Estimation of Risk Premium and Cost-of-Carry models for currency futures contracts

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Abstract The Risk Premium and Cost-of-Carry models regarding the pricing of Australian dollar futures contracts traded on the International Monetary Market of the Chicago Mercantile Exchange are estimated and compared. Cointegrating relationships among the Australian dollar spot and futures prices, and US and Australian risk-free rates of interest, suggest an error-correction representation for the Risk Premium model, and two alternative error-correction formulations for the Cost-of-Carry model. Two significant structural breaks in the futures price series permit estimation of appropriate models for the full sample in the presence of these breaks, for the full sample without explicitly modelling the breaks, and for various sub-samples created by these structural breaks. The Risk Premium and Cost-of-Carry formulations are estimated for all sample sets, the models obtained are found to be statistically adequate, and the qualitative results are reasonably robust across different sample sets for both models.

1. INTRODUCTION

Although financial futures continue to attract attention in global financial markets, the research has not been commensurate with its importance. Recent relevant studies include modelling univariate and multivariate relationships to test market efficiency (Sequeira (1996, 1997)), the derivation of theoretical models of futures pricing (Amin and Jarrow (1991)), and the empirical analyses of these theoretical models (Heaney and Layton (1996)).

In this paper, two standard models of currency futures prices are estimated. Time series data on the Australian dollar futures prices are interesting as two significant structural breaks are observed in the futures prices over the full sample period. These breaks correspond to the events surrounding the Gulf Crisis in late 1990 and the recovery of the Australian economy in late 1993. Such breaks permit estimation of appropriate futures pricing models for the full sample in the presence of these breaks, for the full sample without explicitly modelling the breaks, and for the various sub-samples created by these structural breaks.

In Section 2, the Risk Premium and Cost-of-Carry hypotheses are presented. Alternative standard and error-correction representations of these two models are examined in Section 3, and the data are described in Section 4. Section 5 presents the empirical results, including tests of non-stationarity in the presence of structural breaks and cointegration tests. Some concluding remarks are given in Section 6.

2. MODELS OF FUTURES PRICES

2.1 Risk Premium model

The Risk Premium hypothesis (RPH) as discussed in Fama (1984) investigates the variability of the risk premium and expected rates of currency depreciation in the foreign exchange market. Fama argued that, under market efficiency and rational expectations, the forward (futures) exchange rate is equal to the expected future spot rate plus a risk premium.

Based on the earlier analysis in Fama and Farber (1979) and the theoretical model of Stulz (1981), the RPH is specified in natural logarithms as:

(1) $$f_{t+k|t} = E_t(s_{t+k}) + \pi_{t+k|t}$$

where $f_{t+k|t}$ is the price of a k-period futures contract at time t, $E_t(s_{t+k})$ is the forecast of the future spot price at time $t+k$, conditional on the information set at time t, and $\pi_{t+k|t}$ is the (time varying) expected risk premium from time t to time $t+k$.

Research in futures markets typically focuses on shorter-time horizons, namely smaller values of k. As tradeable assets, futures contracts can be sold or bought at each time period in between the time the contract is first listed on the exchange, through to the maturity of that particular contract. Analyses involving one-day ahead forecasts are, therefore, useful in explaining price behaviour in such markets. Setting k=1, equation (1) can be rewritten as:

(2) $$f_t = E_t(s_{t+1}) + \pi_t$$

where $f_t \equiv f_{t+1|t}$ and $\pi_t \equiv \pi_{t+1|t}$

2.2 Cost-of-Carry model

The Cost-of-Carry model is a standard model of futures pricing. This model uses a no-arbitrage argument by factoring in the carrying costs involved in holding an underlying asset until maturity. Currency futures contracts are contracts in which the underlying asset is a foreign currency, and the carrying costs are essentially domestic and foreign risk-free rates of interest.

Under a no-arbitrage argument, the futures prices of foreign exchange currency futures are derived by Amin and Jarrow (1991) within the framework of Heath et al. (1992). Such prices can be expressed as follows:

(3) $$F_{t+k|t} = S_t . \frac{p^f_{t+k|t}}{p^d_{t+k|t}} \cdot \exp\theta_{t+k|t}$$

where $p^f_{t+k|t} = \exp(-kr^f_{t+k|t})$

and $p^d_{t+k|t} = \exp(-kr^d_{t+k|t})$.

