Efficiency of Exchange Rate Determination: The Case of Kuwait

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Introduction

Most small open countries outside Europe continue to impose controls on foreign exchange and international capital flows. As a result, almost all research on the operation of foreign exchange markets has concentrated on large industrial countries that no longer impose such controls. Kuwait, however, provides an outstanding opportunity to study the foreign exchange market in a small country without restrictions on foreign exchange or international capital flows. In this paper we use this opportunity to evaluate the efficiency of the foreign exchange market for Kuwaiti dinar.

In an efficient market, traders, speculators and arbitrageurs can make only a normal rate of return. There is no economic profit from trading, speculation or arbitrage. The next section discusses the data and the following two sections test for profit in cross rate and covered interest rate arbitrage. The fourth section uses daily dinar exchange rates to examine the issue of excessive volatility in Kuwaiti exchange rates and the effect of official intervention in the market for Kuwaiti dinar. The fifth section takes up the issue of forward rates as predictors of future spot rates. The final section summarizes and presents our conclusions.

Data

The data used in this section are based on daily bid-ask quotes for inter bank dinar spot and three month forward prices of U.S. dollars, British pound sterling, German marks and Japanese yen, spot dollar prices of sterling, marks and yen, and three month interest rates for Kuwait, Britain, Germany, Japan and the United States. The quotes were supplied to us by The Gulf Bank and cover the period from January, 1984, through June, 1989.

Cross Rate Arbitrage

In an efficient foreign exchange market, competition should eliminate economic profit from cross rate arbitrage. Ignoring bid-ask spreads, equation (1) describes a typical equilibrium condition for cross rate arbitrage.

$$(\mathrm{KD}/\$)(\$/£) = (\mathrm{KD}/£) \tag{1}$$

The KD price of pound sterling must be consistent with KD price of dollars and the dollar price of pounds.

With bid-ask spreads, the equilibrium condition is a bit more complicated. For example, in order for there to be no arbitrage profit, the bid price for pounds in terms of dinar $(\mathrm{KD}/£)^B$ must be greater than the KD/$ offer rate $(\mathrm{KD}/\$)^O$ times the $/£ offer rate $(\$/£)^O$. If that condition does not hold, it is possible for an arbitrageur to buy dollars with dinar at the offer rate, use those dollars to buy pounds at the offer rate, and then sell those pounds at the bid rate for a dinar profit.

Using daily data we tested the efficacy of cross rate arbitrage for dinar prices of sterling, marks and yen. After adjusting for the bid-ask spread, there is no evidence of any profit from cross rate arbitrage. That is, for example, (KD/$)($/£) minus (KD/£) never exceeds the relevant bid-ask spread. This result indicates a highly organized market for Kuwaiti dinar because the bid-ask spread does not cover all the transaction costs. In stock markets for example, Demsetz (1968) estimates that total transaction costs are about 2.5 times the bid-ask spread.

Interest Rate Arbitrage

In an efficient market for foreign exchange, competition should eliminate any economic profit from interest rate arbitrage. Ignoring transaction costs, the following equilibrium condition should hold.

$$f_t - s_t = i_t - i_t^* \tag{2}$$

where, for example, f_t is the logarithm of the dinar price of dollars in the 3 month forward market, s_t is the logarithm of the dinar price of dollars in the spot market, i_t is the 3 month dinar interest rate in the inter bank market, and i_t^* is the 3 month interest rate for dollars in the inter bank market.

The net covered yield from arbitrage is the interest rate differential $i_t - i_t^*$ minus the forward premium $f_t - s_t$. Daily net covered yields using 3 month interest rates and forward exchange rates were calculated for Kuwait versus Britain, Germany, Japan and the United States. In each case, after adjusting for the effects of bid-ask spreads in a way similar to the one used in the last section, there were about three none zero net covered yields out of about 1,300 observations per exchange rate.

These results indicate that the inter bank market for Kuwaiti dinar is well organized and functions smoothly. But one must be careful in drawing conclusions about the operation of covered interest arbitrage in general from results derived from inter bank data. Coulbois and Prissert (1974) claim that in eurocurrency markets international banks routinely use spot and forward rates for dollars and U.S. interest rates to set other inter bank interest rates so as to make covered arbitrage unprofitable. If banks trading the dinar follow a similar strategy, then the absence of net covered yields may be more a reflection of institutional practice than effective arbitrage. We would have liked to have analyzed the relation between inter bank and domestic dinar interest rates, but we did not have daily interest rates from the Kuwait capital markets.

Behavior of Daily Exchange Rates

Excessive Volatility: The most common measure of volatility is the variance in the difference of the logarithm of exchange rates. Table (1) shows the variances for differences in logarithms of daily spot and forward exchange rates for the dinar and dollar versus Britain, Germany, and Japan, and the Kuwaiti dinar versus the U.S. dollar.[1] The most obvious feature of Table (1) is that the variance of the KD/$ is only one fifth or less of the variance of any of the other rates. This is probably the result of official intervention, which is discussed in the next subsection. For the dinar-dollar, spot rates are less volatile than forward rates, which is consistent with intervention in spot markets, but for dinar prices of other currencies the variance for spot and forward rates is about the same. In addition, dollar prices of marks, yen and pounds are more volatile than their corresponding KD prices.

TABLE (1)
VARIANCES FOR DIFFERENCES
IN LOGS OF DAILY EXCHANGE RATES

Exchange Rate	Spot Rates First Half	Spot Rates Second Half	Forward Rates First Half	Forward Rates Second Half
KD/$	0.041	0.053	0.051	0.061
KD/DM	0.512	0.278	0.531	0.278
KDIYen	0.219	0.241	0.229	0.244
KD/Pound	0.619	0.304	0.648	0.316
DM/$	0.738	0.496	NA	NA
Yen/$	0.380	0.493	NA	NA
$/Pound	0.790	0.480	NA	NA

Many politicians, business people and economists believe that fluctuations in exchange rates are excessive. But any attempt to evaluate the volatility of exchange rates requires some measure of appropriate volatility. In the absence of a generally acceptcd theory of the determination of exchange rates, no such measure can exist. The only alternative is to develop some reasonable benchmark for evaluating volatility. The most common method is to use the volatility implied by purchasing power parity. See for example, Frenkel and Mussa (1980) and Flood (1981).

But there are serious limitations in using PPP as a benchmark. One is that PPP is generally interpreted as a long-run theory. As a result, short-run deviations of actual rates from those implied by PPP do not imply 'excessive' volatility. Indeed, most interpretations of PPP assume that short-run adjustments require short-run deviations from PPP. Another limitation is that prices used in conventional wholesale and consumer price indexes are not auction prices. As a result, comparing the volatility of exchange rates to the volatility of ratios of price indexes is like comparing the volatility of the price of bread at a local grocery store in Chicago to the volatility of the price of wheat on the Board of Trade in Chicago.

Levich (1981), Bergstrand (1983), Frenkel and Goldstein (1988), and Bui`and Pippenger (1990) compare exchange rate volatility to the volatility of asset prices and prices of commodities in auction markets. Exchange rates are uniformly less volatile than other asset prices and commodity prices in auction markets. Their results raise serious questions about excessive volatility.

TABLE (2)
VARIANCES FOR DIFFERENCES
IN LOGS OF 3 MONTHS INTEREST RATES

Country	First Half	Second Half
Kuwait	13.18	13.83
Britain	2.57	1.52
Germany	2.21	3.35
Japan	2.01	2.29
United States	1.51	1.55

We do not have auction prices for comrnodities in Kuwait, but we do have daily interest rates that we can use as a benchmark. Table (2) shows the variances for differences in the logarithms of 3 month interest rates.[2] The smallest variance for interest rates is two or three times larger than the variance for the most volatile exchange rate in Table (1). These results are consistent with other comparisons of the volatility of exchange rates and other asset prices. Exchange rates may fluctuate more than ratios of price indexes, but they are less volatile than other auction prices.

