Covered Interest Parity, capital controls and financial integration

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Abstract

This paper tests for Covered Interest Party (CIP) among the U.S. and five major industrialised countries over the period 1986–1998 while considering the effect of capital controls and the extent of financial integration. This is accessed by using two test methods: the Augmented Dickey Fuller (ADF) and a new test developed by Im, Pesaran, and Shin (2003). While structural breaks can lower ADF's test power even more, the latter test will allow to confirm or reject CIP depending on whether a panel data set comprising covered interest differentials is stationary or not. This test offers significant advantages over the ADF test that might accept the null of nonstationarity on account of low test power. The results obtained can verify CIP when capital controls are relaxed and are always stronger with the Eurocurrency than with the Treasury Bill rates.

Keywords: Covered Interest Parity, Capital Controls, Financial Integration, Unit Root Test

JEL Classification: C33, F30, G15

Introduction

The main purpose of this paper is to assess the validity of Covered Interest Parity (CIP), which if it is upheld, will imply not only capital market efficiency, but also enhanced financial integration among the countries in study. We focus also on essential structural changes such as the abolition of capital controls and the Exchange Rate Mechanism crisis. In order to serve the purposes of this analysis, we test whether the covered interest differentials contain a unit root by employing the univariate Augmented Dickey Fuller (ADF) test. Since the conventional ADF test is argued to suffer from power deficiency, we also employ an alternative method that holds distinct advantages over standard univariate unit root tests. Namely the panel data unit root test developed by Im, Pesaran and Shin (2003); a new, more powerful method of assessing the stationarity of CIP deviations.

The remaining paper is divided in five sections. In the first one we provide a brief outline of the theoretical background associated with interest parity. The second section presents a synopsis of the recent empirical evidence on interest parity. The econometric methodology and the data are illustrated in the third section whereas the results and their interpretation are given in the fourth section. Finally, we use our last section for concluding remarks.

Theoretical Background

A lavish amount of studies has identified CIP as a key behavioural relationship in many exchange rate determination models. On top of its use as indicator of foreign exchange market efficiency, CIP is also able not only to explain covered interest arbitrage but also to specify conditions for speculation in currency markets. The earliest, lucid statement of CIP is attributed to Keynes "...forward quotations for the purchase of the currency of the dealer money market tend to be cheaper than spot quotations by a percentage per month equal to the excess of the interest which can be earned in a month in the dearer market over what can be earned on the cheaper." (Keynes, 1971, p. 103) Overall, CIP is an important parity, linking both spot and forward exchange rates with the domestic and foreign risk-free rate of return.

$$F = S\ (1+r\ /\ 1+r^*) \quad \text{or} \quad F\ /\ S = (1+r\ /\ 1+r^*) \qquad (1)$$

Where F and S are, respectively, the forward and spot exchange rates, r is the domestic rate of interest and r* is the foreign rate of interest. Equation (1) states that the interest differential between two assets, identical in every respect except of denomination currency, should be zero by the time we allow cover to be taken within the forward exchange market. In other words, CIP theorem dictates that the forward rate must be equal to the spot rate adjusted for a factor given by the ratio of domestic and foreign returns.

While CIP can also be written as:

$$r = r^* + (F - S)\ /\ S \qquad (2)$$

Uncovered interest parity (UIP) on the other hand predicts that the equilibrium exchange rate depends not only on domestic and foreign interest rates but also on the expectations with respect to future exchange rates, i.e. S^e. This is written as:

$$r = r^* + (S^e - S)\ /\ S \qquad (3)$$

and presents a combined speculative and interest arbitrage position. Under conditions of full capital mobility and risk-neutrality, the spot foreign exchange markets are in equilibrium when all currencies offer the same expected rate of return.

In contrast to most fundamental economic relationships, CIP relies on very few assumptions regarding the tastes or behaviour of the agents operating in the market. No assumptions are required on expectation formulation, neither on utility maximization or attitude towards risk since these transactions involve no risk. In literature, CIP requires foreign exchange markets to be organized, with well-defined rates which are unconditionally accessible to informed market participants. Additionally transaction costs are perceived to be low enough so as to be negligible.

The arguments of arbitrage and least cost dealing are the factors enforcing covered interest arbitrage. Obviously, when CIP is not satisfied then profit opportunities emerge. The idea that arbitrage will eliminate unexploited profit opportunities and restore equilibrium is traced back to the 18th century. Every time enormous profit opportunities appear in any particular trade, "... a sufficient number of capitalists will be induced to engage in it, who will, by their competition reduce the profits to the general rate of mercantile gains." (Ricardo, 1811, p.9)[1]

However, even if arbitrage condition is not violated, a variety of reasons may prevent CIP from holding. Numerous of studies have been undertaken on each and every factor, indicating rather mixed results.