In equation (3), $r^f_{t+k|t}$ represents the foreign k-period interest rate at time t, and $r^d_{t+k|t}$ represents the domestic k-period interest rate at time t, and $\theta_{t+k|t}$ represents an adjustment term for the marking-to-market feature of futures markets contracts. As described in Brenner and Kroner (1995), this marking-to-market term depends on the volatilities of the interest rate and spot processes, as well as the forecast time horizons, and decreases to zero as $k \to 0$ (that is, as the contract matures). Substituting the expressions for $p^f_{t+k|t}$ and $p^d_{t+k|t}$ in (3) yields the following expression:

(4) $$F_{t+k|t} = \frac{S_t \cdot \exp(-kr^f_{t+k|t}) \cdot \exp\theta_{t+k|t}}{\exp(-kr^d_{t+k|t})}$$

Using the natural logarithms of (4), the Cost-of-Carry model for foreign exchange currency futures is obtained as follows:

(5) $$\ln F_{t+k|t} = \ln S_t + kr^d_{t+k|t} - kr^f_{t+k|t} + \theta_{t+k|t}$$

Following the convention of setting k=1, and denoting $\ln F_{t+1|t}$, $\ln S_t$, $r^d_{t+1|t}$, $r^f_{t+1|t}$ and θ_{t+1} by f_t s_t, r^d_t, r^f_t and θ_t respectively, equation (5) can be written as:

(6) $$f_t = s_t + r^d_t - r^f_t + \theta_t$$

3. ALTERNATIVE MODELS

3.1 Standard specifications of the models

Based on the theoretical models of the Risk Premium and Cost-of-Carry hypotheses, empirical specifications corresponding to the two models can be derived. Accordingly, the Risk Premium model given in equation (2) can be specified as follows:

(7) $$f_t = \alpha_0 + \alpha_1 s_{t+1} + \alpha_2 \pi_t + \eta_{t+1}$$

where f_t is the (logarithmic) price of a one-period ahead futures contract at time t, s_{t+1} is the (logarithmic) spot price at time $t+1$, and π_t is the (logarithmic) one-period ahead time-varying risk premium. The standard RPH given in equation (7) may also be expressed in the following form:

(8) $$s_{t+1} = \beta_0 + \beta_1 f_t + \beta_2 \pi_t + v_{t+1}$$

Similarly, the empirical form of the Cost-of-Carry model in equation (6) can be rewritten as follows:

(9) $$s_t = \beta'_0 + \beta'_1 f_t + \beta'_2 r^d_t - \beta'_3 r^f_t + \beta'_4 \theta_t + v'_t$$

3.2 Error-correction representations of the hypotheses

In specifications of the Risk Premium and Cost-of-Carry models, the risk premium and the adjustment term for the marking-to-market feature are not directly observable. Recent studies have shown that the risk premium is covariance stationary. Park and Phillips (1989) have shown that a stationary variable can be omitted from a cointegrating regression without affecting the consistency of the coefficient estimates or the power of hypothesis testing procedures. Consequently, if the marking-to-market adjustment term is I(0), the Risk Premium and Cost-of-Carry models can be specified without including these two variables. The two models can, therefore, be estimated directly, even when the futures prices, spot prices, and domestic and foreign risk-free rates of interest contain stochastic trends.

Within a cointegration framework, equations (8) and (9) can be rewritten without the risk premium and the marking-to-market adjustment term.

Then the Risk Premium and the Cost-of-Carry models can be expressed as equations (10) and (11), respectively:

$$(10) \qquad s_{t+1} = \beta_0 + \beta_1 f_t + u_{t+1}$$

$$(11) \qquad s_t = \beta_0' + \beta_1' f_t + \beta_2' r_t^d + \beta_3' r_t^f + u_t'$$

To enable a comparison of both the Risk Premium and Cost-of-Carry models, a time lead of one period is used in equation (11). Within a cointegration framework, time leads or lags do not affect the results of hypothesis tests. Equation (11) can be rewritten as:

$$(12) \qquad s_{t+1} = \beta_0' + \beta_1' f_t + \beta_2' r_t^d + \beta_3' r_t^f + u_{t+1}'$$