The relatively large variance for Kuwaiti interest rates in Table (2) and the relatively low variance for dinar exchange rates in Table (1) suggests that stabilizing exchange rates may have amplified fluctuations in inter bank dinar interest rates. If interest rate arbitrage is effective, part of the shock from changes in foreign interest rates is absorbed by spot and forward exchange rates. But leaning against the wind in the dinar market for foreign exchange reduces the amount of the shock absorbed by the foreign exchange market and increases the amount of the shock that is passed through to domestic inter bank interest rates. How much the increased volatility in the inter bank market affects purely domestic interest rates depends on the strength of the link between the inter bank rates and the domestic market.

Stabilization: Officially the Kuwait dinar is pegged to an unspecified basket of currencies. But an examination of changes in daily exchange rates did not reveal any obvious pattem of relatively constant exchange rates punctuated by occasional discrete changes. Instead, the exchange rate behaves like a floating rate where the central bank leans against the wind.

As shown in Pippenger and Phillips (1973), leaning against the wind can reduce short- run volatility in exchange rates without affecting long-run movements. If exchange rates are martingales, in the absence of intervention, leaning against the wind introduces positive serial correlation at short lags into changes in exchange rates. Figures (1) to (3) report autocorrelation functions for daily changes in the log of various currencies for the second half of the period. Estimates for the first half are essentially the same. Figure (I) shows autocorrelation estimates for changes in the log of dinar prices of dollars. The estimate at lag one is positive and significant at well below the 5 percent level while longer lags are generally insignificant. This pattern is not present in other currencies. As an example of the autocorrelation functions for the other exchange rates, Figure (2) shows the autocorrelation estimates for dinar prices of marks and Figure (3) shows estimates for mark prices of the dollar. These estimates are consistent with the rates being martingales. This pattern suggests that the Kuwaiti authorities leaned against the wind in the dinar market for dollars, but not in dinar markets for other currencies.

Spectral density estimates provide another way of looking at the structure of a stochastic process. The spectral density function is the Fourier transform of the autocorrelation function. It describes how the variance in a series is distributed by frequency after that variance has been normalized to one. The advantage of this normalization over the spectrum is that it allows for a more direct comparison of the structure of different series just as in the time domain autocorrelation functions provide a more direct comparison than autocovariance functions. If the Kuwaiti authorities lean against the wind for dinar prices of dollars, but not other dinar exchange rates, then there should be a tendency for high frequency estimates, which correspond to the short run, to be lower for the dollar than other currencies and low frequency estimates, which correspond to the long run, to be higher for dollars than for other currencies.

Figure (4) shows spectral density estimates for changes in the log of dinar prices of dollars and, as an example of other dinar rates, spectral density estimates for changes in the log of dinar prices of marks. The estimates are for the second half of the period, but estimates for the first half are quite similar. Spectral density estimates for the yen and pound are quite similar to the one for the mark. Spectral density estimates are quite flat for the mark. Most estimates lie within a 95 percent confidence interval for white noise and there is no tendency for them to decline as frequency increases. Estimates for the dollar, however, lie above the upper limit at the two lowest frequencies and lie within or below the 95 percent confidence region at higher frequencies.[3] The results from the spectral densities suggest that the Kuwaiti authorities appear to be leaning against the wind with respect to dinar prices of dollars, but are not doing the same for dinar prices of other currencies. This interpretation also is consistent with the pattern in Table (I) where the volatility of the KD/$ is much less than the volatility of other KD rates.

Relationships between currencies also support this view. In general one would expect a positive relation between the KD prices of pounds, marks and yen, which is the pattern between KD prices of pounds, marks, and yen. Figure (5) shows the cross correlation function between dinar prices of marks and sterling for the last half of the period. The estimate at zero lag is positive and highly significant while estimates at almost all other lags are generally insignificant. The first half of the period shows a similar pattern as does the dinar price of yen versus dinar prices of pounds and marks for both sub periods. This pattern also holds for dollar prices of marks, yen and pounds in both sub periods. The cross correlation pattern for the dinar price of dollars versus the dinar price of marks, yen or pounds is the reverse. Figure (6) shows cross correlation estimates between log changes in dinar prices of dollars and marks for the second half of our data. Once again almost all the lags other than zero are insignificant, but for the zero lag the estimate is highly significant and negative. This pattern is consistent with the authorities leaning against the wind for the dinar price of the dollar, but not for other currencies. Consider the simple cross rate arbitrage equation used earlier.

$$(\mathrm{KD}/\$)(\$/£) = (\mathrm{KD}/£) \tag{1}$$

Suppose some shock causes dollars to appreciate 5 percent with respect to all other currencies. KD/$ rises 5 percent, $/£ falls 5 percent and KD/£ is unchanged. But if Kuwaiti authorities resist movements in the dinar price of dollars and KD/$ rises only 2 percent, then cross rate arbitrage requires that the dinar price of pounds fall by about 3 percent. Leaning against the wind can account for the contemporary inverse relation between changes in the dinar price of dollars and changes in dinar prices of other currencies.

Forward Rates as Predictors of Future Spot Rates

Theoretical Relationships: Almost all theoretical discussions of the relationship between forward rates and future spots rates use rational expectations. Given the assumption, which is usually implicit, that there are no information costs, rational expectations imply that expected future spot rates are unbiased predictors of actual future spot rates. For an excellent discussion of rational expectations, see Sheffrin (1983).

$$s_{t+1} = E[s_{t+1}/\Phi_t] + \epsilon_t \tag{3}$$

where s_{t+1} is the logarithm of actual spot rates at time $t+1$, E is the expectations operator, $E[s_{t+1}/\Phi_t]$ is the log of the expectation of the spot rate at $t+1$ conditional on the information Φ_t) available at time t, and ϵ_t is an uncorrelated random variable. In order to simplify notation, s^E_{t+1} is used in place of $E[s_{t+1}/\Phi_t]$. In this context it is legitimate to equate the economic concept of a market expectation with the mathematical concept of expectation because rational expectations assumes that a 'correct' model exists and that market participants behave as though they know that model.

If, in addition, markets are competitive, there are no transaction or adjustment costs and no intervention in forward markets, then uncovered interest parity described by equation (4) holds:

$$s^E_{t+1} = s_t + i_t - i^*_t - \pi_t \tag{4}$$

where i_t and i^*_t are domestic and foreign interest rates on assets with the same maturity as the expected future spot rate, these assets are identical in all respects except currency denomination, and π_t is a risk premium. Under these conditions, covered interest rate arbitrage described by equation (5) also holds.

$$f_t = s_t + i_t - i_t^* \tag{5}$$

Equations (3) through (5) imply that predictive errors equal the risk premium π_t plus the error term ϵ_t in equation (3).

$$f_t - s_{t+1} = \pi_t + \epsilon_t \tag{6}$$

Positive information, transaction or adjustment costs imply a much more complicated relationship between forward rates and corresponding future spot rates. The nature of that relationship depends on the characteristics of the various costs and how market participants respond to those costs. The difficulty of modelling the effects of these costs probably explains why they have generally been ignored. Since such an endeavor is far beyond the objectives of this paper, all we can say about such costs is that, at a minimum, they would introduce an additional error term e_t into equation (6). Without a formal model of the effects of transaction and adjustment costs, about the only restriction we could place on e_t is that it has a root less than unity. But even that weak restriction has some testable implications.

Standard Test Equations: Empirical research on forward rates as predictors of future spot rates concentrates on two test equations. Both ignore information, transaction and adjustment costs, and assume a zero risk premium and no intervention. The first simply regresses future spot rates against corresponding forward rates.

$$s_{t+1} = \alpha_0 + \alpha_1 f_t + z_t \tag{7}$$

Under the null hypothesis, which assumes no information, transaction or adjustment costs and no intervention or risk premia, α_0 is zero, α_1 is one, and z_t is uncorrelated.

