WORKING PAPERS IN ECONOMICS

Do Movements in the Forward Discount on the Australian Dollar Predict Movements in Domestic Interest Rates? Evidence from a Time Series Analysis of Covered Interest Parity in Australia in the late 1980s

by

C.I. Karfakis and A.J. Phipps

No. 187 May 1993

DEPARTMENT OF ECONOMICS

The University of Sydney
Australia 2006

Do Movements in the Forward Discount on the Australian Dollar Predict Movements in Domestic Interest Rates? Evidence from a Time Series Analysis of Covered Interest Parity in Australia in the late 1980s

by

C.I. Karfakis and A.J. Phipps

No. 187 May 1993

ABSTRACT

This paper examines covered interest parity using cointegration techniques on a daily data set for Australian dollar/US dollar spot and forward exchange rates and Australian and US interest rates. While the forward premium and the interest rate differential cointegrate in both the 3 month and 6 month markets, the data reject the formal restrictions of covered interest parity. Well defined error-correction mechanisms suggest that the forward premium bears the burden of adjustment to the long run cointegrating relationship and that past changes in the forward premium predict changes in the interest rate differential.

National Library of Australia Card Number and ISBN 0 86758 ~~[illegible]~~ 776 8

CONTENTS

Do Movements in the Forward Discount on the Australian Dollar Predict Movements in Domestic Interest Rates? Evidence from a Time Series Analysis of Covered Interest Parity in Australia in the late 1980s[1]

I. INTRODUCTION

One of the major isssues concerning Australian monetary policy in the deregulated environment of the late 1980s was the extent to which the Reserve Bank varied interest rates in order to stabilize the Australian dollar. This paper presents evidence which is consistent with the view that Australian financial markets at least anticipated that the Reserve Bank would vary interest rates to smooth the currency. The evidence emerges from a vector autoregressive (VAR) analysis of changes in the forward premium on the Australian dollar and changes in the interest rate differential on Australian and US bank accepted bills in the late 1980s. The VAR analysis supports strongly a short run dynamic model in which changes in the forward premium predict changes in the interest rate differential. This suggests that when the Australian dollar was under speculative pressure, as indicated by an increase in the forward discount, financial markets reacted by raising interest rates on Australian commercial paper (relative to US interest rates) in anticipation of a tightening of monetary policy by the Reserve Bank.

The VAR results mentioned above come from a cointegration analysis of covered interest parity (CIP) in Australia and the depiction of the associated short run dynamics by error correction (EC) VAR models. The CIP theorem is, of course, of interest in its own right. The interest rate parity theorem provides a theoretical framework linking domestic and foreign money markets and the spot and forward exchange markets. CIP is among the best known of conditions for an absence of pure arbitrage opportunities and, as such, is taken as evidence for market efficiency. Given the strong empirical support for CIP provided by Taylor (1987) using a high quality, high frequency data set and given the inate plausibility of the theorem itself, it is rather surprising that there has been a dearth of supporting empirical

[1]The authors are extremely grateful to the Reserve Bank and the Commonwealth Bank for the provision 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.

evidence for CIP in Australia. Turnovsky and Bell (1983) provide weak support for CIP over the period 1974-1983, while the analysis of Chong (1987) supports CIP since the floating of the dollar. Neither study allows for the possibility of unit roots in the data generating processes for the forward premium and the interest rate differential with the consequence that the standard statistical procedures used to test for CIP may be invalid. Clearly there is a need to examine further the long run relationship between the forward premium on the Australian dollar and an appropriate interest rate differential and to test properly the restrictions implied by the CIP theorem. However, we believe that rejection of the exact restricions of CIP need not be interpreted as grounds for rejecting the hypothesis that the Australian dollar forward market is efficient. Failure of CIP to hold exactly may be explained by the existence of adjustment costs and/or variable risk premia.

The purpose of the present study is threefold. First, we test for cointegration between the forward premium on the Australian dollar (in terms of the US dollar) and the interest rate differential on Australian and US bank accepted bills for both the 3 month and 6 month markets, using techniques developed by Johansen and Juselius (1990).[2] Second, we examine the CIP theorem by testing the implied coefficient restrictions both directly in the cointegrating vector by standard likelihood ratio tests and indirectly by the method suggested by Liu and Maddala (1992). Finally, the paper examines the information content of the cointegrating relationship by examining the short run dynamics implied by the associated EC models. In particular, we investigate whether changes in the interest rate differential between Australia and the US help predict movements in the forward premium/discount, and vice versa. The major innovation of this study is that it is based on daily data. This moderately high frequency data set allows the estimation of 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.

[2] This paper is a refinement and extension of Karfakis and Phipps (1991). The major improvements in this study as compared with the previous one are: (i) the size of the sample is extended by two years; (ii) the cointegration tests are done using the maximum likelihood techniques of Johansen and Juselius (1990) rather than the approach of Engle and Granger (1987); (iii) we test the restrictions implied by CIP directly and (iv) we pay far more attention to the information content of the EC models associated with CIP.