Following Engle and Granger (1987), if the futures and spot prices are cointegrated, there exists an error-correction representation of the relationship between the two variables. Assuming the spot and futures prices are cointegrated, the Risk Premium hypothesis given by equation (10) can be rewritten as an error-correction representation as follows:

$$(13) \qquad \Delta s_{t+1} = b_0 + b_1 \Delta s_t + b_2 \Delta f_t - a(s_t - \beta_1 f_{t-1}) + \varepsilon_{t+1}$$

The Cost-of-Carry hypothesis given by equation (12) may be reformulated according to the stationarity and cointegration properties of the futures prices (f_t), spot prices(s_{t+1}), domestic risk-free rate of interest (r_t^d), and foreign risk-free rate of interest (r_t^f). The order of integration of the four variables, s_{t+1}, f_t, r_t^d and r_t^f, and the type of cointegrating relationships among the four variables, are important in identifying the appropriate Cost-of-Carry specification.

Various combinations of the variables are possible. However, economic rationale indicates feasible combinations of two cointegrated variables between futures and spot prices, and between the domestic and foreign interest rates. Accordingly, from the stationarity and cointegrating properties of the four variables, four interpretable cases can be identified as follows:

(1) all four variables are I(1) and cointegrated;

(1') all four variables are I(1) and not cointegrated;

(2) two subsets comprising two I(1) variables in each subset are cointegrated;

(2') one subset of two I(1) variables is cointegrated, and the other subset of two I(1) variables is not cointegrated.

In case 1, all four variables are I(1) and cointegrated. The error-correction representation of the relationship between these four variables can be formulated as follows:

$$(14) \qquad \Delta s_{t+1} = b_0' + b_1' \Delta s_t + b_2' \Delta f_t + b_3' \Delta r_t^d + b_4' \Delta r_t^f - a'(s_t - \beta_1' f_{t-1} - \beta_2' r_{t-1}^d - \beta_3' r_{t-1}^f) + \varepsilon_{t+1}'$$

Case 1' occurs when all four variables are I(1) and not cointegrated. No long run relationships exist among the variables, and a regression involving the four variables will result in the "spurious regression" problem described in Granger and Newbold (1974). The equation needs to be respecified.

Case 2 occurs when the two subsets, comprising two I(1) variables in each subset, are cointegrated. Since the feasible combinations of two cointegrated variables among the four are the futures and spot prices, and the domestic and foreign interest rates, the two cointegrated subsets will comprise (s_{t+1}, f_t) and (r_t^d, r_t^f). The error-correction representation of case 2 is given by:

$$(15) \qquad \Delta s_{t+1} = b_0'' + b_1'' \Delta s_t + b_2'' \Delta f_t + b_3'' \Delta r_t^d + b_4'' \Delta r_t^f - a''(s_t - \beta_1'' f_{t-1}) - c''(r_{t-1}^d - \beta_2'' r_{t-1}^f) + \varepsilon_{t+1}''$$

Case 2' describes a situation where two I(1) variables are cointegrated, and the other two I(1) variables are not cointegrated. The equation is unbalanced and needs to be re-specified.

Therefore, of the possible cases examined, Cases 1' and 2' are eliminated as inappropriate formulations of the Cost-of-Carry model because they are unbalanced and need to be re-specified.

4. DATA

The futures contracts used in this study are Australian dollar futures contracts traded on the International Monetary Market (IMM) of the

Chicago Mercantile Exchange. Data on futures and spot prices of the Australian dollar are in natural logarithms, while data on the US 90-day Treasury spot and Australian 90-day bank accepted bill rates are in levels. The foreign risk-free rate of interest in the Cost-of-Carry model is represented by 90-day bank accepted bill rates, with the US Treasury bill rate used as the domestic risk-free rate of interest.

In this paper, the futures price data cover a total of twenty-seven contracts between 13 November 1989 and 17 July 1996. A continuous time series of futures prices is obtained by rolling over the current futures contract two weeks before maturity. Contracts are linked by excluding the last two weeks prior to delivery of the current contract, using volume data as a guide. Following this procedure, a total of 1621 observations on the Australian dollar currency futures series are obtained.

An examination of the time plots of futures and spot prices reveals structural breaks in the futures price series at observations 190 and 937 in the sample period. Consequently, the empirical analysis is based on an analysis of the following three sample sets:

Set 1: the full sample with two structural breaks;
Set 2: the full sample without structural breaks;
Set 3: the three sub-samples.