Using mostly data between the United States and countries such as Canada, the UK. and Germany, estimates of α_0 usually are not statistically significantly different from zero and estirnates of α_1 normally are within two standard errors of unity. See Chiang (1988) for a critical discussion of these results. Since both spot and forward rates behave like martingales, equation (7) is subject to spurious correlation. As a result, current research usually normalizes equation (7) by subtracting current spot rates from both sides of the equation.

$$s_{t+1} - s_t = \beta_0 + \beta_1(f_t - s_t) + z_t \tag{8}$$

Under the null hypothesis, β_0 is zero and β_1 is unity because market forecasts of changes in spot rates $f_t - s_t$ are unbiased estimates of actual changes $s_{t+1} - s_t$, and z_t is uncorrelated.[4]

Using data for Britain, Canada, Germany and the United States, estimates of equation (8) yield results that appear to conflict with those from equation (7). Estimates of β_1 usually are statistically different from one, not statistically different from zero, and negative.

Insignificant estimates for β_1 can be reconciled with rational expectations. If inflation is negligible and spot rates are martingales because they reflect all relevant information, then expected future spot rates equal current spot rates. In that case, forward premia would reflect risk premia or the effects of transaction costs, neither of which, under the assumption of rational expectations, must be correlated with future changes in spot rates.

The strong tendency for estimates of β_1 to be negative is much harder to explain. It appears that the market systematically misforecasts even the direction of change. If forward rates predict a rise in spot rates, rates are more likely to fall than rise. See Boyer and Adams (1988) and Levine (1989) for attempts to explain this behavior. Although there has been a large amount of research on the relation between forward rates and future spot rates between the United States and other members of the OECD, there has been almost no research for other countries and none that we are aware of for a small open economy like Kuwait.

Evidence for Kuwait: Table (3) shows estimates of equation (7) using 3 month forward rates for dinar prices of British pounds, German marks, Japanese yen, and U.S. dollars. we match forward and future spot rates using procedures followed by Levine (1989) and discussed in Riehl and Rodriguez (1983). Under the null hypothesis, overlapping observations imply correlated errors. If the forward rate exceeds the future spot rate today it is almost certain to do so tomorrow. In order to avoid this problem, we initially use none overlapping observations. With daily data from January 1984 to June 1989 this procedure yields only 21 observations per country pair. Hansen and Hodrick (1980) have developed a technique that compensates for this serial correlation and allows one to use all the data. As is shown below, their technique is not likely to add much to the results reported here.

TABLE (3)

FORWARD RATE AS PREDICTOR OF FUTURE SPOT RATE: KUWAIT VERSUS BRITAIN, GERMANY, JAPAN AND THE UNITED STATES*

$$s_{t+1} = \alpha_O + \alpha_1 f_t + z_t$$

Country	α_o	α_1	Std. Error	D.W.	R^2
Britain	0.4426	0.9294#	0.0513	1.4560	0.7910
	(0.6645)	(8.4811)			
Germany	0.1974	0.9617#	0.0540	1.2430	0.9284
	(0.6617)	(15.6961)			
Japan	0.0324	0.9774#	0.0545	1.3773	0.9495
	(1.1533)	(18.9108)			
United States	1.6835	0.7031#	0.0230	1.9398	0.5175
	(1.9079)	(4.5149)			

* t statistics in parentheses. # Within two standard errors of unity.

None of the estimates of α_0 in Table (3) are significantly different from zero, none of the estimates of α_1 differ from 1.0 by more than two standard errors, and none of the Durbin- Watson statistics imply serially correlated errors. These results are similar to the early estimates of equation (7) between the U.S. and other OECD countries and have been used to conclude that there is no risk premium and expectations in dinar exchange markets are rational.

The 21 observations per series in Table (3) do not use all the information available in the daily data. For each none overlapping interval, after accounting for holidays, there are approximately 60 business days. We could run 60 sets of regressions like those reported in Table (3). An alternative is to use the technique developed by Hansen and Hodrick (1980). But the Hansen and Hodrick approach requires software that we do not have, so we sampled the other 59 sets of regressions. Table (4) shows a typical result. The estimates are almost identical to those reported in Table (3). Based on these results, we believe that the increase in the t statistics that we would obtain with the Hansen and Dodrick technique is not worth the added econometric complexity.

If forward and future spot rates have unit roots, estimates of equation (7) are subject to spurious correlation. In that case, the appropriate test for a long-run link is a test for cointegration. For a discussion of the tests for error correction and cointegration see Engle and Granger (1987) and Engle and Yoo (1987). The appendix presents a detailed discussion of cointegration.

The first step is to evaluate the roots of the daily future spot and forward exchange rates. Table (5) shows the augmented Dickey-Fuller (ADF) statistics for weekly future spot and forward rates.[5] Weekly data allows us to exploit the data more fully while avoiding any weekend effects. For all countries, the estimates are consistent with the null hypothesis of a unit root.

TABLE (4)

FORWARD RATE AS PREDICTOR OF FUTURE SPOT RATE: KUWAIT VERSUS BRITAIN, GERMANY, JAPAN AND THE UNITED STATES*

$$s_{t+1} = \alpha_0 + \alpha_1 f_t + z_t$$

Country	α_0	α_1	Std.Error	D.W.	R^2
Britain	0.4706	0.9250#	0.0524	1.6277	0.7846
	(0.6985)	(8.3193)			
Germany	0.2176	0.9579#	0.0526	1.1711	0.9323
	(0.7552)	(16.1770)			
Japan	0.0321	0.9774#	0.0536	1.2305	0.9525
	(1.1747)	(19.5250)			
United States	1.6905	0.7019#	0.0228	2.0367	0.5281
	(1.9607)	(4.6116)			

* t statistics in parentheses.
\# Within two standard errors of unity.

TABLE (5)

UNIT ROOT TESTS: WEEKLY DATA JANUARY 1984 TO JUNE 1989

Country	Levels Forward Rate	Levels Future Spot Rate	Changes Forward Rate	Changes Future Spot Rate
Britain	-2.780	-2.771	-6.860*	-6.698*
Germany	-1.141	-0.752	-7.664*	-7.998*
Japan	-1.667	-0.790	-6.644*	-5 .902*
United States	-2.047	-1.516	-7.265*	-7.358*

* Significant at 5 percent level.

Table (6) shows the augmented Dickey-Fuller tests for cointegration between weekly future spot and forward rates. Although the statistic for Britain is close to being significant, none of the other estimates are even close to being significant at the 5 percent level. Future spot and forward rates appear not to be cointegrated.[6]

TABLE (6)

TESTS FOR COINTEGRATION BETWEEN FORWARD RATES AND FUTURE SPOT RATES: WEEKLY DATA JANUARY 1984 TO JUNE 1989

Country	ADF
Britain	-3.447
Germany	-2.872
Japan	-2.591
United States	-3.188

* Significant at 5 percent level.

Table (7) shows estimates for equation (8) using none overlapping data. Once again Durbin-Watson statistics show no evidence of autocorrelated errors, but now two estimates or β_o are significantly different from zero, all estimates of β_1 are negative and two of these estimates are significant. Using other none overlapping data sets only reinforces the results in Table (7). Forward premia are not only biased predictors of future changes in spot rates, they systematically mispredict the direction of change.

Although this relationship is not unique to Kuwait, it is much stronger for Kuwait than for most other countries. If additional research indicates that the misprediction is associated with a risk premium, the relatively strong inverse relationship for Kuwait probably is related to its exposed position during the Gulf war.

TABLE (7)

FORWARD PREMIA AS PREDICTORS OF FUTURE CHANGES IN SPOT RATES: KUWAIT VERSUS BRITAIN, GERMANY, JAPAN AND THE UNITED STATES*

$$s_{t+1} - s_t = \beta_0 + \beta_1(f_t - s_t) + z_t$$

Country	β_0	β_1	Std.Error	D.W.	R^2
Britain	-0.0469#	-7.0495##	0.0391	2.0280	0.3692
	(-2.5531)	(-3.3350)			
Germany	0.0540	-5.9295	0.0525	1.3013	0.0562
	(1 .5000)	(-1.0641)			
Japan	0.0693##	-8.5559#	0.0480	1.8814	0.1944
	(3.0628)	(-2. 1418)			
United States	-0.0046	-1.8762	0.0235	2.4532	0.0597
	(-0.7269)	(-1.0987)			

* t statistics in parentheses.