II. THEORETICAL AND METHODOLOGICAL ISSUES

For two countries with a high degree of international capital mobility, the CIP hypothesis may be tested by examining restricitions in the following equation

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

where $F_{t,t+1}$ denotes the forward exchange rate contracted at time t for payment at time t +1 and S_t denotes the spot exchange rate; r and r_t* are domestic and foreign interest rates and u_t is the error term. The hypothesis of CIP implies that α=0, β=1 and that u_t is white noise.[3]

CIP may be thought of as a long run equilibrium relationship and, as such, may be examined from the viewpoint of cointegration. Before applying cointegration testing procedures, it is customary to test the hypothesis that the individual series contain a unit root, that is, that they are integrated of order one (I(1)) since standard statistical inference may be invalidated if the data are nonstationary (Fuller, 1985). To this end, the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1981) may be used. The existence of a long run cointegrating relationship, like CIP above, may be tested by examining the stationarity of the process u_t (Engle and Granger, 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). The Granger representation theorem, presented by Granger and Engle (1987), states that if a set of variables are cointegrated there always exists at least one associated EC mechanism, and vice versa. Thus, if we establish that the forward premium on the Australian dollar (FP) and an associated interest differential (IDIF) are both I(1) and are cointegrated there exits an EC VAR specification of the form

$$\Delta FP_t = a_1 RES_{t-1} + \sum_{i=1}^{n} b_{1i}\Delta FP_{t-i} + \sum_{i=1}^{n} c_{1i}\Delta IDIF_{t-i} + \varepsilon_{1t}\ ; \quad a_1 < 0 \qquad (2)$$

$$\Delta IDIF_t = a_2 RES_{t-1} + \sum_{i=1}^{n} b_{2i}\Delta FP_{t-i} + \sum_{i=1}^{n} c_{2i}\Delta IDIF_{t-i} + \varepsilon_{2t} \qquad (3)$$

where RES are the residuals from the cointegrating vector. The error terms ε_{1t} and ε_{2t}

[3] 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.

are assumed to be white noise processes.

A cointegrating vector may thus be thought of as a long run equilibrium relationship which drives the short run dynamic EC mechanisms. Johansen and Juselius(1990) show how the cointegrating vector(s), the error correction parameters and the parameters of lagged differences of endogenous variables may be estimated using full information maximum likelihood techniques. Tests for the existence of any number of cointegrating (eigen)vectors are then based upon the number of significant associated eigenvalues, with the appropriate tables for inference being given in their paper. When one has found a system that has acceptable statistical properties, restrictions on the cointegrating vector(s) and the error correction parameters may be tested using standard likelihood ratio tests. If the forward premium and the associated interest rate differential turn out to be cointegrated, the existence of one or two associated EC mechanisms implies that there must be Granger causality running in at least one direction between the two variables and that therefore one variable can be used to forecast the other (Granger, 1986).

III. EMPIRICAL ANALYSIS

III.1. The Data

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 in the Interbank Market 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.

The data were available for five years from the beginning of January 1984 to the end of December 1988. The data are illustrated in Charts 1 and 2. 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.[4] For this reason, we confined our analysis to the period from the beginning of February 1985 to the end of December 1988 . The failure of CIP to hold in the earlier sub-period and the strong relationships thereafter are well illustrated in Charts 1 and 2.

CHART 1: FP3 AND IDIF3 (1/1/84 to 31/12/88)

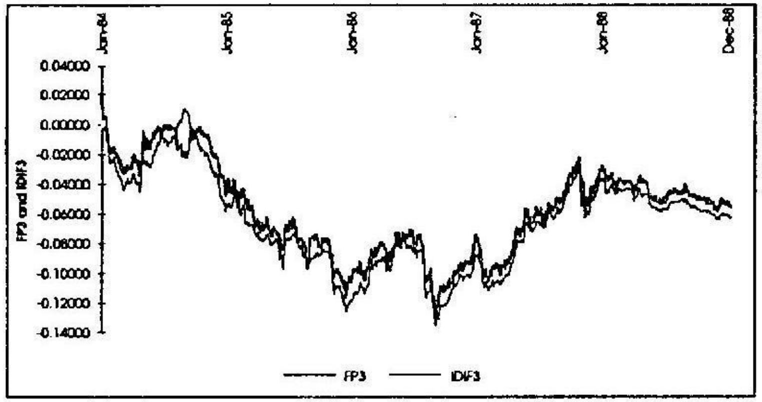
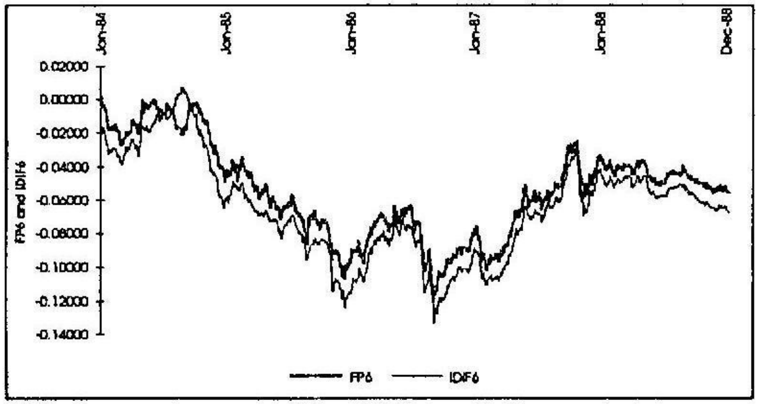


CHART 2: FP6 AND IDIF6 (1/1/84 to 31/12/88)



[4] From the beginning of January 1984 to the end of January 1985, FP3 and IDIF3 failed to cointegrate. 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.

Because the daily data excluded observations for each weekend and public holiday, we were faced with the choice of treating the weekend and holiday breaks either as identical to overnight breaks to produce a continuous data set or as substantially different and hence as missing observations. The main cost of treating breaks as missing observations is that incorporating longer lags into an estimated relationship requires a substantial reduction in the number of available observations and makes it difficult to compare estimates with different lags. For these reasons, we have opted in this study to work with a continuous data set.[5]

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: ADF TESTS FOR UNIT ROOTS

	Variable			
	FP3	IDIF3	FP6	IDIF6
ADF Statistic		*Levels*		
without trend	-2.4438	-1.8990	-2.1602	-1.6512
with trend	-2.1355	-1.6361	-1.8450	-1.4276
		First Differences		
without trend	-23.7378	-21.9540	-23.0583	-22.6670
with trend	-23.7837	-22.0048	-23.0843	-22.6908

Notes: (i) the ADF statistics were calculated with one lag of the dependent variable which was sufficient to ensure that the residuals were "white noise".
(ii) The number of observations for the ADF test on the levels was 1195 and for the test in first differences 1194 . The critical values for ADF at the 95% level were -2.8644 (without trend) and -3.4160 (with trend).