More or less it may be due to any feature related to transaction costs, capital market imperfections, non-comparability of assets, government intervention and regulation, lack of equivalence in assets, capital controls, political or sovereign risk, Central Bank intervention and the cost of collecting information. Then again, as Frankel (1992) advocates, covered interest parity is upheld when those restrictions are relaxed, along with the steady process of technical and institutional innovation that has taken place all over the world, and argues that CIP is a more suitable guide in assessing the degree of financial integration, since the currency premiums are more variable than the covered interest differential (country premium).

The reason of considering financial market integration according to Logue et al., (1976) is to determine how independent a single nation can be of another nation in the conduct of its domestic financial policy. But first we need to specify what international financial integration is. Unfortunately, there exists no explicit definition of international financial integration. The extreme cases of perfect or zero financial integration are found only in the literature and imply, respectively, the absence or presence of any barriers that may prevent investors from modifying their portfolios instantaneously. Therefore in this paper, we will refer to financial integration as the ease with which assets are traded across national borders and currencies of denomination. The building blocks of financial integration are more or less capital mobility and asset substitutability. Eijffinger and Lemmen (2003) present how different degrees of capital mobility and asset substitutability can affect CIP equation.

Figure 1: Different degrees of capital mobility and asset substitutability with CIP.

CIP		Asset Substitutability	
		Perfect	Imperfect
Capital Mobility	Perfect	**I**: $i = i^* + (f-s)$	**II**: $i = i^* + (f-s) + AR + PR$
	Imperfect	**III**: Impossible	**IV**: $i = i^* + (f-s) + AR + CC + PR$

where (f-s) is the forward premium or discount. AR refers to the asset-specific types of risk such as default risk, liquidity risk, tax status, etc. PR implies the political risks associated to the asset. It suffices for now, to say that those risks involve the uncertainty about future government actions while CC represents the controls on capital. Such controls can take several forms and may serve a range of objectives, usually they are designed to limit or redirect capital flows. According to Eijffinger and Lemmen (2003) there are three more factors that may deter capital mobility and asset substitutability; namely transaction costs, exchange risks and purchasing power risks. However, they suggest that deviations from interest rate parity are a measure of financial integration and they argue that for perfect financial integration exchange risks, political risks and purchasing power risks do not need to be absent.

Overall, when CIP holds, confirms the low of one price which states that securities identical in all respects must be priced identically, especially when the markets are integrated. Additionally, zero deviations from CIP will suggest the existence of a more stable exchange rate regime and hence increased capital market efficiency, and unarguably financial integration, while rejection of it may imply higher degree of monetary autonomy and by taking the argument further, the significance of capital controls.

Empirical Evidence

Numerous studies have focused on Covered Interest Parity and the several issues related to it. Even Keynes had reported remarkable deviations from CIP during the 1920s, which, back then, he attributed to political risk, capital market imperfections or heavy speculation. Officer and Willet (1970) are among the first ones to empirically identify the reasons why similar domestic and foreign financial assets are still less than perfect substitutes when exchange rate risk is removed by the purchase of forward cover.

Accordingly, Officer and Willet (1970) investigate the arbitrage schedule, i.e. linking short term capital placements to the covered interest differentials. They suggest that total covered arbitrage activity does not depend only on the value of the covered differentials, but also on its composition and on the state of speculative expectations. By following what they term 'Portfolio-Balance Theory' point out that "...failure of interest rate parity to occur need not imply either disequilibrium or market imperfections" (Officer and Willet, 1970, p.255). In short, they attribute such failure on two causes: the transaction costs and a positively, less than perfectly elastic, 'medium'-run or 'long'-run supply curve of funds for arbitrage.

Aliber (1973) can be used as an example to take the argument further. He attempts to explain the deviations from CIP in terms of 'other risks' which account for 'differentiating' what might appear to be similar assets. He argues that: if the only difference between two assets is the currencies of denomination; then the interest differential will be equal to the forward exchange rate premiums that must be paid in order to cover against exchange risk. He carries on by advocating that assets denominated in different currencies —and thus issued in different countries, bear additional risks with them. Subsequently, the forward premium is influenced fundamentally by the stance of policy. Apart from the possibility of a change in the exchange rate, there remains a political risk associated to the asset. The definition of political risk is ". . . the probability that the authority of the state will be interposed between investors in one country and investment opportunities in other countries" (Aliber, 1973, p.1453). The basic notion in Aliber's paper (1973) is that the political risk associated with prospective capital controls can lead to deviations from CIP. By using 3-months Treasury Bill (TB) rates for the U.K. and U.S. during January 1968 - June 1970, he finds that the traditional pair does not satisfy the comparability criterion since securities are issued in financial centres that differ in political risk. Indeed, his findings reveal that the deviations are smaller when the external dollar and sterling deposits are used instead of the traditional, national ones.