Significant at the 5 percent level.

Significant at the 1 percent level.

One possibility is that markets predict the direction correctly most of the time, but, perhaps because of actual or potential official intervention, markets occasionally predict a large rise (fall) when there is a large fall (rise). In order to check this possibility, we calculate the number of days a predicted change in the dinar price of a currency has the same sign as the actual change and the number of days the signs are opposite. If the actual or predicted change is zero, the day is ignored. This procedure yields about 1,100 observations for each currency. The percentages of the predictions that are correct are as follows: Britain 42 percent, Germany 61, Japan 60 and the United States 45. Taking the four countries as a whole, there are slightly more correct predictions, 202. With about 4,400 observations, this is a small margin, about 5 percent. If there is a tendency for the market to predict the direction of small changes more accurately than large changes, it is very slight.

Figures (7) through (10) plot actual and predicted changes in exchange rates using weekly rather than daily data. The most notable feature of the figures is the relatively small size of predicted changes. Even when markets predict direction correctly, they grossly underestimate magnitudes of change. But this pattern does not imply inefficiency. In the absence of an inflation differential, if spot rates are martingales because they fully reflect all available information, then rational expectations imply that expected future spot rates equal current spot rates. In that case, the foreign exchange market is efficient and, if there is a zero risk premium, the forward premium is zero.

Transaction Costs: Given the evidence from other financial markets supporting efficiency, most economists are unwilling to accept results like those reported in the last subsection as evidence of inefficiency in the foreign exchange market. Instead, most economists interpret the differences between forward rates and future spot rates as a risk premia. Indeed, most of the literature refers to $f_t - s_{t+1}$ as 'the risk premium' rather than the more neutral term 'predictive error.' Another possible source for the predictive error, which is generally ignored, is transaction costs. Longworth, Boothe and Clinton (1983) mention the possibility, but reject it because transaction costs are relatively small, but most other researchers ignore the possible effects of transaction costs. One reason these costs are usually ignored may be because many researchers do not have bid and ask prices.

Table (8) shows the results of estimating equation (7) after making a simple adjustment for transaction costs. In that table future spot rates are calculated as follows: If the bid-ask spread for the future spot rate overlaps the bid-ask spread for the forward rate, the future spot rate is set equal to the forward rate. If the spreads do not overlap and the future spot rate is above the forward rate, the future spot rate in Table (8) is set equal to the forward rate plus the gap between the forward ask and future spot bid. If the spreads do not overlap and the future spot is below the forward rate, the future spot rate is set equal to the forward rate minus the gap between the forward bid and future spot ask. All forward rates on which adjusted future spot rates are based are mid points between bid and ask rates. A comparison of Tables (3) and (8) shows that this adjustment has almost no effect on results from estimating equation (7).

TABLE (8)
FORWARD RATE AS PREDICTOR OF ADJUSTED FUTURE SPOT RATE: KUWAIT VERSUS BRITAIN, GERMANY, JAPAN AND THE UNITED STATES*

$$s_{t+1} = \alpha_0 + \alpha_1 f_t + z_t$$

Country	α_o	α_1	Std. Error	D.W.	R^2
Britain	0.4284	0.9316#	0.0494	1.4719	0.8042
	(0.6701)	(8.8361)			
Germany	0.1918	0.9629#	0.0522	1.2583	0.9330
	(0.6658)	(16.2695)			
Japan	0.0327	0.9756#	0.0529	1.4001	0.9521
	(1.1969)	(19.4402)			
United States	1.6905	0.7019#	0.0228	2.0367	0.5281
	(1.9607)	(4.6116)			

* t statistics in parentheses.
# Within two standard errors of unity.

Transaction costs introduce a kind of neutral range in to equations like (7) and (8). As long as this neutral range is small relative to the variability of the explanatory variable, the econometric effects of these costs are likely to be relatively small. For a discussion of this point and some evidence of the econometric effects of transaction costs, see Maasoumi and Pippenger (1989) and Davutyan and Pippenger (1990).

Since the forward rate in equation (7) is close to a martingale, its variance is likely to be very large relative to the neutral range generated by transaction costs. But with stable and relatively small differences in inflation rates between countries, forward rates move very closely with spot rates and there is relatively little variability in the forward premium. See Figures (7) to (10). In that case, transaction costs could have important econometric effects. In order to evaluate the possible effects of transaction costs in estimating equation (8), we tried several possible adjustments. Table (9) reports the results of estimating equation (8) with one set of adjusted data. Other adjustments yield similar results. Future spot rates in Table (9) are the same as in Table (8). Spot rates are adjusted as follows: If bid-ask spreads for spot and forward rates overlap, the spot rate is set equal to the mid point of the forward rate. If the spreads do not overlap, the spot rate equals the mid point of the forward rate plus (or minus if appropriate) the gap between the spread.

TABLE (9)
FORWARD PREMIA AS PREDICTORS
OF FUTURE CHANGES IN SPOT RATES: KUWAIT VERSUS BRITAIN, GERMANY, JAPAN AND THE UNITED STATES*

$$s_{t+1} - s_t = \beta_0 + \beta_1(f_t - s_t) + z_t$$

Country	β_o	β_1	Std. Error	D.W.	R^2
Britain	-0.0469#	-7.0495##	0.0391	2.0280	0.3692
	(-2.5531)	(-3.3350)			
Germany	0.0540	-5.9295	0.0525	1.3013	0.0562
	(1.5000)	(-1.0641)			
Japan	0.0327	-8.5559#	0.0480	1.8814	0.1944
	(1.1969)	(-2.1418)			
United States	-0.0327	-1.8762	0.0235	2.4532	0.0597
	(-0.7269)	(-1.0987)			

* t statistics in parentheses.
\# Significant at 5 percent level.
\## Significant at 1 percent level.

A comparison of Tables (7) and (9) shows that the estimates are essentially the same. The switch in results from equation (7) to (8) does not appear to be the result of the effects of transaction costs. If additional research with other countries supports this result, then we can eliminate one possible explanation of the apparently conflicting results from equations (7) and (8).

Adjustment Costs: Essentially all research on forward rates as predictors of future spot rates is based on an equilibrium model like the one described above. Using this model in empirical work implicitly assumes that adjustment costs are unimportant and foreign exchange markets adjust rapidly as compared to the sampling frequency in the data. This assumption is almost never stated explicitly because there is a very widespread consensus that foreign exchange markets and other highly organized financial markets adjust almost instantaneously.

But there is evidence that raises serious questions about this consensus. The evidence in Pippenger (1978) is consistent with rather slow portfolio adjustment in covered interest rate arbitrage. Perhaps more important is the research on bank portfolio behavior. This work suggests that it takes major banks weeks rather than hours to readjust their portfolios. See for example Spindt and Tarhan (1980). Since large money center banks presumably adjust more rapidly than most participants in organized financial markets, these results suggest that adjustment could take a long time. If portfolio adjustment is not as rapid as is generally assumed, then there should be some evidence that predictive errors tend to decline in the long run. We examine this possibility by testing weekly predictive errors for unit roots and estimating spectral densities for weekly changes in predictive errors.

If spot and forward rates have unit roots, as Table (5) indicates, and are not cointegrated, as Table (10) indicates, then predictive errors should have unit roots. But if adjustment costs introduce inertia into portfolio adjustmcnt, then errors should tend to disappear in the long-run and predictive errors should not have unit roots.

