THE ROLLING SPOT FUTURES CONTRACT: AN ERROR CORRECTION MODEL ANALYSIS

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A new instrument for the management of foreign exchange risk, the rolling spot futures contract, was introduced by the Chicago Mercantile Exchange in 1993. It provides an alternative to the use by traders of the interbank spot and currency swap markets for rolling forward speculative spot foreign exchange positions. Because it produces the same impact on a trader's profit-and-loss position as do interbank spot and swap transactions, the rolling spot futures contract is the economic equivalent of that market. Consequently, the rolling spot futures rate and the interbank spot rate should move together, providing no opportunity for arbitrage.

The objective of this investigation is to study the stochastic dynamic relationship between the spot exchange rate and the rolling spot futures exchange rate for the British pound (BP) and the Deutsche mark (DM). The theory of cointegration, introduced by Granger (1981) and further developed by Engle and Granger (1987), is employed to investigate the short-run and long-run relationship. Since the rolling spot futures contract is a recent innovation, the present work represents an initial study of its characteristics.

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The article is organized as follows. The first section describes the equivalence between interbank spot/swap trading and the rolling spot futures contract. The data and methodology used in this study are then discussed and the empirical evidence is presented. Arbitrage opportunities do not exist. It is shown that the spot exchange rate and the rolling spot futures exchange rate are integrated processes. It is also found that the spot exchange rate shares a long-run relationship with the rolling spot futures exchange rate. An appropriate error correction model (ECM) is estimated and found to be potentially informative in forecasting the spot exchange rate based on the rolling spot exchange rate.

THE INTERBANK MARKET AND THE ROLLING SPOT FUTURES CONTRACT

In the interbank market much of the trading in foreign currencies is done for the purpose of earning speculative profits, with the remaining trading undertaken to meet the needs of bank customers. Spot currency transactions for the purchase of one currency and the sale of another are completed on the value date, which is two days following the trade date. A trader can close out his/her spot position by transacting an offsetting spot trade to be settled on the same value date, with the resulting profit or loss determined by the spot rates at which the two transactions are undertaken. Alternatively, the trader may wish to keep his position open beyond the trade date in expectation of a favorable exchange rate movement. Instead of using a second spot transaction to close out his original position, the trader can "roll forward" this position past the value date by use of a currency swap, which involves simultaneously selling (buying) a currency in a spot market transaction and buying (selling) an identical amount of the currency in a forward transaction. The swap thus offsets the value date cash flows and moves the outright spot foreign exchange position forward one day. The forward rate for the swap is obtained by adjusting the spot rate for the swap points, which are calculated from the interest rates at which the two currencies can be borrowed/loaned overnight. When the position is closed out, the profit which is realized is determined by the change in the outright spot rate (foreign exchange risk) and by the cost of rolling the spot position from one day to the next (interest rate risk). The spot foreign exchange position can be rolled forward from one day to the next via a series of currency swaps until the trader closes out his position.

The rolling spot futures contract provides the trader with an alternative approach, which allows him to closely match the flows and outcome of a spot/swap strategy in the interbank market, while avoiding some of the problems of the interbank market. Contracts are available for three currencies: the Deutsche mark, the Japanese yen (contract size $250,000 for each currency), and the British pound (contract size L250,000). They are on a March, June, September, and December contract cycle, with maturities on the third Wednesday of the month.

In the interbank currency market, several sources of risk are present which inhibit forward trading, including entry–exit risk, settlement risk, and credit risk, as well as transactions costs. Traders operate in this market via privately negotiated transactions in which they may not have full access to all counterparties and, thus, may not be able to get the best available price. When closing an existing position, the trader may receive a less-than-optimal price from the original counterparty. Also, unwinding with another counterparty may require posting substantial credit lines. Further, settlement risk arises from the possibility of error in the settlement process. Default risk may also be potentially significant. In contrast, the rolling spot contract eliminates counterparty risk, since the exchange is the counterparty for all contracts. The clearinghouse arrangement also provides price transparency and easy entry and exit and does not use up bank credit lines.

