effects on the spot rates.

In estimating the eq. (6), an appropriate lag length must be selected for the lag variables of ΔY_{t-i} and ΔX_{t-j}. A variety of operational solutions to the problem of choosing the optimal lag length are available in the literature. Most of these solutions [Akaike (1974); Amemiya (1980); Mallows (1973); Parzen (1977)] are designed to minimize the mean square of error of prediction. Geweke and Meese (1981) find no significant differences between the results of these methods. In this study, an optimal lag length is selected using Akaike's final prediction error (FPE) method, which minimizes the values of

$$\text{FPE} = [(T + g + 1)/(T - g - 1)](\text{SSE}/T) \tag{7}$$

where T is the number of observations, and g is the number of lags in the autoregression. This criterion is widely used in the literature [e.g., Fung and Lie (1990); Hsiao (1981)].

To apply the Akaike test, the optimal order of β_i's in eq. (6) is first determined by constraining all τ to zero. Then, autoregressions containing from 1 to 20 lags are estimated and the FPEs compared. After obtaining the optimal lag of β_i, the optimal lag terms of τ_j using FPEs from $m = 1$ up to $m = 20$ are estimated.

[3]Many criteria are suggested by Engle and Granger (1987) to test for cointegration. However, they recommend the ADF test.

Once the model with optimal lags is estimated for the period 1983–1990, the changes in the cross market terms, X variables, are tested to determine whether there is any significant impact on changes in the Y variable. This hypothesis can be tested using a Wald test. An error correction model [eq. (6)] is estimated in its restricted form (R) (that is, with the coefficients on lagged cross market terms constrained to zero). The model is then estimated in its unrestricted form (U) by removing the constraint. The Wald test is applied to assess the significance of the unconstrained terms.[4]

One important issue raised in the literature is that the relationship between the forward rate and future spot rates may change over time. Fama (1984) demonstrates the existence of time varying risk premium in the T-bill and T-bond markets while Barnhart and Szakmary (1991) show the time varying premiums in the currency forward markets. Furthermore, the forecasting results reported by Bessler and Covey (1991) on U.S. Cattle Futures Prices using the error correction model are consistent with time varying risk premium properties. Following Barnhart and Szakmary's (1991) study, the study also uses Quandt's (1958) likelihood ratio test to determine the most likely break point in the ECM so as to divide the whole sample into two periods. The model is estimated for the entire sample period, and then re-estimated for each of two subperiods. Then, by comparing the statistics of the two subperiods and the entire period, the Chow test is used to examine whether any structural changes have taken place over the test period.[5]

EMPIRICAL RESULTS

Eurodollar deposits are U.S. dollar deposits held in a commercial bank outside the United States, either a foreign bank or a foreign branch of a U.S. bank. London dominates the Eurodollar deposit market; thus, rates in this market are based on the London Interbank Offer Rate (LIBOR) from five major banks.

Eurodollar futures contracts are traded at the International Monetary Market (IMM) and at the London International Financial Futures Exchange (LIFFE). The contract is based on a 3-month, $1 million Eurodollar time deposit, and it is a cash settlement contract. Garbade and Silber (1983b) document the importance of cash settlement, maintaining that cash settlement improves the contribution of futures contracts to economic welfare.

Eurodollar futures contracts traded at the IMM are used here because that market is more active. The final settlement price is determined by the Clearing House. The settlement price is based on quotes from 12 reference banks, all major banks in the London Eurodollar market. The two highest and the two lowest quotes are eliminated; the arithmetic mean of the remaining eight quotes is used then for the settlement process.

[4]The Wald test statistic (which is also called the incremental F test) is calculated as:

$$[\mathrm{SSE}(R) - \mathrm{SSE}(U)]/\mathrm{SSE}(U)] * [df(U)/(df(R) - df(U))]$$

where SSE(R) is the sum of squares of error for the restricted version, U denotes the unrestricted version, and df is the degree of freedom.