Table (10)

UNIT ROOT TESTS FOR WEEKLY PREDICTIVE ERRORS

Country	ADF
Britain	-3.495*
Germany	-2.890
Japan	-2.530
United States	-3.439

* Significant at 5 percent level.

Lack of cointegration between future spot and forward rates should make this test unnecessary. But if the theory is correct and the cointegrating vector is unity, then we can gain some power by testing the predictive errors for unit roots. Table (10) shows the ADF statistic for the predictive errors.[7] The estimate for Britain is just significant at the 5 percent level and the estimate for the U.S., is close to being significant at the 5 percent level, but Germany and Japan are not even close to being significant. If there is a long-run link between forward and future spot rates, it is either very weak or the long-run is measured in years rather than months.

We also compute spectral densities for the predictive errors using the same weekly data used in the tests for unit roots and cointegration. If there is a long-run link, spectral estimates should show signs of declining at the very shortest frequencies, which correspond to the very longest cycles. Figures (11) to (14) show the spectral densities for weekly changes in predictive errors. Although the decline is statistically significant only for the dinar price of marks, in all four figures estimates start to decline as frequency falls below 0.038, which corresponds to a six month cycle. These results, like those in Table (10) suggest that there may be a long-run link between forward rates and future spot rates.

With 5.5 years of data, the longest observable cycle is 5.5 years and there is only one observation for that cycle. Like tests for unit roots and cointegration, tests based on spectra are limited by the relatively short time span covered by the data. The only way to resolve this problem is to obtain data for a much longer period. Since the bank that supplied us with the data apparently went back as far as it could, the only alternatives are to wait for two or three years, or to find another data source that goes back farther.

Summary and Conclusions

The behavior of daily dinar-dollar exchange rates indicates that the Central Bank of Kuwait has systematically leaned against the wind. Changes in dinar-dollar rates are autocorrelated, which is consistent with leaning against the wind, and the relation between cross rates also is consistent with leaning against the wind. There is, however, no evidence that the central bank attempts to moderate day-to-day fluctuations in dinar prices of other currencies. Moderating short-run movements in dinar-dollar exchange rates may have beneficial effects on trade and capital flows for Kuwait, but it also may amplify short-run fluctuations in short-term interest rates in Kuwait. With effective covered interest rate arbitrage, changes in foreign interest rates are partially absorbed by changes in spot and forward dinar exchange rates. But if official intervention moderates movements in spot rates, then these changes must be passed through to either forward rates or dinar interest rates.

The foreign exchange market for dinar appears to be efficient, or at least as efficient as foreign exchange markets between OECD countries. There is no evidence of any significant lapses in either cross rate or covered interest rate arbitrage. But like other countries, forward premia, which represent the markets prediction of the future change in spot rates, are negatively correlated with actual changes. When there is a positive forward premium and the market predicts a rise in the dinar price of a currency, the price is more likely to fall than rise. For other countries, in most cases this negative relationship is not statistically significant for each currency individually, but for Kuwait it is significant for two out of four countries. If this pattem is the result of a risk premium, then it seems likely that it is related to the Gulf war and should moderate with the end of the war.

At this time it is not clear what conclusions one should draw from the inverse relationship between predicted and actual changes. It seems unlikely that it is the result of risk premia and, on the surface, the negative relationship appears to be inconsistent with efficiency. But until we have a better understanding of the source of the inverse relationship, any rejection of efficiency must be tentative. In any case, our results indicate that the foreign exchange market for dinar is at least as efficient as other foreign exchange markets such as the dollar and pound sterling, which are much larger.

Footnotes

(1) Variances multiplied by 10^4.

(2) Variances multiplied by 10^4.

(3) The increase in the spectral estimates for the two highest frequencies could be the result of small errors in the data.

(4) If α_1 in equation (7) does not equal unity, equation (8) contains an inappropriate linear restriction. See Haynes and Stone (1982) for a discussion of the possible effects of such a restriction.

(5) The ADF statistic is calculated using a constant, trend and four lagged changes. These results are not sensitive to lag length. Phillips-Perron t tests without trend and using two lags yield similar results.

(6) The ADF statistic uses four lags without trend or a constant. These results are not sensitive to lag length and Phillips-Perron t tests using two lags yield similar results.

(7) The ADF statistic is calculated using a constant, trend and four lagged changes. Phillips-Perron t tests without trend and using two lags cannot reject a unit root for any of the series.

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Appendix

Cointegration

Suppose x_t and y_t are I(d) where d is the number of times x_t and y_t must be differenced in order to make them stationary time series. If there is a linear combination of x_t and y_t that requires less differencing in order to be stationary, then x_t and y_t are cointegrated.

More formally, let ϵ_t be a linear transformation of x_t and y_t.

$$\epsilon_t = \Phi_1 x_t + \Phi_2 y_t \tag{1}$$

If there exists a parameter vector Φ for which ϵ_t in equation (1) is I(d-b) with b greater than zero, then x_t and y_t are cointegrated of order d, b. See Engle and Granger (1987). If d minus b equals zero, then the time paths for x_t and y_t tend to converge in the long run.

Suppose x_t is a martingale and a proportional error correction process constrains the deviation between x_t and y_t

$$x_t = x_{t-1} + n_t \tag{2}$$

$$\Delta y_t = -\lambda(y_{t-1} - x_{t-1}) + u_t \tag{3}$$

where n_t and u_t are white noise error terms and λ is none negative, but less than one. Since x_t is a martingale, it is I(1) and has a unit root. y_t also is a none stationary process because it is the sum of a stationary and none stationary process.

$$y_t = \{1/[1+(\lambda-1)L]\}u_t + \{\lambda L/([1+(\lambda-1)L][1-L])\}n_t$$

Where the first term on the right hand side is a stationary process and the second is nonstationary. Because of the error correction mechanism, x_t and y_t are cointegrated, and the difference between x_t and y_t is a stationary stochastic process.

$$y_t - x_t = (1-\lambda)(y_{t-1} - x_{t-1}) + u_t \tag{4}$$

Rewriting equation (4) yields an expression that is closely related to the test for unit roots discussed next.

$$\Delta(y_t - x_t) = -\lambda(y_{t-1} - x_{t-1}) + u_t \tag{4'}$$

If λ is greater than zero and less than one, $y_t - x_t$ is stationary. If λ is zero, $y_t - x_t$ is a martingale, which is not stationary.

Engle and Granger (1987) suggest the following procedure for testing for cointegration. First, run an ordinary least squares regression between x_t and y_t, and then establish the root for the error from that regression. In the example used above, which is applicable to purchasing power parity, if the error is a stationary process, the two series are cointegrated.

The first step in testing for cointegration is to confirm that the series are not stationary. Two stationary time series are trivially cointegrated. Using x_t as an example, the first step is to run the following regression:

$$\Delta x_t = \alpha_o + \alpha_1 T + \alpha_2 x_{t-1} + \sum_i \beta_i \Delta x_{t-i} + \epsilon_t \tag{5}$$

$$i = (1, ..., m)$$

where ϵ_t is assumed to be an identically distributed random variable, T is a time trend, and here m equals 2.

The null hypotheses is that x_t has a unit root, which implies that α_2 in equation (5) equals zero. For example, applying equation (5) to x_t in equation (3), which is a martingale, yields estimates of α_0, α_1 and α_2 that equal zero. The statistic $\hat{\tau}_\tau$ proposed in Dickey and Fuller (1979) for testing the hypotheses that α_2 equals zero is given by the t statistic for α_2. Critical values for the augmented Dickey Fuller Statistic (ADF) are given in the bottom part of Table 8.5.2 in Fuller (1976).