In contrast, when the data are differenced, nonstationarity can be rejected in all cases. Hence, time-series modelling of CIP requires first-difference transformation of the variables to induce stationarity. Otherwise, by estimating the relationship in the levels one can obtain spurious outcomes (Granger and Newbold, 1974; Phillips, 1986).

[5] In our earlier study, Karfakis and Phipps (1991), we chose to treat the breaks as missing observations. Although the estimation method in that study was Engle and Granger rather than Johansen and Juselius, the estimated cointegrating vector was almost identical. The major differences between the two studies are, as one might expect, in the estimated short-run dynamics.

The results of the Johansen maximum likelihood procedures used to test for cointegration between the forward premium and the interest rate differential are set out in Table 2 (for the 3 month market) and in Table 3 (for the 6 month market). The number of lags in the VAR was set at 8 by reference to standard LR tests. We reject the null hypothesis of zero cointegrating vectors in favour of the alternative that there exists at most one such vector. This conclusion is supported by both the maximum eigenvalue and the trace tests described by Johansen and Juselius (1990).

TABLE 2: JOHANSEN MAXIMUM LIKELIHOOD TESTS FOR COINTEGRATION; 3 MONTH FORWARD PREMIUM AND INTEREST RATE DIFFERENTIAL

List of variables included in the cointegrating vector:
FP3 IDIF3 Intercept
945 observations from 253 to 1197. Maximum lag in VAR = 8.

Cointegration LR Test Based on **Maximal Eigenvalue** of the Stochastic Matrix

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	51.8012	15.6720	13.7520
r<= 1	r = 2	3.0782	9.2430	7.5250

Cointegration LR Test Based on **Trace** of the Stochastic Matrix

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	54.8794	19.9640	17.8520
r<= 1	r = 2	3.0782	9.2430	7.5250

Estimated Cointegrated Vector(s) (Normalized in Brackets). Chosen r = 1.

FP3	IDIF3	Intercept
17.2666	-16.3579	-.065017
(-1.0000)	(.94737)	(-.00397)

Estimated Adjustment Matrix (Normalized in Brackets). Chosen r =1.

FP3	IDIF3
-.011978	.003699
(.20683)	(-.063869)

Test of CIP Restrictions (Intercept = 0.00 Slope = 1.00) on Cointegrated Vector.
LR Test of Restrictions CHI-SQ(2)= 48.9551 [.000]

TABLE 3: JOHANSEN MAXIMUM LIKELIHOOD TESTS FOR COINTEGRATION; 6 MONTH FORWARD PREMIUM AND INTEREST RATE DIFFERENTIAL

List of variables included in the cointegrating vector:
FP6 IDIF6 Intercept
945 observations from 253 to 1197. Maximum lag in VAR = 8.

Cointegration LR Test Based on **Maximal Eigenvalue** of the Stochastic Matrix

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	33.6039	15.6720	13.7520
r<= 1	r = 2	3.7368	9.2430	7.5250

Cointegration LR Test Based on **Trace** of the Stochastic Matrix

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	37.3406	19.9640	17.8520
r<= 1	r = 2	3.7368	9.2430	7.5250

Estimated Cointegrated Vector(s) (Normalized in Brackets). Chosen r = 1.

FP6	IDIF6	Intercept
16.7275	-15.4091	-.07977
(-1.0000)	(.92118)	(.00477)

Estimated Adjustment Matrix (Normalized in Brackets). Chosen r =1.

FP6	IDIF6
-.00725	.004525
(.12131)	(-.07569)

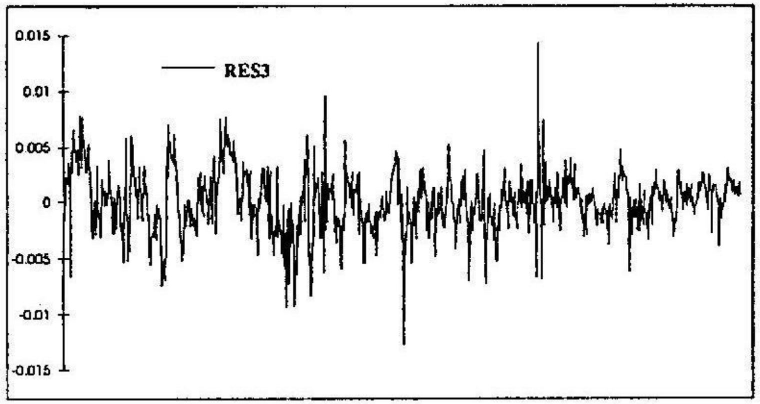
Test of CIP Restrictions (Intercept = 0.00 Slope = 1.00) on Cointegrated Vector.
LR Test of Restrictions CHI-SQ(2)= 32.5141 [.000]

Normalising the cointegrating vectors on the 3 month and 6 month forward premiums yields two equations which reflect long run relationships suggestive of CIP:

$$FP3 = 0.004 + 0.947*IDIF3 + RES3 \quad (4)$$
$$FP6 = 0.005 + 0.921*IDIF6 + RES6 \quad (5)$$

Graphs of the residuals from the cointegrating vector for the 3 month market are presented in Chart 3.[6]

CHART 3: RESIDUALS FROM THE COINTEGRATING VECTOR (3 MONTH MARKET)



While the existence of a cointegrating relationship between the forward premium and the interest rate differential may be taken as evidence in favour of a long run relationship between the two such as CIP, it is important to test the exact restictions implied by the model, namely that the slope coefficient is unity and that the intercept is zero. The likelihood ratio tests reported at the bottom of Tables 2 and 3 strongly reject such restrictions on the cointegrating vector.