[5]The Chow test statistic is computed as:

$$[\mathrm{SSE}(1 + 2) - ((\mathrm{SSE}(1) + \mathrm{SSE}(2)))/(k + 1)]/[(\mathrm{SSE}(1) + \mathrm{SSE}(2))/(n_1 + n_2 - 2k - 2)$$

where SSE(i) is the sum of squares of error for the ith period; k is the number of dependent variables; and n_1 and n_2 are the number of observations for the first and second periods of the observations [see Maddala (1977)].

Daily observations for the 3-month Eurodollar deposit rates and the nearby Eurodollar futures rates are from the *Wall Street Journal*.[6] The study covers the period from the beginning of 1983 to the end of 1990.

Results on the Unit Root Tests

The results of the unit root test as specified in eq. (3) for the level and the first difference of the interest rates are reported in Table I. In panel (a), the magnitude and significance of the b_1 coefficients for each series show that the hypothesis of stationarity is rejected for both the level of futures and its deposit rates. This result suggests that the futures and deposit rates are nonstationary. This is not surprising. Goldenberg (1989) and Herbst, McCormack, and West (1987) found nonstationarity of futures prices for the agricultural commodities markets and stock indices, respectively.

In panel (b), each series of first differences in the interest rates displays stationarity, as indicated by the large negative ADF t-values on the b_1 coefficients. These results demonstrate that the futures and the deposit rates are integrated in the first order [i.e., $I(1)$]. The results of unit root tests (not reported here) are robust for inclusion of higher lags (up to 15 lags).

Results on Cointegration Tests

The results of the OLS cointegration regression for eq. (4) and for eq. (5) using four lags are reported in Table II. The relevant ADF t-statistics on the ϕ coefficients are −9.13 and −9.70 for the futures and the deposit rates, respectively. These statistics are less than the critical value of −3.77 at the 1% level, confirming the presence of cointegration

[6]The Eurodollar rates are price quotes at the end of the day in London while the futures settlement prices are quotes at 2:00 PM Chicago time, which is 8:00 PM London time. Thus, the quotes are recorded at different times. Because this study employs an error correction model that involves the use of differencing and lagged variables, the bias due to data nonsynchronization is minimized.

Table I
RESULTS OF UNIT ROOT TESTS FOR DAILY EURODOLLAR FUTURES AND DEPOSIT RATES, 1983–1990

(a) Test for the Level of Rates

Dependent Variable	b_1	ADF t-Ratio for b_1	b_2	b_3
Futures	−0.003	−1.563	−0.196	−0.015
Deposit rate	−0.003	−1.484	−0.290	−0.094

(b) Test for the First Difference of Rates

Dependent Variable	b_1	ADF t-Ratio for b_1	b_2	b_3
Futures	−1.189	−27.26[a]	−0.009	−0.021
Deposit rate	−1.406	−30.13[a]	0.113	0.014

[a]significant at 5% level. The critical values for this ratio using 5% significant level for n(sample size) = 500 and infinity are −2.87 and −2.86, respectively.

Table II
RESULTS OF THE COINTEGRATION TESTS FOR EURODOLLAR FUTURES AND DEPOSIT RATES, 1983–1990

Dependent Variable	c	α	R^2	ADF-t Value for ϕ (with 4 Lags)
Futures	−0.259	1.045	0.964	−9.74
	(0.038)	(0.004)		
Deposit rate	0.548	0.922	0.964	−9.70
	(0.037)	(0.004)		

The above parameters are obtained for the following equation [eq. (4) in text]: $y_t = c + \alpha X_t + u_t$; standard deviations are in parentheses. The critical value for ϕ [eq. (5) in text: $\Delta u_t = \phi_1 u_{t-1} + \Sigma_{i=1 \text{ to } n} b_i \Delta u_{t-i} + e_t$] at the 1% level is −3.77 [Engle and Granger (1987, p. 268)].

between the Eurodollar futures and its cash markets. The results of cointegration are robust for inclusion of more lagged variables; but are not reported here.

