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COVERED INTEREST PARITY AND THE EFFICIENCY OF THE AUSTRALIAN DOLLAR FORWARD MARKET: A COINTEGRATION ANALYSIS USING DAILY DATA

by

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ABSTRACT

This paper examines covered interest parity and speculative efficiency using cointegration techniques on a daily data set for Australian dollar/US dollar spot and forward rates and Australian and US interest rates. Cointegration between the forward premium and the interest rate differential in both the 3 month and 6 month markets establishes covered interest parity as a possible long run equilibrium relationship for the sample period. However, both a well defined EC mechanism and the fact that past changes in the interest rate differential help predict the forward premium suggest the markets did not utilise all available information efficiently. Neither the 3 month nor the 6 month forward rate cointegrate with the spot rate implying that these variables may have drifted apart over the sample period. Speculative efficiency may be rejected for these markets.

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CONTENTS

COVERED INTEREST PARITY AND THE EFFICIENCY OF THE AUSTRALIAN DOLLAR FORWARD MARKET: A COINTEGRATION ANALYSIS USING DAILY DATA [1]

I. INTRODUCTION

The interest rate parity theorem (IRPT) provides a theoretical framework linking the domestic and foreign interest rates and the spot and forward exchange markets. It plays a key role in exchange rate modelling. Under the hypothesis of speculative efficiency, the forward rate is an unbiased predictor of the future spot rate and both the covered and uncovered versions of the theorem are linked together.

The empirical literature on the IRPT and speculative efficiency in Australia seems to provide contradictory evidence. Tease's (1988) analysis has shown that the speculative efficiency hypothesis can be rejected in the 30-day market but not in the 15-day or 90-day market in the post-float period. Madsen (1990) has provided evidence against the hypothesis before February 1985, but in favour of it after the float. Turnovsky and Bell (1983) provide weak support for the IRPT over the period 1974-1983, while, the analysis of Chong (1987) supports covered interest parity since the floating of the dollar. More recently, Kearney and MacDonald (1991) reject efficiency of the Australian forward exchange market. They use the technique developed by Fama (1984) for separating the forward premium into a risk premium and forecasting error and demonstrate the existence of a time-varying risk premium as well as autocorrelation in forecast errors.

The purpose of the present study is threefold. First, it tests the covered IRPT for the Australian dollar/US dollar using cointegration techniques developed by Engle and Granger (1987). Then, it examines the information content of the cointegrating relationship. It investigates whether changes in the interest rate differential between Australia and US help predict movements in the forward premium/discount, and vice versa. Finally, the study provides evidence on the speculative efficiency hypothesis by means of cointegration analysis.

[1]The authors are extremely grateful to the Commonwealth Bank for the provision of much of the data used in this study and in particular to Hugh Harley and Gary Shilson-Josling for their friendly help and advice. Needless to say they are in no way responsible for the conclusions expressed in this paper. Jack Towe provided sterling assistance with data preparation and computing and Ashok Parikh and Jeff Sheen offered helpful comments on an earlier draft.

The major innovation of this study is that it is based on daily data. This moderately high frequency data set allows the estimation of error correction (EC) models in which adjustment may take place quite rapidly. There appears to be a general consensus that adjustment in financial markets is very rapid.

The rest of the paper is organised as follows. Section II, outlines theoretical and methodological issues. Section III, presents and discusses the empirical results. Concluding remarks are provided in Section IV.

II. THEORETICAL AND METHODOLOGICAL ISSUES

In a two-country context with highly substitutable assets, international portfolio equlibrium is specified as

$$(F_{t-1,t} - S_t)/S_t = \alpha + \beta(r_t - r_t^*) + u_t \qquad (1)$$

where $F_{t-1,t}$ and S_t denote, respectively, the forward rate contracted at time t-1 for payment at time t and the spot rate; r_t and r_t^* denote the domestic and foreign interest rates and u_t is the error term.[2] The hypothesis of covered IRP implies that $\alpha=0$, $\beta=1$ and u_t is white noise.

Under the joint hypothesis of rationality and risk neutrality, the speculative efficiency theorem states that

$$\ln S_t = \gamma + \delta \ln F_{t-1,t} + \varepsilon_t \qquad (2)$$

where ε_t is the error term. If $\gamma=0$, $\delta=1$ and ε_t is white noise, the forward rate is an unbiased predictor of the future spot rate.