An alternative way of testing the restrictions of CIP has been suggested by Liu and Maddala (1992). They propose a two part procedure involving an examination of the divergences from CIP (D = FP - IDIF). A necessary condition for CIP to hold is that the divergences, D, should be I(0). This condition is satisfied for both the 3 month and 6 month markets. The ADF(1) statistic for D3 (= FP3 - IDIF3) over our sample period is -21.97 which compares with a 95% critical value of -3.34 while the ADF(1) statistic for D6 is -22.95. However, cointegration is not sufficient to establish the restriction that the slope coefficient is unity. It is also necessary that the divergences, D3 and D6, be serially uncorrelated.[7] The data strongly reject the hypothesis that the D3 divergences are serially uncorrelated. The LM statistic for 12

[6] A graph of the RES6 residuals, which is very similar to that of RES3, is presented in the Appendix .
[7] If D is I(0) and serially correlated, the unit slope coefficient and hence CIP are rejected. To see this rewrite the equation $FP = \alpha + \beta IDIF + v$ as $FP - IDIF = \alpha + (\beta - 1)IDIF + v$. The presence of serial correlation in D (= FP - IDIF) implies it contains a permanent shock component i.e. it contains the same degree of persistence as IDIF, even though v is I(0). That is, the presence of serial correlation in D implies $\beta \neq 1$.

lags in the autocorrelation function, which is distributed as $\chi^2(12)$, is 73.84 compared with a 95% critical value of 21.03. The corresponding LM statistic for D6 is 155.12 which also leads to a rejection of the hypothesis of serially uncorrelated residuals. The Liu and Maddala tests reject the hypothesis that the slope coefficient is unity for both the 3 month and 6 month markets, confirming the results from the direct tests of the restrictions in the cointegrating vectors presented in Tables 2 and 3. In short, CIP appears not to hold exactly.

However, we believe that rejection of the exact restrictions of CIP need not be interpreted as grounds for rejecting the hypothesis that the Australian dollar forward market is efficient. Failure of CIP to hold exactly may be explained by the existence of adjustment costs and/or of variable risk premia. The existence of transactions costs implies that there is a band of values over which arbitrage conditions need not hold. Frenkel and Levich (1975) analysed the transactions cost band and concluded that, once such costs were taken into account, the empirical data were consistent with CIP.

An alternative explanation for the failure of CIP to hold exactly in our estimates may be found in the existence of variable risk premia. There appear to be substantial and variable risk premia on private paper[8] (Bank Accepted Bills in our study) relative to government paper (Treasury Notes in Australia and Treasury Bills in the US). The mean premium in proportionate terms on 3 month private paper in the US based on monthly data for our sample period was 0.108 (10.8%) while the mean premium in Australia was 0.066 (6.6%). In spite of this, the premium in absolute terms was higher for Australia than for the US because Australian interest rates were substantially higher for the whole of the sample period. As a result, the US-Australia Bank Bill interest rate differential was larger in absolute terms, on average and for most of the sample period, than the US-Australia Treasury Bill/Note interest rate differential. It may be argued that most interest arbitrage takes place in relatively risk-free Treasury Bills and Notes and hence that the appropriate interest rate differential for CIP is that between the rate on US Treasury Bills and the rate on Australian Treasury Notes. The interest rate differential on Bank Accepted Bills overstates the interest rate differential on Treasury Bills/Notes. This may well account for the findings reported in this paper.

III.3 Error Correction Models

Having established that the forward premium and the interest rate differential cointegrate for both the 3 month and 6 month markets, it is appropriate to examine the associated EC mechanisms which describe the short run dynamics. Thus we estimate equations of the following form

[8] Evidence for such a risk premium in Australia is provided by McDonald, Kendall and Ridley (1993)

$$\Delta FP3_t = a_1 RES3_{t-1} + \sum_{i=1}^{n} b_{1i} \Delta FP3_{t-i} + \sum_{i=1}^{n} c_{1i} \Delta IDIF3_{t-i} + \varepsilon_{1t} \; ; \quad a_1 < 0 \qquad (6a)$$

and

$$\Delta IDIF3_t = a_2 RES3_{t-1} + \sum_{i=1}^{n} b_{2i} \Delta FP3_{t-i} + \sum_{i=1}^{n} c_{2i} \Delta IDIF3_{t-i} + \varepsilon_{2t} \qquad (7a)$$

where RES3 are the residuals from the cointegrating equation for the 3 month market. Corresponding equations (6b and 7b) may be estimated for ΔFP6 and ΔIDIF6. The results are reported in Table 4.

TABLE 4: ESTIMATES OF THE EC MODELS AND GRANGER- CAUSALITY TESTS

		Coefficient Estimates			Summary Statistics		
Eq. No.	Dependent Variable	a_k	$\sum_{i=1}^{7} b_{ki}$	$\sum_{i=1}^{7} c_{ki}$	R_{bar}^2	SEE	Q(90) [MSL]
6a	ΔFP3	-0.1987*	0.3951	-0.0590	0.053	0.002	75.89
		(5.3976)	(1.8595)	(0.2789)			[.855]
7a	ΔIDIF3	0.0553*	0.9979*	-0.05844*	0.296	0.002	72.42
		(1.8866)	(5.9018)	(3.4714)			[.913]
6b	ΔFP6	-0.1157*	0.1320	0.1165	0.051	0.002	85.26
		(3.5595)	(0.6102))	(0.5732)			[.622]
7b	ΔIDIF6	0.0701*	1.1860*	-0.6480*	0.285	0.002	94.48
		(2.5914)	(6.5821)	(3.8275)			[.353]