The cointegration relationship between the Eurodollar futures and deposit rate is tested using eq. (4) with the constraints that $c = 0$ and $\alpha = 1$. It is found that ϕ [with an intercept included in eq. (5)] is −11.14, a result supporting cointegration between these two markets after controlling the effects of other factors that may affect the intercept and slope of the cointegration relationship. An error correction model is used then to analyze the relationship between the Eurodollar futures and Eurodollar time deposit rates.

Results on Error Correction Model

Table III reports the estimation results of the optimal error correction model for the Eurodollar futures and Eurodollar deposit rates over the entire sample period. For the deposit rate model (i.e., deposit rate is used as the dependent variable), the optimal lag structure consists of 16 lagged deposit rate terms and 6 lagged futures rate terms. The adjusted R^2 is 8.9%. The residuals in both regressions appear to be white noise. DW statistics are about 2.0. An important result is that the z_{t-1} is significant at a 5% level, which supports the use of ECM instead of the VAR model that ignores this error correction term. The Wald test suggests that the futures rates have a statistically significant effect on the spot rate (deposit rate) at any conventional significance level. This result supports the price discovery hypothesis of the futures market, a finding consistent with previous studies [e.g., Oellerman and Farris (1985); Herbst, McCormack, and West (1987)].

The optimal lag for the futures rate model contains one lagged variable for the futures rate and six lagged variables for the deposit rates. The adjusted R^2 is 10.1%, a result similar to the deposit model. The coefficient for the error correction term (i.e., z_{t-1}) is highly significant at a 5% level. The Wald test statistic is 6.54, which is statistically significant at any conventional significance level. Since this test suggests that historical spot rates have a significant influence on the futures rate, a form of feedback appears to have occurred between the futures and cash markets during these time periods. This result is similar to that of Oellermann and Farris (1985), who examine live beef cattle prices. As previously noted by Granger (1986) and confirmed by the error correction model above, if two prices on different assets are cointegrated, part of the price changes will, in general, be predictable. Garbade and Silber (1983a) also support the presence of feedback effects from both markets.

Table III
ESTIMATION OF THE ERROR CORRECTION MODEL WITH OPTIMAL LAGS FOR THE EURODOLLAR FUTURES AND EURODOLLAR DEPOSIT SPOT RATES, 1983–1990

	Dependent Variable (ΔY)	
Coefficient	**Deposit Rate**	**Futures Rate**
Constant	−0.024 (−3.19)[a]	0.023 (5.60)[a]
z_{t-1}	−0.043 (−3.32)[a]	−0.092 (−8.07)[a]
ΔY_{t-1}	−0.240 (−9.58)[a]	−0.179 (−8.07)[a]
ΔY_{t-2}	−0.078 (−3.08)[a]	
ΔY_{t-3}	−0.008 (−0.32)	
ΔY_{t-4}	−0.040 (0.03)	
ΔY_{t-5}	0.037 (1.47)	
ΔY_{t-6}	0.012 (0.02)	
ΔY_{t-7}	−0.036 (−1.50)	
ΔY_{t-8}	−0.007 (−0.32)	
ΔY_{t-9}	0.041 (1.74)	
ΔY_{t-10}	0.004 (0.17)	
ΔY_{t-11}	−0.019 (−0.84)	
ΔY_{t-12}	−0.004 (−1.80)	
ΔY_{t-13}	−0.023 (−1.01)	
ΔY_{t-14}	0.041 (1.84)	
ΔY_{t-15}	0.002 (0.11)	
ΔY_{t-16}	0.012 (0.62)	
ΔX_{t-1}	0.089 (3.90)[a]	0.014 (0.57)
ΔX_{t-2}	0.039 (1.70)	0.053 (2.20)[a]
ΔX_{t-3}	0.009 (0.37)	0.067 (2.80)[a]
ΔX_{t-4}	−0.026 (−1.13)	0.096 (4.03)[a]
ΔX_{t-5}	0.039 (1.70)	0.116 (4.98)[a]
ΔX_{t-6}	0.038 (1.74)	0.081 (3.65)[a]
adj R^2	0.089	0.101
F	9.59	29.57
DW	1.99	2.00
Wald test	3.76	6.54
d.f.	(6,1997)	(6,2022)
Sig. level	0.001	0.000

[a]denotes significance at a 5% level. The lags used above are determined by the Akaike criterion. The Wald test is used to test the impact of cross market terms on the dependent variable; d.f. denotes degree of freedom.