5. EMPIRICAL RESULTS

Data on the futures and spot price series exhibit two significant structural breaks for the full sample at observations 190 and 937, corresponding to days in September 1990 and September 1993, respectively. In September 1990, falling Australian dollar futures and spot prices corresponded with the events surrounding the Gulf Crisis when world oil prices doubled. The second structural break occurred around the period when recovery of the Australian economy was being consolidated in late 1993.

In the presence of structural breaks, tests of non-stationarity are affected, in that Dickey-Fuller and Phillips-Perron test statistics are biased toward the non-rejection of a unit root. In testing the stationarity properties of the four variables, the unit root testing strategy proposed by Perron's (1989), which tests for unit roots in the presence of structural breaks, is applied.

5.1. Tests of non-stationarity in the presence of structural breaks

The structural break points at observations 190 and 937 are applied to all four variables. Two different types of unit root tests are applied to the three sample sets. Perron's unit root testing strategy is employed for sample set 1 to determine the order of integration of all four variables in the presence of the two main structural breaks. Augmented Dickey-Fuller (ADF) tests are used for sample sets 2 and 3, when the analysis involves either the full sample period without the structural breaks, as in set 2, or when the analysis is conducted as three separate sub-samples, as in set 3. The three sub-samples in set 3 are as follows:

Set 3A: observations 1 to 190;
Set 3B: observations 191 to 937;
Set 3C: observations 938 to 1621.

For sample set 1, the unit root testing strategy is conducted by regressing each of the four variables separately according to model (B) in Perron (1989). This model is estimated as:

$$(16) \qquad y_t = \bar{\mu}^B + \bar{\theta}^B DU_t + \bar{\beta}^B t + \bar{\gamma}^B DT_t^* + \bar{\alpha}^B y_{t-1} + \sum_{i=1}^{k} \bar{c}i \Delta y_{t-i} + \bar{e}_t$$

In (16), the ADF regression specifies a null hypothesis of a permanent change in the magnitude of the drift term versus the alternative of a change in the slope of the trend, t; $DU = 1$ if $t > \tau$ and is zero otherwise; $DT_t^* = t - \tau$ for $t > \tau$ and is zero otherwise; τ refers to the time of the break, that is, the period in which the change in the parameters of the trend function occurs; $\bar{\mu}^B$ is the estimated drift term in the regression; and Δy_{t-i} are the first differences of lagged values. The pth order ADF statistic for testing $\alpha^B = 1$, denoted ADF(p), is given by the t-ratio of $(\bar{\alpha}^B - 1)$ in (16).

In set 1, the full sample set is divided into two sub-samples based on the break point occurring at observations 190 and 937. The first sub-sample is from observations 1 to 936, with the second sub-sample based on observations 191 to 1621. Results of the ADF test for all four variables and their first differences are presented in Tables 1 and 2. A Newey-West covariance matrix, denoted NW, is used for several of the ADF regressions when LM tests for the presence of heteroskedasticity and serial correlation are found to be significant. Dickey-Fuller (DF) or ADF statistics obtained from the test are compared with critical values at the 5 percent significance level for the appropriate value of λ, the ratio of the pre-break sample size to the total sample size.

For all four variables, the unit root hypothesis is not rejected at the 5 percent level in both sub-samples in sample set 1. The results suggests that all four variables contain a unit root and are defined by a stochastic shift occurring at two break points, denoted by *DL1* and *DL2*, respectively.

In sample sets 2 and 3, the ADF(p) statistic is given by the t-ratio of the OLS estimate of β in the ADF regression below (see Campbell and Perron (1991)):

$$(17) \qquad \Delta y_t = \alpha + \gamma t + \beta y_{t-1} + \sum_{i=1}^{p} \delta_i \Delta y_{t-i} + \varepsilon_t$$

where Δy_t is the first difference of the variable, α is the constant of the regression, γ is the coefficient of the trend, Δy_{t-i} is the first difference of lagged values, δ_i is the coefficient of the lagged first difference, and ε_t is the error term of the regression. The pth order ADF statistic, denoted ADF(p) is given by the t-ratio of the OLS estimate of β in equation (17). The time trend is omitted when the ADF statistics, with and without a trend, are not substantially different. To determine the order of the ADF equation, the standard procedure for testing the significance of the coefficients of the lagged first differences is adopted. The ADF statistics are compared with the simulated critical values given in MacKinnon (1991).