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Figure 1
Autocorrelations For Changes In Log Of KD/$

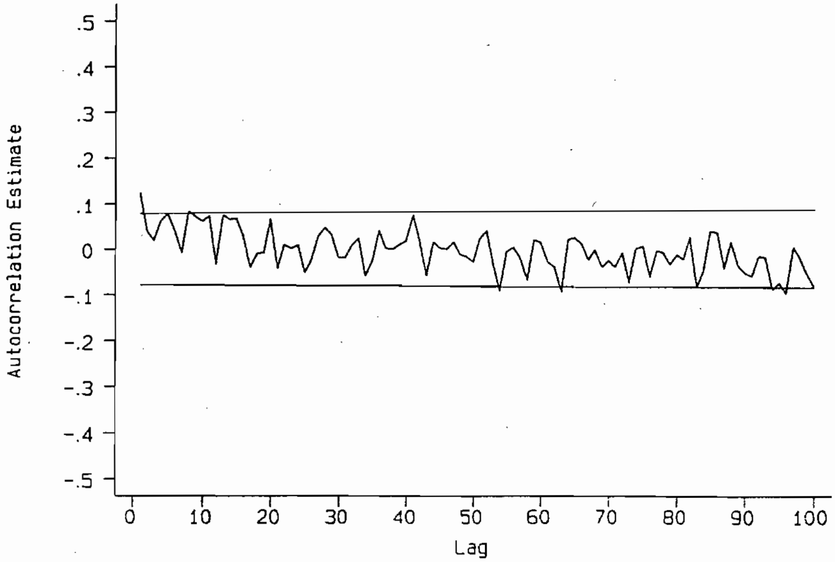


Figure 2
Autocorrelations For Changes In Log of KD/DM

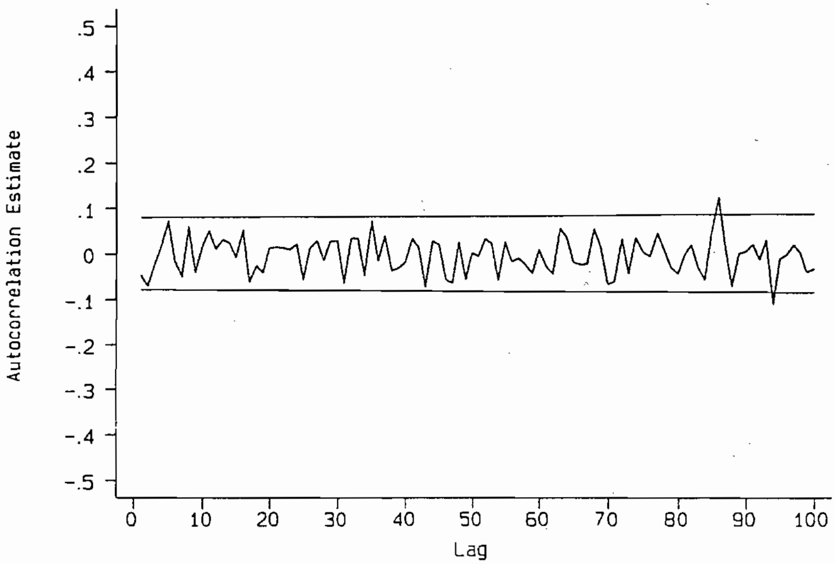


Figure 3
Autocorrelations For Changes In Log of DM/$

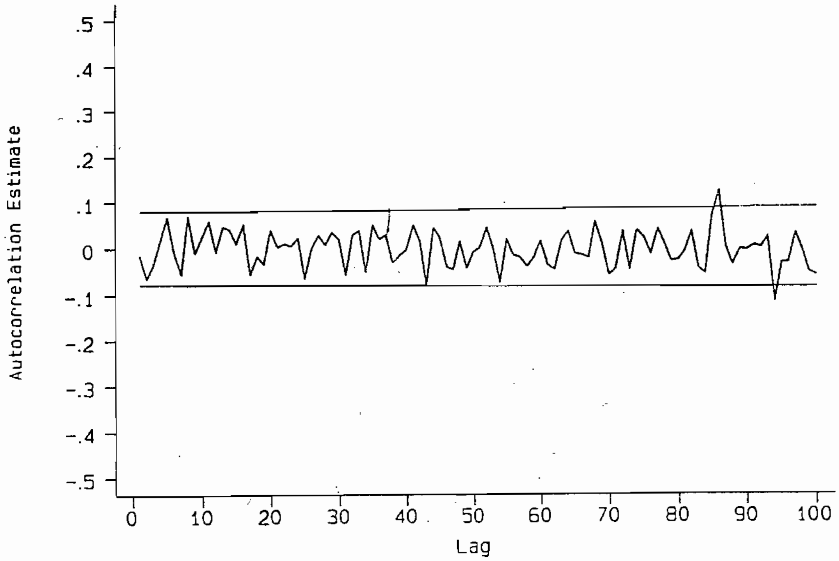


Figure 4
Spectral Density Estimates For Changes In Log Of Exchange Rate:
Daily Second Half Of Period

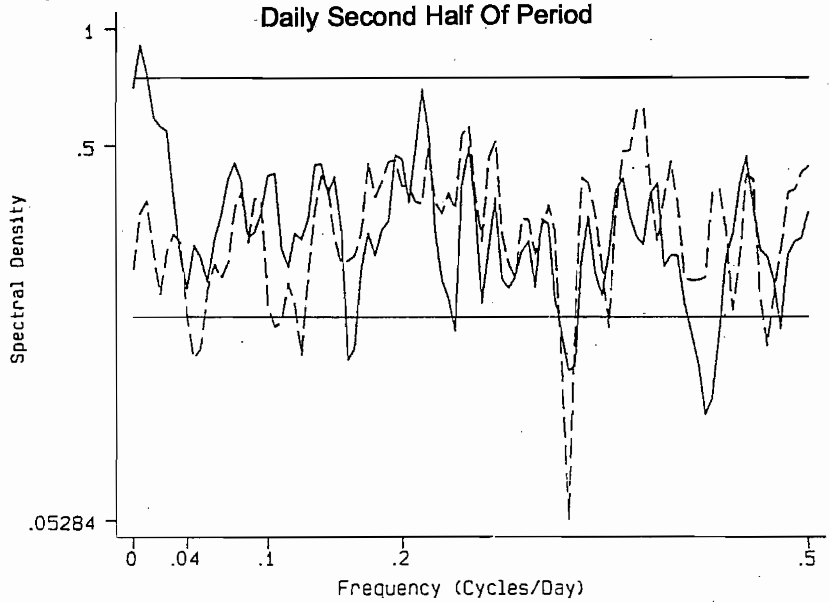


Figure 5
Cross Correlation Estimates Between KD/DM and KD/Sterling
Daily Second Half Of Period

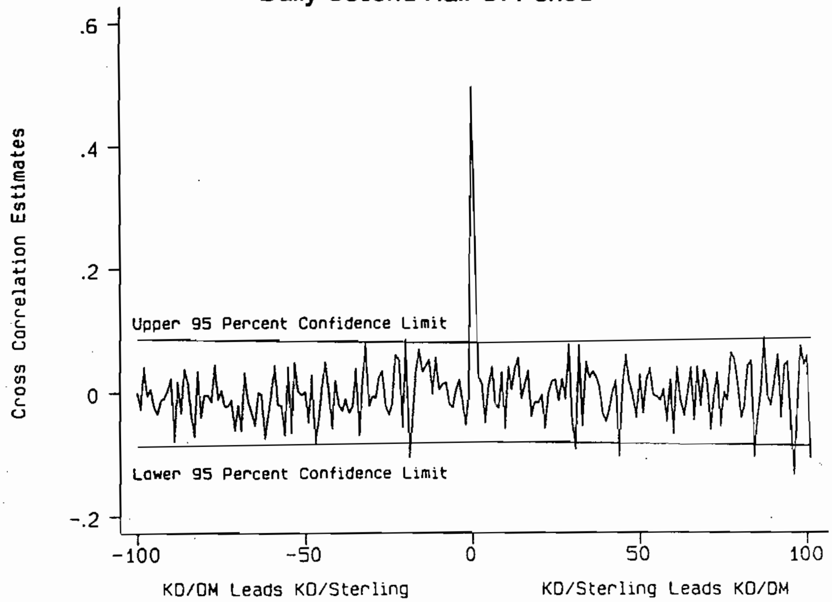


Figure 6
Cross Correlation Estimates Between KD/$ And KD/DM
Dily Second Half Of Period