		Granger - Causality Tests			
		$H_0: b_{k1} = b_{k2} = \ldots = b_{k7} = 0$		$H_0: c_{k1} = c_{k2} = \ldots = c_{k7} = 0$	
Eq. No.	Dependent Variable	F-statistic	[MSL]	F-statistic	[MSL]
6a	ΔFP3	2.6901	[0.0092]	1.11733	[0.3153]
7a	ΔIDIF3	19.0654	[0.0000]	3.8326	[0.0004]
6b	ΔFP6	3.8276	[0.0004]	1.6656	[0.1139]
7b	ΔIDIF6	24.7476	[0.0000]	5.76750	[0.0000]

Notes: (i) t-statistics are in rounded brackets below the estimated coefficients.
(ii) * indicates coefficient is significant at 5% level.
(iii) The marginal significance levels [MSL] for the Ljung-Box Q-statistics (estimated with 90 degrees of freedom) and for the F-statistics in the Granger-causality tests are in square brackets.
(iv) The number of lags used was limited to 7 because LR tests rejected the inclusion of 8 lags in favour of the alternative of 7 lags.

The EC terms (a_{k1}) are significant in the (3 and 6 month) forward premium equations and the (3 and 6 month) interest rate differential equations indicating the existence of forces in the (3 and 6 month) forward exchange and bank accepted bill markets 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 25% (19.87 + 5.53) for the 3 month contract, and 17% (11.57 + 7.01) for the 6 month contract. These estimated rates of adjusment are rather slower than we anticipated (but they are consistent with estimated adjustment matrices obtained by the Johansen and Juselius procedure and reported in Tables 2 and 3). Furthermore, the strong EC mechanisms are inconsistent with the hypothesis of market efficiency because information on changes in the interest rate differential was not incorporated immediately into the forward premium. This apparent market failure may again be accounted for by the existence of transaction costs. However, consistent with prior expectations, both the size and significance of the EC terms in the forward premium equations relative to their size and significance in the interest rate differential equations indicate that most of the burden of adjustment to long run equilibrium is borne by the 3 and 6 month forward premiums.

Of more interest are the results of the Granger-causality tests. Standard F tests allow us to reject strongly the null hypothesis that the coefficients on the lagged forward premium terms amd lagged interest rate differential terms are zero in the 3 and 6 month interest rate differential equations, while we are unable to reject the hypothesis that the coefficients on those terms are zero in the 3 and 6 month forward premium equations. This indicates that, over our sample period, changes in the forward premium Granger-caused changes in the corresponding interest rate differential rather than the other way round. Hence, changes in the forward premium could at that time have been used to predict changes in the corresponding interest rate differential. The $Rbar^2$ for both interest rate differential equations is about 30% indicating that short term interest rate movements are essentially predictable. We believe that the most likely explanation for these findings is that the money markets anticipated a well-defined Reserve Bank policy reaction to speculative attacks on the Australian dollar in this period. Thus, it seems likely that when the Australian dollar was under speculative pressure, as indicated by an increase in the forward discount, financial markets reacted by raising interest rates on Australian commercial paper (relative to US interest rates) in anticipation of a tightening of monetary policy by the Reserve Bank. The significant, negative coefficients on the lagged interest rate differential terms in the interest rate differential equations indicate that generally the market may have overreacted and corrected for this by reducing interest rates subsequently. In general, these results are consistent with the view that Australian financial markets anticipated that the Reserve Bank would vary interest rates to smooth the currency. Of course, there may be other less obvious explanations for these results.

IV. CONCLUSIONS

This paper has examined the covered interest parity (CIP) hypothesis using cointegration techniques on a daily data set for Australian dollar/US dollar spot and forward exchange 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 CIP as a possible long run equilibrium relationship for the sample period. However, formal tests of the restrictions implied by CIP, both directly by likelihood ratio tests on the estimated parameters of the cointegrating vector and indirectly by the method suggested by Maddala and Liu (1992), lead us to reject CIP in its exact form. This and well-defined EC mechanisms suggest that the forward exchange market did not utilise all available information efficiently in the short run. However, we believe that rejection of the exact restricions of CIP need not be interpreted as grounds for rejecting the hypothesis that the Australian dollar forward market is efficient. Failure of CIP to hold exactly may be explained by the existence of adjustment costs and/or variable risk premia.

The fact that changes in the forward premium Granger-caused changes in the corresponding interest rate differential rather than the other way round over our sample period implies that changes in the forward premium could, at that time, have been used to predict changes in the corresponding interest rate differential. We believe that the most likely explanation of these findings is that Australian financial markets anticipated that the Reserve Bank would vary interest rates to smooth the currency.

REFERENCES

Banerjee, Anindya, Juan J. Dolado, David F. Hendry and Gregor W. Smith (1986), 'Exploring Equilibrium Relationships in Econometrics Through Static Models: Some Monte Carlo Evidence', **Oxford Bulletin of Economics and Statistics**, 48, 253-278.

Chong, Peter (1987), 'Does Interest Parity Hold For Australia', in T.J. Valentine (ed) **Bulletin of Money, Banking and Finance, 3**, Macquarie University.

Dickey, David A. and Wayne A. Fuller (1981), 'Likelihood Ratio Statistics for Autoregressive Time Series With a Unit Root', **Econometrica, 49**, July, 1057-1072.

Engle, Robert F. and Clive W.J. Granger (1987), 'Cointegration and Error Correction: Representation, Estimation and Testing', **Econometrica, 55**, March, 251-276.

Engle,Robert F., David F. Hendry and Jean-Francois Richard (1983) 'Exogenity', **Econometrica, 51**, 277- 304.

Engle, Robert F., and Byung S. Yoo (1987), 'Forecasting and Testing in Cointegrated Systems', **Journal of Econometrics, 35**, 143-159.

Fama, E. F. (1984), 'Forward and Spot Exchange Rates,' **Journal of Monetary Economics, 14**, 319-338.