Results for the four variables suggest the presence of a unit root in sample set 2 and all sub-samples in set 3. Unit root tests applied to the first differences of these variables in sets 2 and 3 strongly reject the null hypothesis of a unit root, implying that all four variables are integrated of order one, that is, I(1). Perron's test is not applied to the first difference of the four variables in set 1 as the time plots show no structural breaks in the sample. Since no structural breaks are included in the first differences of the four variables in set 1, the same set of results obtained from the ADF tests on the first differences of set 2 are applicable to set 1.

5.2. Cointegration Tests

Cointegration relationships between the two variables, (s_{t+1}, f_t), for the Risk Premium model, and among the four variables, $(s_{t+1}, f_t, r_t^d, r_t^f)$, for the Cost-of-Carry model, are tested using Johansen's (1991) maximum likelihood procedure. Similar results are obtained for both models in that cointegration is found to exist for all sample sets, except for sub-sample 3A. The results of cointegration tests applied to all the sample sets are given in Tables 3 and 4.

For the Risk Premium model, one cointegrating vector was found to be present in all sample sets, except for sub-sample 3A, in which the tests suggested the absence of cointegration between the two variables. An error-correction representation for each of sample sets 1, 2, 3B and 3C include one error-correction term, and are denoted as AECM, BECM, DECM and EECM, respectively, in Table 3.

For the Cost-of-Carry model, two cointegrating vectors were found to be present in sample set 1, suggesting the presence of two cointegrated subsets, namely (s_{t+1}, f_t) and (r_t^d, r_t^f). An error-correction representation in this case includes two error-correction terms, denoted AECM4 for the cointegrating subset (s_{t+1}, f_t) and AECM5 for the cointegrating subset (r_t^d, r_t^f). The test results for sample 2 suggest the presence of one cointegrating vector, for which the error-correction term among the four variables is denoted BECM1.

In sample set 3, cointegration tests were applied to all three sub-samples, with different results in each case. In sub-sample 3A, the tests suggested the absence of cointegration among the four variables. Only one cointegrating relationship was found in sub-sample 3B, for which the error-correction term is denoted DECM1. In sub-sample 3C, the results suggest the presence of one cointegrating vector, for which the error-correction term is denoted EECM1.

5.3 Estimation results

Cointegration tests revealed the presence of two cointegrating vectors among the four variables in Set 1. Equation (15) is the appropriate model for the Cost-of-Carry model in Set 1. In sample set 2, only one cointegrating vector was found, and the appropriate model is equation (14). No cointegrating relationships were found in sub-sample 3A. Sub-samples 3B and 3C are characterized by one cointegrating vector, and the appropriate model is, similarly, equation (14).

The appropriate Risk Premium and Cost-of-Carry formulations for all sample sets are estimated, and the results are presented in Tables 5 and 6. It is clear that the differences in spot prices (Δs_t) and futures prices (Δf_t) are significant in both models for sample sets 1, 2 and 3C. Differences in the foreign rate of interest (Δr_t^f) are also significant for sample sets 1 and 2 in the Cost-of-Carry model. The structural change dummy variables are not significant for either model in sample set 1. All estimated models appear to be statistically adequate, in that there is an absence of serial correlation, heteroskedasticity and functional form misspecification. Although the LM(N) statistic for normality is significant for all data sets, this is a feature which is evident in most models of futures prices with skewed distributions.

6. CONCLUSION

Two standard models of futures pricing, namely the Risk Premium and Cost-of-Carry model, were estimated. Cointegrating relationships between the Australian dollar spot and futures prices, as well as the US and Australian risk-free rates of interest, suggest an error-correction representation for the Risk Premium model and two alternative error-correction formulations for the Cost-of-Carry hypothesis.
Results from unit root and cointegration tests yield specific formulations for the Cost-of-Carry model in three different sample sets. The Risk Premium and Cost-of-Carry formulations for Australian dollar futures contracts are estimated for all sample sets, the models obtained are found to be statistically adequate, and the qualitative results are reasonably robust across different sample sets for both models. Moreover, the foreign rate of interest is statistically significant in the Cost-of-Carry model for two of the four sample sets.