The results of the Quandt/Chow tests of structural change in the parameters are reported in Table IV. The breakpoint for the deposit rate (in 1985) comes much earlier than for the futures rate (in 1987), implying that the behavior of the spot rate changes earlier

Table IV
QUANDT/CHOW TESTS FOR STRUCTURAL CHANGE IN THE ERROR CORRECTION MODEL (ECM) AND COINTEGRATING RELATIONSHIP IN THE EURODOLLAR FUTURES AND EURODOLLAR DEPOSIT RATES, 1983–1990

(a) Quandt's Log of Likelihood Ratio

Model	Minimum	Breakpoint
Deposit rate	−202.9	1985/2/13
Futures	−26.76	1987/7/28

(b) Chow Test on Error Correction Model

Model	F-Value	d.f.	Sig. Level
Deposit rate	17.65	(23,1956)	0.000
Futures	7.14	(8,2008)	0.000

(c) Chow Test on Cointegrating Relationship

Model	F-Value	d.f.	Sig. Level
Deposit	26.29	(2,2034)	0.000
Futures	116.8	(2,2034)	0.000

Quandt's log of Likelihood Ratio is defined as

$$L_t = 0.5t\ln\sigma^2{}_1 + 0.5(T - t)\ln\sigma^2{}_2 - 0.5T\ln\sigma^2{}_T$$

where $\sigma^2{}_1$, $\sigma^2{}_2$, and $\sigma^2{}_T$ are the ratios of the residual sums of squares to the number of observations when the regression is fitted to the first t observations, the next $T - t$ observations, and the entire T observations. d.f. denotes degree of freedom. The Chow test is used to determine the significance of the structural change during the entire period.

than the futures rate. The Quandt/Chow test rejects stability in the error correction model and the cointegration relationship for both futures and deposit rates markets. The results (in Table IV, panel c) for the cointegrating relationship in both deposit and futures models may suggest a change in the long-run equilibrium in both markets.

Ashley's (1984) test is used to examine the temporal stability of the error correction term (which reflects the long-run adjustment) in the ECM. In this test, the sample is split into two subperiods and dummy variables are used on the error correction term in the ECM. An F-statistic is used to test whether the coefficient for the error correction term [i.e., β_0 in eq. (6)] is the same for the first subperiod and the second subperiod. The results (using Ashley's test) reported in Table V indicate that the F value testing for stability of the error correction term in the deposit rate model is significant at a 5% level. However, the stability of the error correction term in the futures rate model cannot be rejected as a 5% level.

In general, the results of the Quandt/Chow test and Ashley's test imply instability in both the error correction term and the lagged variables in the deposit rate market. However, instability is found to occur only in the lagged variables in the futures market.[7]

[7]Although there is a structural change in the cointegration relationship, Ashley's Test supports stability in the error correction term. The result is probably due to the incorporation of lagged terms in the ECM, which take into consideration the short-run changes in the adjustment process between futures and cash prices over time.

Table V
ASHLEY'S TEST ON STABILITY FOR THE ERROR CORRECTION TERM IN THE ERROR CORRECTION MODEL, 1983–1990

Market	F-Value	d.f.	Sig. Level
Deposit	6.20	(1,1995)	0.013
Futures	3.48	(1,2020)	0.062

d.f. denotes degree of freedom. In Ashley's F-test, we compare eq. (6) in text and also the following equation: $\Delta Y_t = \alpha_0 + \Sigma_{i=1,2}\beta_{0(i)}D_i z_{t-1} + \Sigma_{i=1 \text{ to } n}\beta_i \Delta Y_{t-i} + \Sigma_{i=1 \text{ to } m}\Delta X_{t-j} + v_t$; where D_i is the dummy variable for the ith period. The null hypothesis is that $\beta_{0(i)}$ is the same for both periods.