Frenkel, Jacob and Richard M. Levich (1975), ' Covered Interest Parity: Unexploited Profits?' **Journal of Political Economy, 83**, April, 325-338.

Fuller, W.A. (1967) **Introduction to Statistical Time Series**, John Wiley and Sons, New York.

Fuller, W.A. (1985) 'Nonstationary Autoregressive Time Series', in E.J.Hannan et al., (eds) **Handbook of Statistics 5**, Elsevier Sience Publishers B.V.

Granger, Clive W.J. (1986), 'Developments in the Study of Cointegrated Economic Variables,' **Oxford Bulletin of Economics and Statistics, 48**, August, 213-228.

Granger, Clive W.J. (1988) 'Some Recent Developments in a Concept of Causality', **Journal of Econometrics, 51**, 199- 211.

Granger, Clive and Newbold Paul (1974), 'Spurious Regressions in Econometrics,' **Journal of Econometrics, 2**, 111-120.

Johansen, Soren and Katarina Juselius (1990) 'Some Structural Hypotheses in a Multivariate Cointegration Analysis of the Purchasing Power Parity and the Uncovered Interest Parity for UK', **Discussion Paper, 90-05**, March, Institute of Economics, University of Copenhagen.

Karfakis, Costas I. and Anthony J. Phipps (1991), 'Covered Interest Parity and the Efficiency of the Australian Dollar Forward Market: a Cointegration Analysis Using Daily Data,' **Working Papers in Economics**, No. 165, November.

Kearney, Colm and Ronald MacDonald (1991), 'Efficiency in the Forward Foreign Exchange Market: Weekly Tests of the Australian/US Dollar Rate, January 1984 - March 1987,' **Economic Record, 67**, 237-242

Liu, Peter C. and G. S. Maddala (1992), 'Rationality of Survey Data and Tests for Market Efficiency in the Foreign Exchange Markets,' **Journal of International Money and Finance, 11**, August, 366-381.

Madsen, Jacob B. (1990), 'Is the Forward Market Still Inefficient', **Working Papers** in Economics and Econometrics, February, The Australian National University.

McDonald, A. David, Jon D. Kendall and Tim I. A. Ridley (1993), 'GARCH-M Estimates of Variable Risk Premia for 180-day Australian Bank Bills,' **Economic Record, 69**, March, 10-19.

Phillips, Peter C.B. (1986), 'Understanding Spurious Regressions in Econometrics', **Journal of Econometrics, 33**, 311-340.

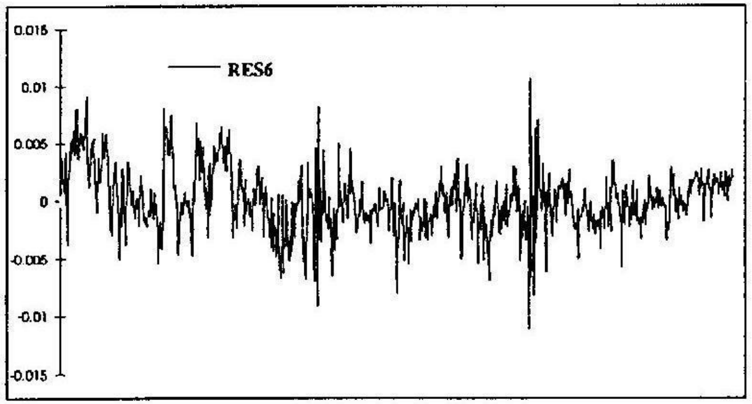
Taylor, Mark P. (1987), 'Covered Interest Parity: A High-frequency, High-quality Data Study,' **Economica, 54**, November, 429-438.

Tease, Warren (1988), 'Speculative Efficiency and the Exchange Rate: Some Evidence Since the Float,' **The Economic Record, 64**, March, 2-13.

Turnovsky, S., and K. Bell (1983), 'Covered Interest Rate Parity and Speculative Efficiency', **The Economic Record, 59**, 271-280.

APPENDIX

CHART 4: RESIDUALS FROM THE COINTEGRATING VECTOR (6 MONTH MARKET)



Working Papers in Economics

139	D.J. Wright	International Technology Transfer and Per Unit Royalties; April 1990
140	P. Ganguli & S. Nath	Optimal Mix of Urban Public Services: The Case of Three Indian Cities; May 1990
141	P.D. Groenewegen	Alfred Marshall's Principles of Economics: A Centenary Perspective from the Antipodes; June 1990
142	J. Sheen	Real Wages and the Business Cycle in Australia; June 1990
143	C.J. Karfakis	A Model of Exchange Rate Policy: Evidence for the US Dollar-Greek Drachma Rate 1975-1987; August 1990
144	C.J. Karfakis & D.M. Moschos	Interest Rate Linkages within the European Monetary System: A Time Series Analysis; August 1990
145	C.J. Karfakis & D.M. Moschos	Asymmetries in the European Monetary System: Evidence from Interest Rates; September 1990
146	W.P. Hogan	International Capital Adequacy Standards; October 1990
147	J. Yates	Shared Ownership: The Socialisation or Privatisation of Housing?; October 1990
148	G. Butler	Contracts in the Political Economy of a Nation; November 1990
149	B. Rao	Some Further Evidence on the Policy Ineffectiveness Proposition; November 1990
150	D.J. Wright	Hidden Action and Learning-By-Doing in Models of Monopoly Regulation and Infant Industry Protection; November 1990
151	C.I. Karfakis	Testing for Long Run Money Demand Functions in Greece Using Cointegration Techniques; November 1990
152	D. Hutchinson & S. Nicholas	The Internationalisation of Australian Business: Technology Transfer and Australian Manufacturing in the 1980s; November 1990
153	B. Rao	A Disequilibrium Approach to the New Classical Model; December 1990
154	J.B. Towe	The Determinants of American Equity Investment in Australia; December 1990
155	E. Jones	Economists, The State and The Capitalist Dynamic; January 1991
156	I.J. Irvine & W.A. Sims	Gorman Polar Forms and the S-Branch Utility Tree; February 1991
157	B. Rao	A Model of Income, Unemployment and Inflation for the U.S.A.; February 1991
158	W.P. Hogan	New Banks: Impact and Response; March 1991
159	P.D. Groenewegen	Decentralising Tax Revenues: Recent Initiatives in Australian Federalism; April 1991
160	C.I. Karfakis	Monetary Policy and the Velocity of Money in Greece: A Cointegration Approach; July 1991
161	B. Rao	Disaggregation, Disequilibrium and the New Classical Model; July 1991
162	Y. Varoufakis	Postmodern Challenges to Game Theory; August 1991
163	Y. Varoufakis	Freedom within Reason from Axioms to Marxian Praxis; August 1991
164	D.J. Wright	Permanent vs. Temporary Infant Industry Assistance; September 1991