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Table 1: Unit root tests of levels of variables

Set	Test	Spot	Futures	US rates	Aust rates
1 (1-936)	Deterministic trend?	No	No	No	No
	Lag length	3	7	1	1
	Covariance formula	OLS	OLS	OLS	NW
	ADF statistic	-2.63	-2.48	-1.39	-2.07
	Critical value (λ = 0.2)	-3.80	-3.80	-3.80	-3.80
1 (191-1621)	Deterministic trend?	No	No	No	No
	Lag length	3	3	9	1
	Covariance formula	OLS	OLS	OLS	NW
	ADF statistic	-3.59	-3.71	-1.22	-2.34
	Critical value (λ = 0.6)	-3.95	-3.95	-3.95	-3.95
2 (1-1621)	Deterministic trend?	No	No	Yes	Yes
	Lag length	3	3	0	4
	ADF statistic	-1.76	-1.78	-0.93	-2.26
	Critical value	-2.86	-2.86	-3.42	-3.42
3A (1-190)	Deterministic trend?	Yes	Yes	Yes	No
	Lag length	0	0	0	1
	ADF statistic	-1.42	-2.02	-2.64	-1.12
	Critical value	-3.44	-3.44	-3.44	-2.88
3B (191-937)	Deterministic trend?	Yes	Yes	Yes	Yes
	Lag length	3	0	1	0
	ADF statistic	-2.31	-2.63	-1.08	-1.19
	Critical value	-3.42	-3.42	-3.42	-3.42
3C (938-1621)	Deterministic trend?	No	Yes	Yes	Yes
	Lag length	0	5	6	5
	ADF statistic	-2.53	-2.73	-0.67	-0.49
	Critical value	-2.87	-3.42	-3.42	-3.42

Note: NW denotes the Newey-West covariance matrix formula. Unless otherwise specified, the OLS covariance formula is used in the calculation of the test statistics.

Table 2: Unit root tests of first difference

Set	Test	Spot	Futures	US rates	Aust rates
2	Lag length	2	2	4	2
	ADF statistic	24.92	-24.89	17.74	21.43
	Critical value	-2.86	-2.86	-2.86	-2.86
3A	Lag length	0	0	0	0
	ADF statistic	12.63	-13.26	14.04	11.09
	Critical value	-2.88	-2.88	-2.88	-2.88
3B	Lag length	2	2	0	0
	ADF statistic	17.28	-17.31	29.09	25.55
	Critical value	-2.87	-2.87	-2.87	-2.87
3C	Lag length	4	2	5	8
	ADF statistic	13.53	-16.71	11.76	-7.68
	Critical value	-2.87	-2.87	-2.87	-2.87

Note: The ADF tests are conducted without a time trend since the t-statistics with and without at trend are not substantially different.

Table 3: Cointegration Tests for s_{t+1} and f_t in the Risk Premium model for different sample sets

Test Statistic	Number of cointegrating vectors				
	Two structural breaks	No structural breaks	Sample set		
			3A	3B	3C
Maximal Eigenvalue	1	1	0	1	1
Trace	1	1	0	1	1

Table 4: Cointegration Tests for s_{t+1} and f_t., r^d_t and r^f_d in the Cost-of-Carry model for different sample sets

Test Statistic	Number of cointegrating vectors				
	Two structural breaks	No structural breaks	Sample set		
			3A	3B	3C
Maximal Eigenvalue	2	2	0	1	2
Trace	2	1	0	1	1

Table 5: Risk Premium models estimated for sample sets 1, 2, 3B and 3C

Variables	Model			
	1	2	3B	3C
Δs_t	-0.163*	-0.163*	-0.046	-0.453*
	(0.034)	(0.034)	(0.657)	(0.000)
Δf_t	0.181*	0.184*	0.093	0.438*
	(0.014)	(0.012)	(0.337)	(0.001)
DL1	0.000			
	(0.189)			0.004
DL2	0.000			(0.261)
	(0.930)			-
AECM	-0.002			
	(0.533)			-
	0.000			
BECM	(0.542)	0.000		-
	-	(0.963)		
DECM		-	0.001	-
	-		(0.088)	
EECM		-	-	-0.002
	-			(0.125)
Test Statistics	**Model**			
	1	2	3B	3C
DW	1.997	1.997	1.996	1.984
LM(S)	0.52	0.52	0.25	2.54
	(0.473)	(0.473)	(0.614)	(0.111)
RESET	4.31*	2.37	0.72	1.33
	(0.038)	(0.124)	(0.937)	(0.249)
Jarque-Bera	723.56*	735.37*	438.15*	71.92*
	(0.000)	(0.000)	(0.000)	(0.000)
LM(H)	0.77	0.56	3.42	0.02
	(0.403)	(0.456)	(0.065)	(0.884)