If the interest rate differential is a stationary process, and the forward premium/discount is also stationary, covered IRP indicates a long run equilibrium relationship. The existence of long run covered IRP can be looked at from the viewpoint of cointegration (Engle and Granger, 1987) by examining the stationarity of the process u_t. In applying the cointegration testing procedure, first the hypothesis that the individual series contain a unit root, that is, that they are integrated of order one (I(1)), needs to be tested, since in this case standard statistical inference is invalidated (Fuller, 1985). To this end, the Dickey-Fuller (DF) and Augmented DF (ADF) tests (Fuller, 1976; Dickey and Fuller, 1981) can be used.

[2] It is well known that equation (1) is only an approximation. The condition for an absence of interest arbitrage, indeed for an absence of speculator and trader arbitrage as well, is

$$(1+r)=(1/S)(1+r^*)F$$

which reduces to

$$(F-S)/S=(r-r^*)/(1+r^*)$$

All the cointegration analysis, including estimation of the EC models, presented in this paper has been repeated for the more exact relationship with no changes to the major findings reported here. These additional results are available from the authors on request.

The Granger representation theorem presented by Granger and Engle (1987) states that if a set of variables are cointegrated then there always exists an EC mechanism, and vice versa. This implies that there must be Granger causality running in at least one direction between the forward premium and interest rate differential and therefore one variable can be used to forecast the other (Granger, 1986). It follows that vector autoregressive (VAR) models in first differences lead to misspecification if the variables are cointegrated.

III. EMPIRICAL ANALYSIS

III.1. The Data

The data employed in this study were provided by the Commonwealth Bank. Our analysis involves the following empirical counterparts to the variables introduced in Section II:

(i) the 3 month forward premium on the A$ (denoted FP3) was calculated by expressing the forward margin on the A$ in US cents as a percentage of the spot rate;

(ii) the 6 month forward premium on the A$ (FP6) was calculated in an analogous manner;

(iii) the 3 month interest rate differential (IDIF3) was approximated by the difference between the yield on US 90 day bank bills and the yield (quoted to buyers) on Australian 90 day bank-accepted bills;

(iv) the 6 month interest rate differential (IDIF6) was approximated analogously by the difference between US and Australian 180 day bank-accepted bill yields;

(v) lnS, lnF3 and lnF6 are the logarithms of the spot rate and three month and six month forward rates respectively.

The data were available for four years from the beginning of January 1984 to the end of December 1987. However, one might expect there to have been a learning period associated with the newly introduced floating exchange rate regime, particularly since it was coupled with ***perceived*** monetary instability leading up to the abandonment of monetary targetting in January 1985.[3] For this reason, we confined

[3] From the beginning of January 1984 to the end of January 1985, covered interest parity clearly failed to hold. In a regression of FP3 on IDIF3, the coefficient on IDIF3 for the earlier sample period was 0.58 (t=18.82) compared with 0.94 (t=143.53) for the period as a whole, and a Chow test for structural stability produced an F value of 162 compared with a critical value of $F_{2,720}=3$ enabling clear rejection of the null hypothesis of equality of parameters in the two sub-periods. Similar problems existed for the 6 month forward market. Indeed, from 20th August to 20th September 1984, the only time during the whole sample period that the interest rate differential favoured the US, the A$ remained at a substantial forward discount.

our analysis to the period from the beginning of February 1985 to the end of December 1987. Because the daily data excluded observations for each weekend, we were faced with the choice or either treating the weekend break as identical to an over night break to produce a continuous data set or treating the weekend break as different and hence as missing observations. Because of the longer time to reflect on information and because there is some screen trading over the weekend, we chose the latter course. The cost of doing so is that incorporating longer lags into an estimated relationship reduces the number of available observations.

III.2 Tests for Unit Roots and Cointegration

With respect to the univariate time series properties of the data, the results reported in Table 1 indicate that nonstationarity cannot be rejected for the levels of all the series at the 5% significance level.