The rolling spot contract is unusual in that while it is a futures contract, it trades on spot terms and at a spot price. Theoretically, there should not be any difference between the rolling spot contract and the interbank spot rate. Consequently, the basis risk should be minimal. However, market microstructure and trading mechanics may induce some inefficiencies. Thus, while the outcome from a position in rolling spot futures contracts will closely match that of a spot/swap strategy in the interbank market, there are several differences. In the interbank market, a trader's profit-and-loss position is affected by changes in the spot exchange rate with a delay of two business days and by the swap rate after three days, while daily profits and losses are cashed the next business day in the futures market via the settlement process of the clearinghouse. Second, profits from an interbank rolling spot position will depend on the spot rate at the times the transactions are undertaken, with swap points negotiated between traders. Profits and losses from a position in the rolling spot futures contract will depend on the exchange rate at which the contract settles at the end of the day, as well as on the swap points as set by the clearinghouse. The latter are determined by a random survey of swap dealers done at 11:00 AM (Chicago time) daily. Allowing for these small differences, the rolling spot futures contract produces the same impact on the trader's profits and losses as does his interbank spot and swap activity. Further, the currency flows are reduced from the full amount of the spot/swap transactions to the settlement variation flows.[1]

Rolling spot contracts can also be combined with other instruments to increase the variety of trading opportunities in the foreign exchange markets. In particular, rolling spot contracts are often combined with exchange-traded currency forward futures contracts for purposes of interest-rate differential trades. Currency forward contracts are, in effect, inverted futures contracts. Thus, a long position in a German mark forward contract, for example, gains if the U.S. dollar rises in value against the mark before expiration of the contract, which is the opposite of the result from a currency futures position. By combining a position in a rolling spot contract with the opposite position in the currency's forward contract, exposure to foreign exchange movement can be eliminated, creating a trade on changes in the interest rate differential for the two currencies.

DATA AND METHODOLOGY

The data analyzed consist of a sample of daily spot exchange rates and rolling spot futures exchange rates for the BP and the DM. These rates were obtained from the Knight Ridder News Service for the period from June 14, 1993, through May 17, 1994, for the BP and from September 14, 1993, through June 20, 1994, for the DM. There are 226 and 195 observations for the BP and the DM, respectively. The first 170 observations are used for model estimation and the remaining 56 and 25 observations are used for out-of-sample forecasting for the BP and the DM, respectively. Similar data were not available for the Japanese yen.

Usually financial and/or economic time series are found to be nonstationary in their levels. Using nonstationary series in statistical estimation can lead to spurious regressions [Granger and Newbold (1974)]. Traditional modeling uses differenced series, which is likely to remove the potentially valuable long-run relationship. Engle and Granger (1987) demonstrate that if two time series are nonstationary and integrated of order one but their linear combination is stationary, they are cointegrated. If a dynamic regression uses first differences, then the model is misspecified because it leaves out the error correction term as well as the short-run dynamics. As such, it fails to take into account the effect of last period's equilibrium error on the magnitude and direction of subsequent

[1]For discussion of interbank spot/swap currency trading see Riehl and Rodriguez (1983) and Bishop and Dixon (1992); the present comparison with the rolling spot futures contract draws also on information provided by the CME.

price changes. If the regression model employs variables in percentage form, it will be misspecified because it ignores the lagged values which capture the short-run dynamics. The modeling framework used in this investigation allows for nonstationarity and incorporates both the short-run dynamics and the long-run relationship.

A variable, y_t, is integrated of order one [i.e., $I(1)$] if it requires differencing once to make it stationary. Consider two time series, x_t and y_t, which are both $I(1)$. Generally speaking, any linear combination of x_t and y_t will be $I(1)$. However, if there exists a linear combination, $z_t = y_t - \alpha - \beta x_t$, which is $I(0)$, then x_t and y_t are cointegrated, according to Engle and Granger, with the cointegrating parameter, β. Cointegration links the long-run relationship between integrated financial variables to a statistical model of those variables.