165	C.I. Karfakis & A.J. Phipps	Covered Interest Parity and the Efficiency of the Australian Dollar Forward Market: A Cointegration Analysis Using Daily Data; November 1991
166	W. Jack	Pollution Control Versus Abatement: Implications for Taxation Under Asymmetric Information; November 1991
167	C.I. Karfakis & A. Parikh	Exchange Rate Convenience and Market Efficiency; December 1991
168	W. Jack	An Application of Optimal Tax Theory to the Regulation of a Duopoly; December 1991
169	I.J. Irvine & W.A. Sims	The Welfare Effects of Alcohol Taxation; December 1991
170	B. Fritsch	Energy and Environment in Terms of Evolutionary Economics; January 1992
171	W.P. Hogan	Financial Deregulation: Fact and Fantasy; January 1992
172	P.T. Vipraio	An Evolutionary Approach to International Expansion: A Study for an Italian Region; January 1992
173	C. Rose	Equilibrium and Adverse Selection; February 1992
174	D.J. Wright	Incentives, Protection and Time Consistency; April 1992
175	A.J. Phipps, J. Sheen & C. Wilkins	The Slowdown in Australian Productivity Growth: Some Aggregated and Disaggregated Evidence; April 1992
176	J.B. Towe	Aspects of the Japanese Equity Investment in Australia; June 1992
177	P.D. Groenewegen	Alfred Marshall and the Labour Commission 1891-1894; July 1992
178	D.J. Wright	Television Advertising Regulation and Programme Quality; August 1992
179	S. Ziss	Moral Hazard with Cost and Revenue Signals; December 1992
180	C. Rose	The Distributional Approach to Exchange Rate Target Zones; December 1992
181	W.P. Hogan	Markets for Illicit Drugs; January 1993
182	E. Jones	The Macroeconomic Fetish in Anglo-American Economies; January 1993
183	F. Gill	Statistics in th Social Sciences A Mixed Blessing? March 1993
184	Y. Varoufakis & S. Hargreaves-Heap	The Simultaneous Evolution of Social Roles and of Cooperation; April 1993
185	C.I. Karfakis & D.M. Moschos	The Information Content of the Yield Curve in Australia; April 1993
186	C.I. Karfakis & A. Parikh	Uncovered Interest Parity Hypothesis for Major Currencies; May 1993
187	C.I. Karfakis & A.J. Phipps	Do Movements in the Forward Discount on the Australian Dollar Predict Movements in Domestic Interest Rates? Evidence from a Time Series Analysis of Covered Interest Parity in Australia in the late 1980s; May 1993

Copies are available upon request from:

Department of Economics,
The University of Sydney,
N.S.W. 2006, Australia.

Working Papers in Economics Published Elsewhere

2	I.G.Sharpe & R.G.Walker	Journal of Accounting Research, *13*(2), Autumn 1975
3	N.V.Lam	Journal of the Developing Economies, *17*(1), March 1979
4	V.B.Hall & M.L.King	New Zealand Economic Papers, *10*, 1976
5	A.J.Phipps	Economic Record, *53*(143), September 1977
6	N.V.Lam	Journal of Development Studies, *14*(1), October 1977
7	I.G.Sharpe	Australian Journal of Management, April 1976
9	W.P.Hogan	Economic Papers, 55, The Economic Society of Australia and New Zealand, October 1977
12	I.G.Sharpe & P.A.Volker	Economic Letters, 2, 1979
13	I.G.Sharpe & P.A.Volker	Kredit and Kapital, *12*(1), 1979
14	W.P.Hogan	Some Calculations in Stability and Inflation, A.R.Bergstrom et.al.(eds.),J.Wiley & Sons,1978
15	F.Gill	Australian Economic Papers, *19*(35),December 1980
18	I.G.Sharpe	Journal of Banking and Finance, *3*(1),April 1978
21	R.L Brown	Australian Journal of Management, *3*(1),April 1978
23	I.G.Sharpe & P.A.Volker	The Australian Monetary System in the 1970s, M.Porter(ed.),Supplement to Economic Board 1978
24	V.B.Hall	Economic Record, *56*(152), March 1980
25	I.G.Sharpe & P.A.Volker	Australian Journal of Management, October 1979
27	W.P.Hogan	Malayan Economic Review, *24*(1), April 1979
28	P.Saunders	Australian Economic Papers, *19*(34),June 1980
29	W.P.Hogan, I.G.Sharpe & P.A.Volker	Economic Letters, 6 (1980), 7 (1981)
30	W.P.Hogan	Australian Economic Papers, *18*(33),December 1979
32	R.W.Bailey, V.B.Hall & P.C.B.Phillips	Keynesian Theory, Planning Models, and Quantitative Economics, G. Gandolfo and F. Marzano (eds.), 2, 703-767, 1987
38	U.R.Kohli	Australian Economic Papers, *21*(39),December 1982
39	G.Mills	Journal of the Operational Research Society(33)1982
41	U.R.Kohli	Canadian Journal of Economics, *15*(2),May 1982
42	W.J.Merrilees	Applied Economics, 15, February 1983
43	P.Saunders	Australian Economic Papers, *20*(37),December 1981
45	W.J.Merrilees	Canadian Journal of Economics, *15*(3),August 1982
46	W.J.Merrilees	Journal of Industrial Economics, *31*,March 1983
49	U.R.Kohli	Review of Economic Studies, *50*(160),January 1983
50	P.Saunders	Economic Record, 57(159), December 1981