TABLE 1: UNIT ROOT TESTS

Statistic	FP3	IDIF3	FP6	IDIF6	lnS	lnF3	lnF6
				VARIABLE			
				Levels			
ADF	-0.93	-1.65	-1.41	-0.77	0.49	0.43	0.37
j	0	1	1	1	0	0	0
LM(2)	1.63	6.04*	1.72	5.70	1.11	1.06	0.32
				First Differences			
ADF	-16.75	-20.79	-14.31	-19.64	-17.99	-10.86	-17.06
j	0	0	0	0	1	1	1
LM(2)	1.20	5.24	0.17	4.5	4.92**	5.06**	5.28**

Notes: (i) j indicates the number of lagged values of the dependent variable used to ensure that the residuals were "white noise". j was chosen using LM tests for serial correlation.

(ii) Because weekends produced "missing observations", the tests were limited to a test for up to second order serial correlation. LM(2) values are provided which may be compared with a critical value of $\chi^2(2) = 5.99$

(iii) * This is marginally greater than the critical value of 5.99 but the addition of further values of the dependent variable left insufficient observations to conduct an LM test, although the ADF statistic remained below (in absolute terms) the critical value.** as for * except that the LM test is for first-order serial correlation only and the critical value of $\chi^2(1)$ is 3.84.

In contrast, when the data are differenced, nonstationarity can be rejected in all cases. The fundamental implication of these findings with respect to the time series modeling of covered interest parity is that first-difference transformation of the variables is required to induce stationarity. Otherwise, by ignoring the problem, one can obtain spurious outcomes (Granger and Newbold, 1974; Phillips, 1986).

The Augmented Dickey-Fuller (ADF) tests, based on the residuals (RES1 and RES2) of the cointegrating equations 1a and 1b, reported in Table 2 lead us to reject the hypothesis that the forward premium and the interest rate differentials are non-cointegrated at the 5% level of significance. One implication is that shocks which affect the discrepancy between the domestic and foreign interest rates are reflected in the forward premium,and thus movements between these variables will be closely associated, obeying an equilibrium constraint.

TABLE 2: TESTS FOR COINTEGRATION BETWEEN FP and IDIF

(1a) $FP3 = 0.004 + 0.95*IDIF3 + RES1$ $\quad R^2 = 0.97$

Unit Root Tests on RES1: ADF = -5.41 ; j = 1 ; LM(2) = 0.58

(1b) $FP6 = 0.007 + 0.94*IDIF6 + RES2$ $\quad R^2 = 0.97$

Unit Root Tests on RES2: ADF = -7.37 ; j = 0 ; LM(2) = 8.20*

Notes: (i) j indicates the number of lagged values of the dependent variable used to ensure that the residuals were "white noise". j was chosen using LM tests for serial correlation.

(ii) * This exceeds the critical value of $\chi^2(2) = 5.99$. With the inclusion of two additional lagged values of the dependent variable, the ADF remained above the critical (in absolute terms) value but the serial correlation in the residuals persisted. Adding further lags meant an LM test could not be conducted.

(iii) Critical values for the ADF test are taken from Engle and Yoo (1987).

An alternative way of modelling and testing equilibrium constraints postulated by economic theory is in the context of an EC model (Banerjee, et al., 1986).Having established the existence of cointegration, it is possible to use the Engle and Granger (1987) two step procedure. Thus, given that FP3 and IDIF3 are both I(1) and are cointegrated there exits an EC specification of the form

$$\Delta FP3_t = -a_1 RES1_{t-1} + \sum_{i=1}^{n} b_{1i} \Delta FP3_{t-i} + \sum_{j=1}^{n} c_{1j} \Delta IDIF3_{t-i} + \varepsilon_{1t} \quad (3)$$

$$\Delta IDIF3_t = a_2 RES1_{t-1} + \sum_{i=1}^{n} b_{2i} \Delta IDIF3_{t-i} + \sum_{j=1}^{n} c_{2j} \Delta FP3_{t-i} + \varepsilon_{2t} \quad (4)$$

and similarly for ΔFP6 and ΔIDIF6.The error terms ε_{1t} and ε_{2t} are assumed to be white noise processes.

The results are reported in Table 3. The EC mechanism is only significant in the forward premium equations indicating the existence of forces in the forward market that operate to restore long run equilibrium after a short run disturbance. The EC terms have the correct signs and indicate that deviations of the forward premium from its equilibrium value were corrected at a daily rate of 21% for the 3 month contract, and 17% for the 6 month contract. These estimated rates of adjusment are rather slower than we anticipated. The insignificance of the EC mechanism in Equations (4a) and (4b) indicates that changes in the interest rate differential do not contain any information about the parameters of the cointegrating regression (1), and hence the IDIF variable can be considered as the driving trend in the relationship (Johansen and Juselius, 1990).