To test whether the series are cointegrated, it is necessary to check that each series is $I(1)$. Testing for unit roots is conducted by performing the augmented Dickey–Fuller (ADF) regression [Dickey and Fuller (1981)], which can be written as:

$$\Delta y_t = a_0 + a_1 y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta y_{t-i} + \varepsilon_t \tag{1}$$

where p is large enough to ensure that the residual series, ε_t, is white noise. The ADF test loses its power for sufficiently large values of p. An alternative test proposed by Phillips and Perron (PP) (1988), which allows weak dependence and heterogeneity in disturbances, is performed using the following regression:

$$y_t = b_0 + b_1 y_{t-1} + u_t \tag{2}$$

where u_t is white noise.

Testing for cointegration is performed once it is found that each series contains one unit root. Test statistics utilize the residuals from the following cointegrating regression:

$$S_t = a_0 + \beta \mathrm{RP}_t + e_t \tag{3}$$

S_t and RP_t stand for the spot exchange rate and the rolling spot futures exchange rate, respectively, at time t.

The e_t will be $I(0)$ if the two series are cointegrated. The ADF test is performed on the estimated residuals, e_t, from eq. (3),

$$\Delta e_t = a e_{t-1} + \sum_{j=1}^{q} \phi_j \Delta e_{t-j} + v_t \tag{4}$$

where q is large enough to make v_t white noise. The estimated residuals are also subjected to the following PP test,

$$e_t = a + \beta e_{t-1} + \gamma_t \tag{5}$$

where γ_t is white noise.

Once it is shown that the series are cointegrated, their dynamic structure can be exploited for further investigation. Engle and Granger prove that cointegration implies and is implied by the existence of an error correction representation of the series involved. ECM abstracts the short and long-run dynamics in modeling the data. The relevant ECM to be estimated is given by

$$\Delta S_t = a + \alpha e_{t-1} + \sum_{i=1}^{m} \gamma_i \Delta S_{t-i} + \sum_{j=1}^{n} \delta j \Delta \mathrm{RP}_{t-j} + u_t \tag{6}$$

where m and n are large enough to make u_t white noise.

Engle and Granger propose a two-step procedure for the estimation of the parameters of model (6). First, S_t is regressed on RP_t using ordinary least squares (OLS) and the residuals are collected [model (3)]. The ECM with the appropriate specification of the dynamics is estimated by OLS in the second stage. The values of m and n are chosen by the Akaike information criterion (AIC) [Akaike (1974)].

The existence of an error correction model implies causality between the series, which means that the model can be used for forecasting. The ECM is expected to provide better forecasts than those from a naive model. The forecasting performance of the ECM will be compared to that of a benchmark naive model by means of the root mean squared error (RMSE). The naive method uses as a forecast the most recent information available concerning the actual value. The forecasting equation is

$$F_{t+i} = x_t \tag{7}$$

where F_{t+i} = the forecast for period, $t + i$,

t = the present period,
i = the number of periods ahead being forecast, and
x = the latest actual value (for period t).

EMPIRICAL FINDINGS

It is useful to look at some basic statistics for the returns of each series before the results of the tests of the unit root process and cointegration

TABLE I

Summary Statistics for British Pound (BP) and Deutsche Mark (DM)

	BPS	*BPRS*	*DMS*	*DMRS*
Mean	−0.0039	−0.0043	−0.0037	−0.0032
Std. Dev.	0.0408	0.0425	0.0404	0.0425
Skewness	0.4844	0.3999	0.3201	0.3046
Kurtosis	1.1273	1.0048	0.8192	1.0631
Maximum	2.0350	2.0772	1.7423	1.9669
Minimum	−1.6302	−1.8018	−1.5057	−1.7933

Summary Statistics: British pound spot rate (BPS) and rolling spot futures exchange rate (BPRS), 226 observations for the period, June 15, 1993, through May 17, 1994; Deutsche mark spot rate (DMS) and rolling spot futures exchange rate (DMRS), 195 observations for the period, September 14, 1993, through June 20, 1994. The returns are computed as $\mathrm{Log}(S_t/S_{t-1}) \cdot 100$, where S_t is the corresponding exchange rate.

TABLE II

Difference Between Log Price Changes of Spot Rate and Rolling Spot Futures Exchange Rate for British Pound (BP), 226 Observations, and Deutsche Mark (DM), 195 Observations

	BP	*DM*
Mean	0.0004	−0.0005
t-Statistics	0.0303	−0.0530

are presented. These are shown in Table I. From these statistics it is clear that the returns are not close to a normal distribution. The kurtosis of each of these currencies is far from 3. This is consistent with the literature.