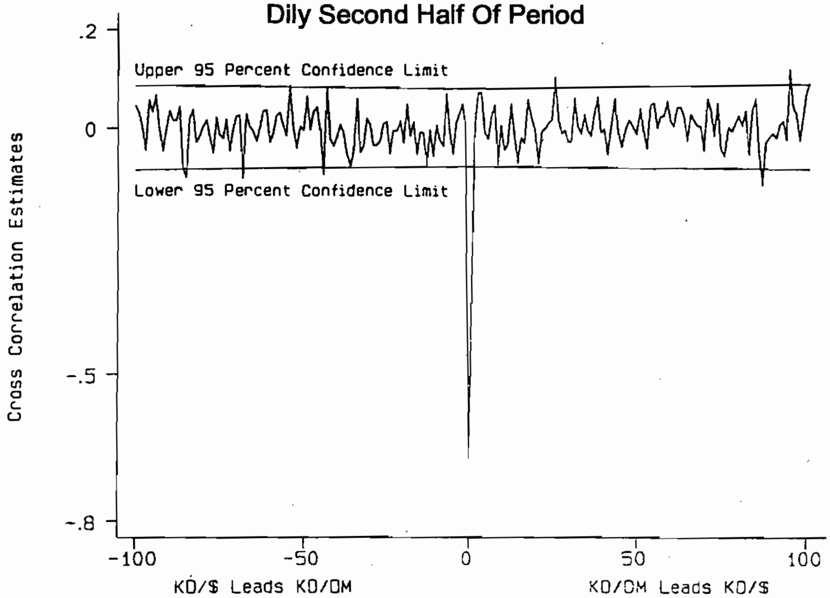


Figure 7
Actual And Predicted Changes In Log Of KD/$

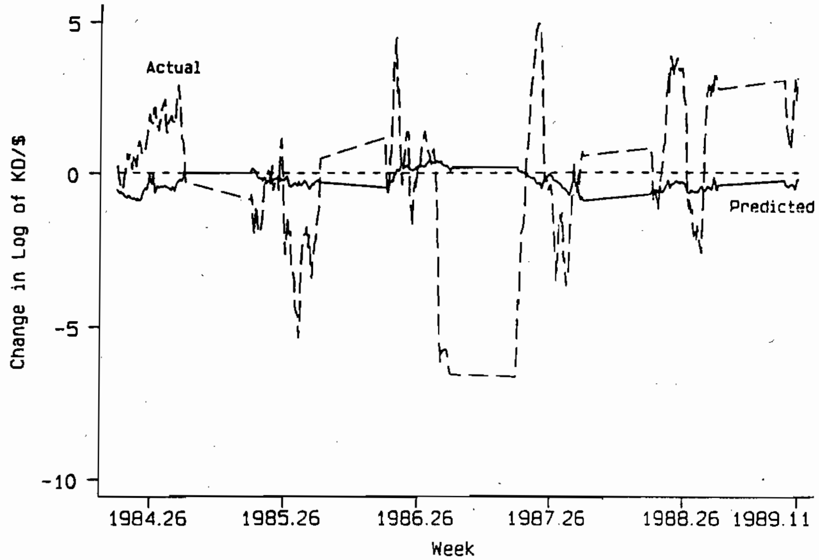


Figure 8
Actual And Predicted Changes In Log Of KD/DM

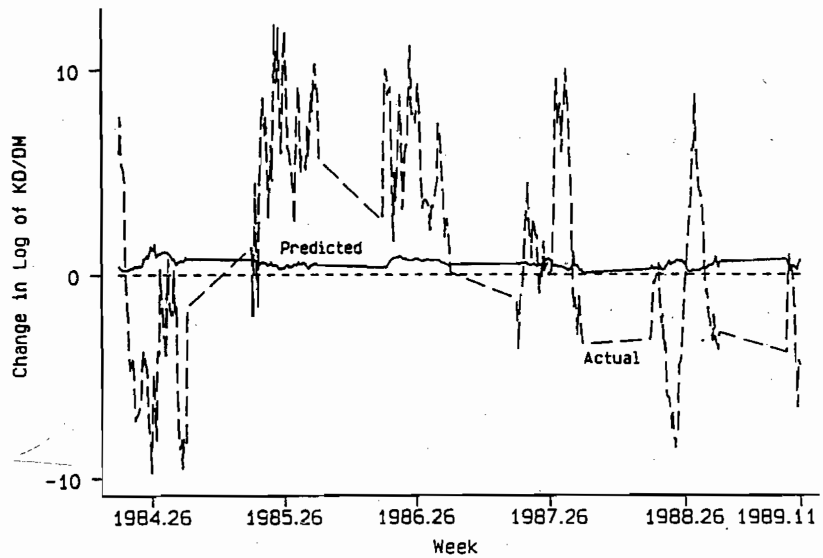


Figure 9
Actual And Predicted Changes In Log Of KD/ Sterling

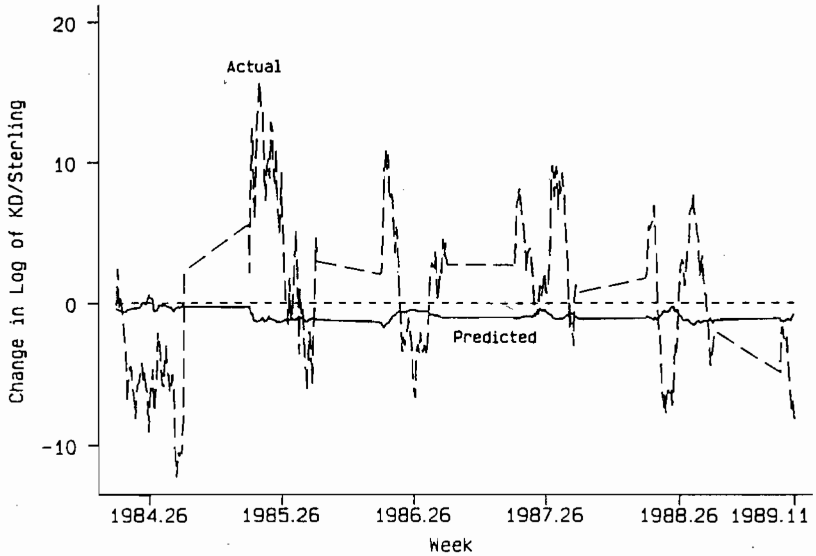


Figure 10
Actual And Predicted Changes In Log OF KD/YEN

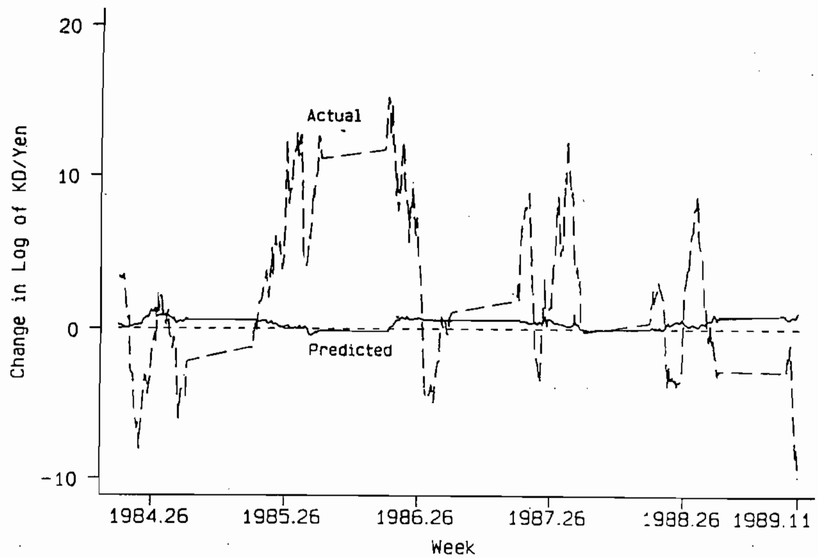


Figure 11
Spectral Density Estimates For Changes In Predicted Error:
KD/$ Weekly January 1984 To December 1989