The instability found in these markets is probably due to the time varying risk premium in their pricing relationship and the large increase in the Eurodollar futures trading in 1985 and 1987, as illustrated in Siegel and Siegel (1989, p. 205). Therefore, the pricing behavior of these two markets in both subperiods needs to be analyzed.

Results on Subperiod Analysis

Several results of the subperiod sample analysis are noteworthy. The results of the ADF tests (not reported here) indicate that interest rates in both the cash and futures markets have a unit root but are stationary after first differencing in both subperiods. Panel (a) in Table VI reports the results of the cointegration test showing that both markets are cointegrated in both subperiods.

The optimal lag structures for cash and futures markets in each subperiod are found to differ from the entire sample period. Panel (b) in Table VI reports these results. In both subperiods, the error correction term, z_{t-1}, and the cross market terms are found to have a significant impact on the dependent variable.

The results of the subperiod analysis indicate that the relationship between the Eurodollar futures and its underlying cash markets is not constant. The changing relationship between these two markets is consistent with the evidence of the time varying risk premium as documented in other studies on different commodities [e.g., Fama (1984); Barnhart and Szakmary (1991)].

CONCLUSIONS

This study analyzes the pricing relationship between interest rates in the Eurodollar futures and its time deposit markets. The results of the analysis indicate that these two interest rate markets are cointegrated.

The analysis from the ECM supports the price discovery function of the Eurodollar futures market; that is, the futures market provides useful information on the future spot market movement. Since historical spot rates are found to predict futures rates, this result indicates that there is a feedback effect from the crash market price to futures prices.

Finally, the relationship between the Eurodollar futures and deposit markets is found to change over time. This result is likely due to the time varying risk premium in these markets.

Since this study finds that prices in both these markets are cointegrated, it should be worthwhile to focus future research on the forecasting aspect of the futures market as suggested by Bessler and Covey (1991). Furthermore, as shown in this study, forecasting

Table VI
RESULTS OF THE COINTEGRATION TESTS AND ERROR CORRECTION MODEL FOR EURODOLLAR FUTURES AND DEPOSIT RATES IN TWO SUBPERIODS

(a) Cointegration Test

Dependent Variable	Period[a]	c	α	ADF-t Values for ϕ (with 4 Lags)[b]
Futures	I	−0.307	1.058	−8.62
		(0.042)	(0.005)	
	II	(0.480)	0.947	−5.69
		(0.085)	(0.010)	
Deposit Rate	I	0.134	0.957	−4.89
		(0.130)	(0.012)	
	II	0.353	0.949	−7.91
		(0.050)	(0.006)	

(b) Error Correction Model Estimates

Dependent Variable	Period	Optimal Lag Structure[c]
Futures	I	(1,6)
	II	(11,1)
Deposit	I	(15,1)
Rate	II	(15,1)

[a]For both the cash and futures markets, the first (I) and second (II) subperiods corresponds to the period before and after the break point reported in Table IV, respectively.

[b]The above parameters are obtained for the following equation [eq. (4) in text]: $Y_t = c + \alpha X_t + u_t$; standard deviations are in parentheses. The critical value for ϕ [eq. (5) in text: $\Delta u_t = \phi_1 u_{t-1} + \Sigma_{i=1 \text{ to } n} b_i \Delta u_{t-i} + e_t$] at the 1% level is −3.77 [Engle and Granger (1987), p. 268].

[c]The first number denotes the optimal lag for the dependent variable; the second number, the lag structure for the cross market variable.

research should include the issue of the time varying risk premium even though it makes accurate forecasting more difficult.

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