Since the rolling spot futures contracts are the economic equivalent of the interbank spot exchange rate, it is reasonable to expect that there cannot be a statistically significant difference between the returns generated from investing in the spot exchange rate and the corresponding rolling spot futures exchange rate. A significant difference allows investors to profit from exploiting the arbitrage opportunities. Table II presents the mean of the difference between the spot and futures returns and their corresponding t-statistics. The results are consistent with this study's expectations. The evidence shows that there is no arbitrage opportunity and that this new instrument serves its intended economic role in risk management.

All the spot exchange rates and the rolling spot futures exchange rates are tested to ensure they are integrated of order one. The results of

TABLE III

Augmented Dickey-Fuller (ADF) and Phillips Peron (PP) Unit Root Tests

	BP		*DM*		*Critical Value (10%)*
Levels	ADF	PP	ADF	PP	
Spot	−1.87	−3.40	−1.72	−2.51	−2.57
Rolling spot	−1.85	−3.46	−1.75	−2.52	−2.57
Differences					
Spot	−4.26	−15.16	−5.13	−13.04	−2.57
Rolling spot	−5.35	−15.75	−3.77	−13.77	−2.57

Augmented Dickey–Fuller (ADF) and Phillips Perron (PP) tests for a unit root in the autoregressive representations of the daily interbank spot exchange rate and the rolling spot futures exchange rates for the British pound (BP) and the Deutsche mark (DM) for the time period, June 15, 1993, through May 17, 1994, for the BP and September 14, 1993, through June 20, 1994, for the DM, respectively. There are 226 observations for the BP and 195 observations for the DM. For each currency 170 observations are used for model estimation, and the remaining 56 and 25 observations are employed for out-of-sample forecasts for the BP and the DM, respectively. Critical values are taken from MacKinnon (1991).

TABLE IV

Augmented Dickey-Fuller (ADF) and Phillips Peron (PP) Cointegration Tests

Regressand: Interbank Spot	*Regressor: Rolling Spot*		*Critical Value (10%)*
	ADF	PP	
BP	−3.69	−8.99	−3.04
DM	−3.49	−14.99	−3.04

Augmented Dickey–Fuller (ADF) and Phillips Perron (PP) tests for cointegration between the daily interbank spot exchange rate and the rolling spot futures exchange rate for the BP and the DM for the time period, June 15, 1993, through May 17, 1994, for the BP and September 14, 1993, through June 20, 1994, for the DM, respectively. The BP has 226 observations, 170 of which are used for model estimation, while the remaining 56 are employed for out-of-sample forecasts. The DM has 195 observations, 170 of which are used for model estimation, with the remaining 25 employed for out-of-sample forecasts. Critical values are taken from MacKinnon (1991).

the ADF and the PP tests are shown in Table III. With the exception of the PP test for the BP, the results indicate that the level series have a unit root in their autoregressive representations. This evidence suggests that the series are nonstationary. Next, the differenced series are checked for the presence of a unit root. The ADF and the PP tests clearly reject the null hypothesis of a unit root. This implies that the differenced series are stationary, i.e., $I(0)$. Therefore, the spot exchange rate and the rolling spot futures exchange rate are integrated of order one.

Since it is shown that each series is $I(1)$, it is necessary to test whether there exists a linear combination of the spot exchange rate and the rolling spot futures exchange rate that is $I(0)$. The series must be

TABLE V

Estimates of the Parameters From the Error Correction Model (6) for the Spot Exchange Rate, (S_t)

Regressor	*Model for ΔS_t*	
	Coefficient	SE
BP		
Constant × 10^{-3}	−0.1283	0.5201
e_{t-1}	−0.1460	0.3177
DM		
Constant × 10^{-3}	0.1700	0.4321
e_{t-1}	0.8891	0.5133

cointegrated if a long-run relationship exists between them. Results of the tests of cointegration are presented in Table IV. The evidence indicates that the spot exchange rate and the corresponding rolling spot futures exchange rate are cointegrated.