TABLE 3: TESTS OF HYPOTHESES ON ESTIMATES OF THE EC MODELS (Equations 3 and 4)

	Depend. Variable	$H_0{:}a_k=0$ a_k ; (t-ratio)	$H_0{:}\ \sum_{i=1}^{3} b_{ki}=0$ LR $\chi^2(3)$	$H_0{:}\ \sum_{j=1}^{3} c_{kj}=0$ LR $\chi^2(3)$	R^2	LM(1)
3a	ΔFP3	-0.207;(-2.24)*	1.23	22.19 *	0.14	1.16
4a	ΔIDIF3	0.058; (0.51)	11.16 *	18.45 *	0.34	3.64
3b	ΔFP6	-0.168;(-2.02)*	4.53	34.94 *	0.09	3.48
4b	ΔIDIF6	0.099; (1.06)	16.10 *	19.27 *	0.58	2.70

Notes: (i) The number of lags used was limited to three because weekends constituted "missing observations". Consequently, the equations were estimated using the Friday observations for the dependent variable.

(ii) The LM test was for first order serial correlation of the residuals and the LM statistic may be compared with a critical value of $\chi^2(1)=3.84$.

(iii) LR indicates the likelihood ratio test for the joint insignificance of the excluded variables. Given that three lagged values are always excluded the critical value of $\chi^2=7.81$.

(iv) * indicates significance at 5% level

This finding can be taken as evidence that the ΔIDIF variable is weakly exogenous for the parameters α and β (Engle, Hendry and Richard, 1983). On the other hand, changes in the interest rate differential provide information that helps predict future movements in the forward premium. These findings are inconsistent with the hypothesis of market efficiency because of the prevalence of the EC specification and because information on IDIF is not incorporated immediately in the forward premium. In the present context, both channels of causality are present, that is, the lagged ΔIDIF is significant, as is the coefficient on the EC term. The significance of the latter shows the pitfalls of ignoring the long run properties of the data and using first difference specifications to detect noncausality patterns (Granger, 1988). The Likelihood ratio statistics do not reject the null hypothesis of an absence of serial correlation at the 5% significance level in each case.

Having established the existence of covered interest rate parity for the Australian dollar/US dollar, we proceed to investigate the speculative efficiency hypothesis using cointegration analysis. The results reported in Table 4 lead us not to reject the hypothesis, at the 5% significance level, of non-cointegration between both the 3 month and 6 month forward rates and the spot rate, implying that these variables will drift apart from each other over time. The forward rates are therefore poor predictors of the future spot rate and speculative efficiency may be rejected for both those markets. This result is consistent with those obtained earlier as well as with the presence of a unit root in the forward premium variable.

TABLE 4: TESTS FOR COINTEGRATION BETWEEN lnS AND LAGGED lnF

(1) LnS = -0.111 +0.688LnF3(-90) + RES3	R^2=0.660
Unit Root Tests on RES3: ADF = -1.34; j=0; LM(1) =0.48	
(2) LnS = -0.323 + 0.167LnF6(-180) + RES4	R^2=0.07
Unit Root Tests on RES4: ADF = -2.12; j=1; LM(1) =9.68 *	

Notes: As per Table 2.

IV. CONCLUSIONS

This paper has examined covered interest parity and the efficient markets hypothesis using cointegration techniques on a daily data set for Australian dollar/US dollar spot and forward rates and Australian and US interest rates. Cointegration between the forward premium and the interest rate differential in both the 3 month and 6 month markets establishes covered interest parity as a possible long run equilibrium relationship for the sample period. However, both a well defined EC mechanism and the fact that past changes in the interest rate differential help predict the forward premium suggest the markets did not utilise all available information efficiently in the short run.

The fact that neither the 3 month nor the 6 month forward rate cointegrated with the spot rate implies that these variables may have drifted apart over the sample period. The forward rates were, therefore, poor predictors of the future spot rate and speculative efficiency may be rejected for these markets. These results are consistent with the findings of Kearney and MacDonald(1991).

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