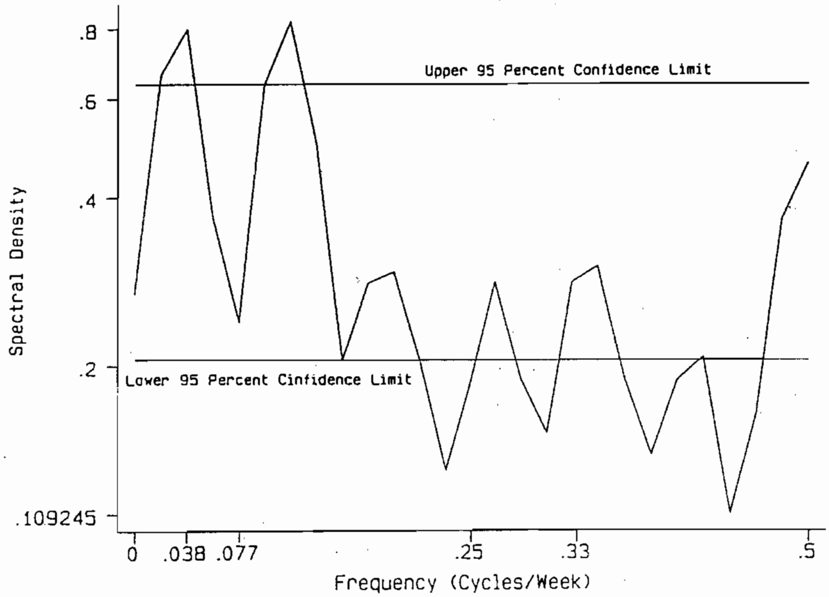


Figure 12
Spectral Density Estimates For Changes In Predicted Error:
KD/DM Weekly January 1984 To December 1989

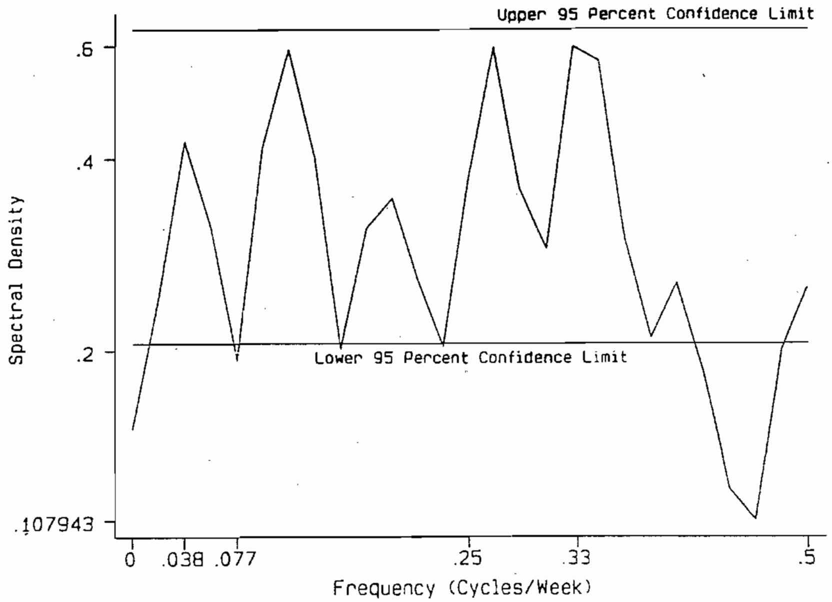


Figure 13

Spectral Density Estimates For Changes In Predicted Error: KD/Pound Weekly January 1984 To June 1989

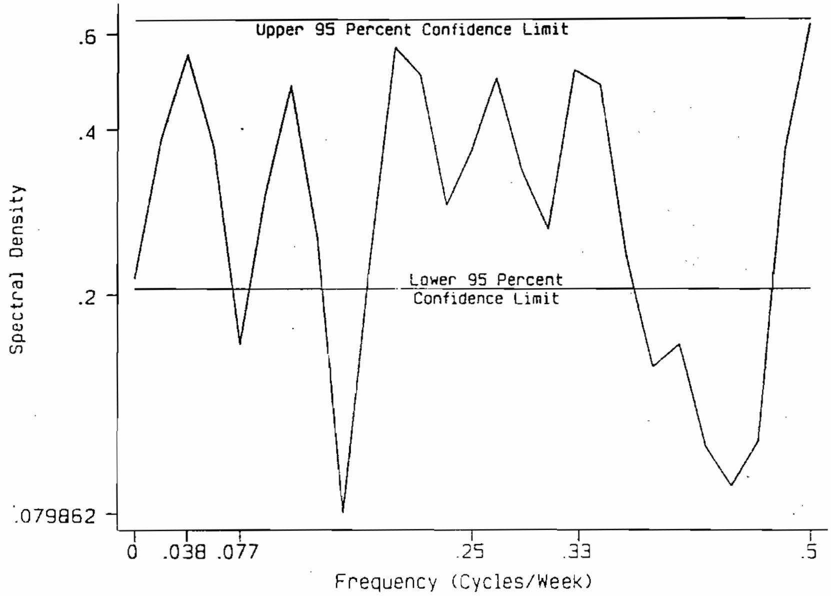
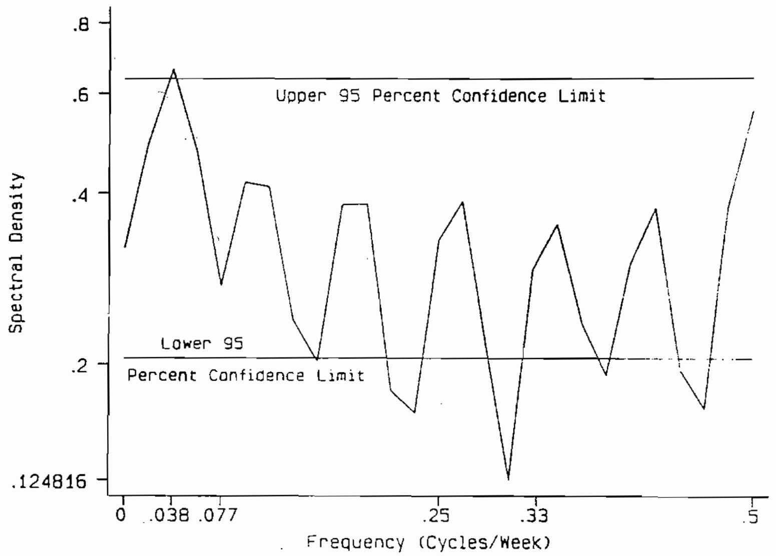


Figure 14

Spectral Density Estimates For Changes In Predicted Error: KD/YEN Weekly January 1984 To December 1989



EFFICIENCY OF EXCHANGE RATE DETERMINATION: THE CASE OF KUWAIT

John Pippenger

Yousuf Hassan. J. Mohamad

The foreign exchange market for Kuwaiti dinar appears to be as efficient as foreign exchange markets for OECD countries. After adjusting for the effects of bid-ask spreads, there is no evidence of significant deviations from either cross rate or covered interest rate arbitrage. Like other exchange rates, dinar rates are volatile, but substantially less volatile than short- term interest rates. The relation between forward rates and future spot rates is the same as for the United States and other large countries. There is a small but systematic inverse relationship between the change in spot rates predicted by forward premia and the actual changes in spot rates. Whether this pattern should be interpreted as evidence rejecting efficiency or one of the other assumptions underlying the statistical tests is, at this time, not clear.