Cointegration suggests that the series have an error correction representation and, conversely, an ECM implies that the series are cointegrated [Engle and Granger (1987)]. The ECM (6) provides a parsimonious representation of the stochastic dynamic relationship between the series by expanding the available information set. For example, the last period's equilibrium error is incorporated through the error correction term.

Table V presents the estimates of the parameters of model (6). The intercept from model (6) is found to be statistically insignificant. This appears to imply the absence of a linear trend in the data-generation process. The error correction coefficient is negative and statistically insignificant. In three cases the coefficient of e_{t-1} is likely to be insignificant: (1) if the two series in the error correction equation are governed by the same external factors; (2) if the right-hand variable follows the equilibrium path set by the left-hand variable; and (3) if the frequency of observations is longer than the adjustment delay [Fritz (1989)].

Cointegration implies the existence of causality between the spot exchange rate and the rolling spot futures exchange rate changes. The estimated ECM is used to develop 56 and 25 one-step ahead forecasts for the BP and the DM, respectively. These forecasts are then compared and contrasted with the naive univariate forecasts. Table VI presents the summary statistics for these forecasts, where it is seen that the forecast standard deviation of the naive model is higher. The ECM has a relatively smaller forecast standard deviation, thus leading to a smaller root mean

TABLE VI

Summary Statistics for 56 and 25 One-Step-Ahead Forecasts for the Spot BP and the Spot DM, Respectively

Statistic	ΔS_t	
	Naive	ECM
BP		
Mean × 10^{-3}	0.1912	−0.1743
SD	0.0038	0.0001
RMSE	0.0105	0.0038
DM		
Mean × 10^{-3}	−1.3846	−0.1061
SD	0.0052	0.0008
RMSE	0.0070	0.0054

RMSE Ratio

Ratio	ΔS_t
ECM/Naive	
BP	0.36
DM	0.77

squared error. It is observed that the ECM outperforms the naive model. It can be inferred that changes in the rolling spot futures exchange rate cause changes in the spot exchange rate in subsequent periods. The ECM reduces the root mean squared error from that of the naive model by about 64% and 23% for the BP and the DM, respectively. This evidence reinforces the superiority of model (6) over model (7).

To summarize, the evidence presented in this article demonstrates that the ECM (6) is better than the naive model (7) in predicting the spot exchange rate. Out-of-sample forecasts reinforce this observation.

CONCLUDING REMARKS

This study has investigated whether or not the spot exchange rate and the rolling spot futures exchange rate share a long-run relationship. Each daily series is tested for the presence of a unit root in its autoregressive representation, and it is found that each series is integrated of order one. Next, the spot exchange rate and the rolling spot futures exchange rate are tested for the existence of an equilibrium long-run relationship. It is observed that the spot exchange rate is cointegrated with the rolling spot futures exchange rate.

Cointegration implies and is implied by the existence of an error correction model. As discussed earlier, the ECM [eq. (6)] integrates the short and long-run dynamics in modeling the data and proves to be an informative modeling technique compared to the naive method [eq. (7)]. The evidence from out-of-sample forecasts shows that the ECM is preferred to the naive model. The ECM reduces the RMSE of the spot exchange rate changes by a considerable margin, indicating that it would be more effective in forecasting the spot exchange rates. Investors, corporations, and others can benefit by using this framework in designing their investment, financing, portfolio management, and trading strategies. Useful future research can test the robustness of this framework in the presence of taxes and transaction costs.

The existence of an equilibrium long-run relationship between the spot exchange rate and the rolling spot futures exchange rate has implications with respect to the usefulness of the rolling spot futures contract. The introduction of this contract by the CME in 1993 created a new risk-management vehicle which is intended to be the economic equivalent of the interbank spot market. The evidence from cointegration and the error correction model developed here indicates that the rolling spot contract is fulfilling the purpose for which it was designed. This is borne out by the market's acceptance of the Deutsche mark and yen rolling spot contracts, although the British pound contract has generated less trading following the period of its introduction.[2]

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[2]This information is based on private communication with officials of the CME concerning the status of the British pound rolling spot contract.

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