53	J.Yates	AFSI, Commissioned Studies and Selected Papers, AGPS, IV 1982
54	J.Yates	Economic Record, 58(161), June 1982
55	G.Mills	Seventh Australian Transport Research Forum-Papers, Hobart, 1982
56	V.B.Hall & P.Saunders	Economic Record, 60(168), March 1984
57	P.Saunders	Economic Record, 59(166), September 1983
58	F.Gill	Economie Appliquee, 37(3-4), 1984
59	G.Mills & W.Coleman	Journal of Transport Economics and Policy, 16(3), September 1982
60	J.Yates	Economic Papers, Special Edition, April 1983
61	S.S.Joson	Australian Economic Papers, 24(44),June 1985
62	R.T.Ross	Australian Quarterly, 56(3), Spring 1984
63	W.J.Merrilees	Economic Record, 59(166), September 1983
65	A.J.Phipps	Australian Economic Papers,22(41),December 1983
67	V.B.Hall	Economics Letters, 12, 1983
69	V.B.Hall	Energy Economics, 8(2), April 1986
70	F.Gill	Australian Quarterly, 59(2), Winter 1987
71	W.J.Merrilees	Australian Economic Papers,23(43),December 1984
73	C.G.F.Simkin	Singapore Economic Review,29(1),April 1984
74	J.Yates	Australian Quarterly, 56(2), Winter 1984
77	V.B.Hall	Economics Letters, 20, 1986
78	S.S.Joson	Journal of Policy Modeling, 8(2), Summer 1986
79	R.T.Ross	Economic Record, 62(178), September 1986
81	R.T.Ross	Australian Bulletin of Labour, 11(4), Sept.1985
82	P.D.Groenewegen	History of Political Economy, 20(4),Winter 1988 Scottish Journal of Political Economy,37(1)1990
84	E.M.A.Gross, W.P.Hogan & I.G.Sharpe	Australian Economic Papers, 27(50), June 1988
85	F.Gill	Australian Bulletin of Labour, 16(4),Dec.1990
94	W.P.Hogan	Company and Securities Law Journal, 6(1), February 1988
95	J.Yates	Urban Studies, 26, 419-433, 1989
96	B.W.Ross	The Economic and Social Review, 20(3),April 1989
97	F.Gill	Australia's Greatest Asset: Human Resources in the Nineteenth and Twentieth Centuries, D.Pope(ed.), Federation Press, 1988
98	A.J.Phipps	Australian Economic Papers, 31(58), June 1992
99	R.T.Ross	Australian Bulletin of Labour, 15(1), December 1988
100	L.Haddad	Hetsa Bulletin, (11), Winter 1989
101	J.Piggott	Public Sector Economics - A Reader, P.Hare(ed.), Basil Blackwell, 1988
102	J.Carlson & D.Findlay	Journal of Macroeconomics, 13(1), Winter 1991
102	J.Carlson & D.Findlay	Journal of Economics and Business, 44(1), Feb.1992

104	P.D.Groenewegen	Decentralization, Local Government and Markets: Towards a Post-Welfare Agenda, R.J. Bennet (ed.) Oxford University Press, 6, 87-115, 1990
107	B.W.Ross	Prometheus, 6(2), December 1988
108	S.S.Joson	Rivista Di Diritto Valutario e Di Economia Internazionale, 35(2), June 1988
112	P.Groenewegen	NeoClassical Economic Theory 1870 to 1930 K.Hennings & W.Samuels (eds.), 13-51, 1990
113	V.B.Hall, T.P.Truong & V.A.Nguyen	Energy Economics, 12(4) October 1990
114	V.B.Hall, T.P.Truong & V.A.Nguyen	Australian Economic Review, (87) 3'89
115	F.Gill	Australian Journal of Social Issues, 25(2), May 1990
116	G.Kingston	Economics Letters, 15 (1989)
117	V.B.Hall & D.R.Mills	Pacific and Asian Journal of Energy, 2(2), December 1988
118	W.P.Hogan	Abacus, 25(2), September 1989.
120	P.Groenewegen	Flattening the Tax Rate Scale: Alternative Scenarios & Methodologies, (eds.) J.G. Head and R. Krever, 1, 3-31, 1990
122	W.P.Hogan & I.G. Sharpe	Economic Analysis and Policy, 19(1), March 1989
123	G.Mills	Journal of Transport Economics and Policy, 23, May 1989
126	F.Gill	The Australian Quarterly, 61(4), 1989
128	S.Lahiri & J.Sheen	The Economic Journal, 100(400), 1990
130	J.Sheen	Journal of Economic Dynamics and Control, 16,1992
135	Y.Varoufakis	Economie Appliquee, 45(1), 1992
141	P.Groenewegen	Australian Economic Papers, 31, 1992
143	C.J.Karfakis	Applied Economics, 23, 1991
144	C.J.Karfakis & D.Moschos	Journal of Money, Credit, and Banking, 22,(3),1990
147	J.Yates	Housing Studies, 7, (2), April 1992
158	W.P.Hogan	Economic Papers, 10,(1), March 1991
160	C.J.Karfakis	Applied Financial Economics, 1,(3), Sept.1991
163	Y.Varoufakis	Science and Society, 56(4), 1993