Table 6: Cost-of-Carry models estimated for sample sets 1, 2, 3B and 3C

Variables	Model			
	1	2	3B	3C
Δs_t	-0.170*	-0.174*	-0.063	-0.456*
	(0.028)	(0.024)	(0.545)	(0.000)
Δf_t	0.182*	0.189*	0.108	0.440*
	(0.014)	(0.01)	(0.264)	(0.001)
Δr^d_t	0.003	0.003	0.002	-0.002
	(0.260)	(0.215)	(0.579)	(0.656)
Δr^f_t	0.005*	0.005*	0.005	0.004
	(0.014)	(0.009)	(0.067)	(0.261)
DL1	0.000	-	-	-
	(0.764)			
DL2	0.000	-	-	-
	(0.502)			
AECM4	-0.05	-	-	-
	(0.729)			
AECM5	0.000	-	-	-
	(0.542)			
BECM1	-	0.000	-	-
		(0.802)		
DECM1	-	-	0.034	-
			(0.157)	
EECM1	-	-	-	-0.005
				(0.125)
Test Statistics	**Model**			
	1	2	3B	3C
DW	1.998	1.999	1.999	1.984
LM(S)	0.02	0.000	0.005	2.54
	(0.901)	(0.995)	(0.944)	(0.111)
RESET	0.50	0.011	4.93*	1.33
	(0.479)	(0.916)	(0.026)	(0.249)
Jarque-Bera	752.26*	752.12*	519.7*	71.92*
	(0.000)	(0.000)	(0.000)	(0.000)
LM(H)	0.77	1.583	1.02	0.02
	(0.380)	(0.208)	(0.313)	(0.884)

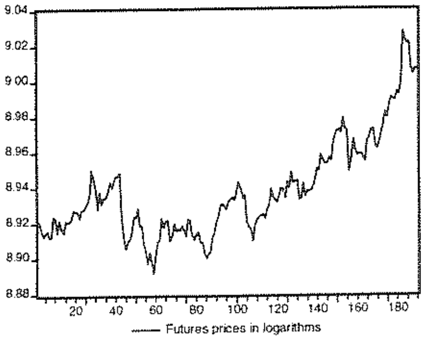
Notes for Table 4 and 5:

a. DW denotes the Durbin-Watson statistic, LM(S) is the Lagrange Multiplier test for serial correlation. RESET is Ramsey's test for functional form misspecification. Jarque-Bera is the test for normality, and LM(H) is the Lagrange Multiplier test for Heteroskedasticity.

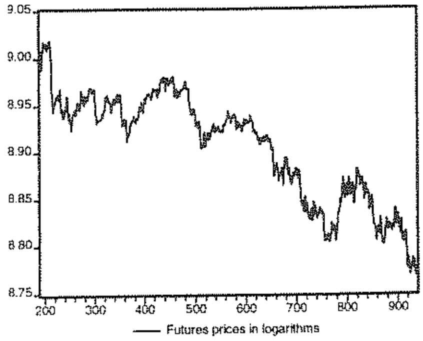
b. Figures in parentheses are p-values; * denotes significance at the 5% level

Australian dollar futures prices

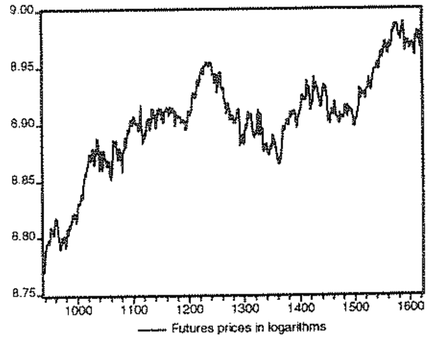
Observations 1 to 190 (13 Nov 89 to 5 Sep 90



Observations 191 to 937 (6 Sep 90 to 30 Sep 93

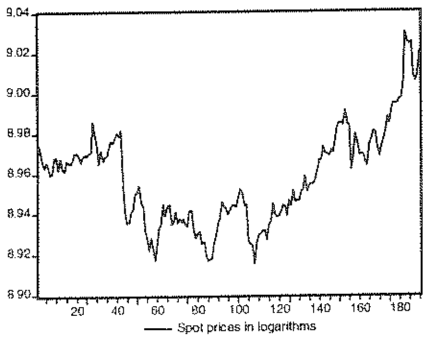


Observations 938 1621 (1 Oct 93 to 17 Jul 96)

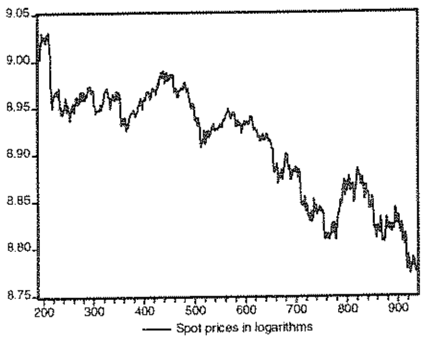


Australian dollar spot prices

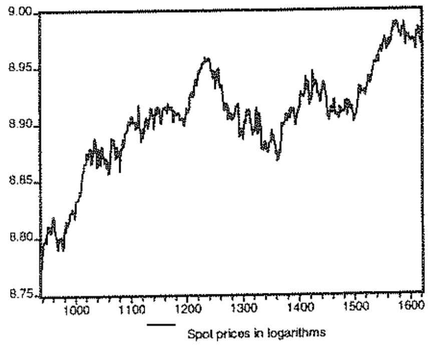
Observations 1 to 190 (13 Nov 89 to 5 Sep 90)



Observations 191 to 937 (6 Sep 90 to 30 Sep 93)

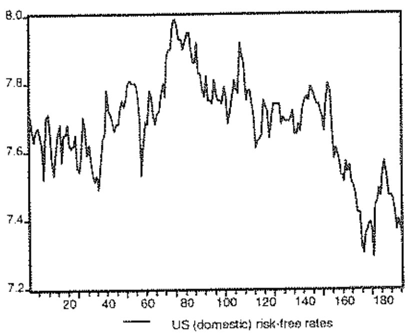


Observations 938 1621 (1 Oct 93 to 17 Jul 96)

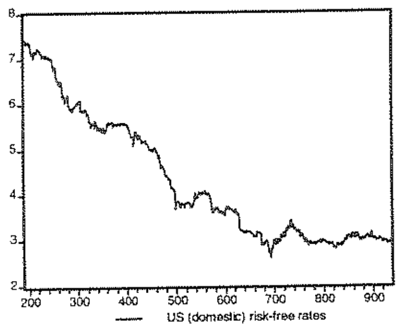


US risk-free interest rates

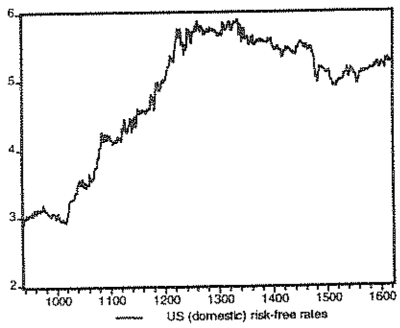
Observations 1 to 190 (13 Nov 89 to 5 Sep 90)



Observations 191 to 937 (6 Sep 90 to 30 Sep 93)

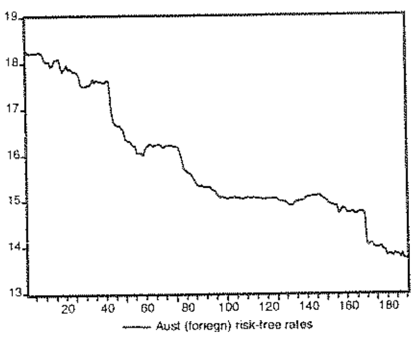


Observations 938 to 1621 (1 Oct 93 to 17 Jul 96)

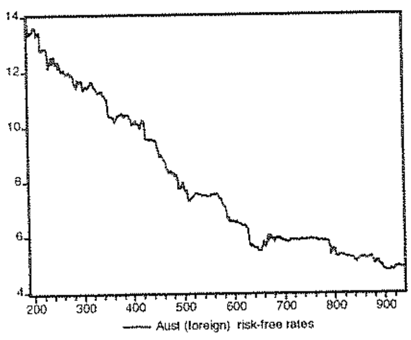


Australian risk-free rates

Observations 1 to 190 (13 Nov 89 to 5 Sep 90)



Observations 191 to 937 (6 Sep 90 to 30 Sep 93)



Observations 938 to 1621 (1 Oct 93 to 17 Jul 96)