Logue et al. (1976) used quarterly uncovered interest rates, in order to compare the results from 1958 throughout 1971:Q1, with those from 1958 to 1973:Q2. By applying factor analysis, they deduce on the degree of financial integration as being weaker during the fixed rate period than in the latter case of fixed/floating rate period. This method allows to detect the existence of an underlying pattern, which can 'reduce' the data to a set of factors, less in number than the set of variables. They propose that the move towards a floating exchange rate regime has boosted capital market interdependence.

Their proposition is enhanced by the obtainment of fewer significant principal components, explaining the covariation of nominal interest rates.

Frenkel & Levich (1977) utilize basic economic theory to suggest the creation of a 'natural band' around the interest rate parity line, within which no covered arbitrage is profitable. Its creation is due to the transaction costs and/or if the elasticities of demand and supply (of securities and foreign exchange) are less than infinite. The introduction of capital controls, as argued, will increase the transaction costs for agents and consequently increase the width of the 'natural band.' For different pairs of securities using U.S.-Canada and U.S. - U.K. Treasury Bills (both the traditional and the external pair of interest rates), the estimated costs represent a similar proportion to the deviations from the interest parity line, leading to the conclusion that the allowance for such costs accounts for most of the apparent profit opportunities. Thus, the hypothesis that the markets are highly efficient in eliminating unexploited profit opportunities is confirmed. Moreover, those departures are even less when Euro-deposit rates are used — since they are more compatible with the comparability criterion, but significantly more (about 20%) when Treasury Bill discounts are used.

On exploring Aliber's notion, Dooley and Isard (1980) studied Germany in the early 1970s because of the series of controls on capital inflows imposed at that time. The paper's intention is an effective separation of the interest differential, due to the political risk associated with the existing controls and the differential due to prospective controls. They advocate that conflicting stories suggest the same thing. ". . .the estimation of the arbitrage schedule is the key to separating the interest differential due to capital controls already in place from [...] the prospect of additional controls."(Dooley and Isard: 1980, p.373)

They use a simple model of portfolio behaviour to explain the January 1970- December 1974 differential between the 3-month Euro mark deposit interest rate in Zurich and Frankfurt interbank loan rate. The regression parameters were estimated by the Ordinary Least Squares method, while they estimate the effect of capital controls by using five zero-one dummy variables corresponding to the five key-periods that major capital restrictions were imposed. For their tightest interval, between February and October 1973, the estimates obtained represent more than seventy percent of the interest differential observed at that period. Therefore, they suggest that "... interest differential due to political risk is negatively related to the exchange risk premium." (Dooley and Isard, 1980, p.375)

Another interesting paper examining the extent to which capital controls interfere with interest rate parity is the one by Otani and Tiwari (1982). They place their analysis within the Japanese foreign exchange market for the period January 1978 to March 1981. During those three years the Japanese government introduced a series of measures so as to influence the capital flows according to their 'needs'. Additionally, they are interested in measuring the distortions that such controls may impose in the foreign exchange market. By using daily observations of interest rates and exchange rates both in Tokyo and London foreign exchange market they suggest that the calculated differentials are randomly distributed around the zero mean, almost for the entire period in London's case. There assets are traded more freely and institutional controls are less. For Tokyo, these were significantly different from zero.

In the search of some quantitative insight concerning the actual interdependence among international money and capital markets, Nellis (1982) uses principal component analysis. He investigates the effect that exchange rate regimes impose on financial integration, by using both covered and uncovered interest rates for Canada, France, Germany, United Kingdom and the U.S. for the period between July 1962 and January 1980. Of course, in order to study the international convergence of interest rates, Nellis (1982) distinguishes the sample period into three subperiods in relation to the exchange rate regime. That is fixed-, floating exchange rate and transition period. Factor analysis as argued in the paper, is valuable due to its data reduction capability. Therefore, in order to extract the factor loadings, Nellis (1982) utilizes the most popular one, the principal components analysis. This method makes no particular assumption about the underlying structure of the variables and ensures that factors are orthogonal. Clearly, it is the explanatory power of the most powerful factor, which allows them to make inferences on the level of financial integration. The findings suggest that a high level of integration is still the case, but it appears to be weaker than that, during the fixed exchange rate period.

An exemplary empirical work in support of CIP and consequently of market efficiency is that of Taylor (1987). The crucial difference of his work from the majority of empirical studies undertaken so far is that he does not use data from published sources. Instead, the researcher directly recorded the data from the London-foreign exchange market during November the 11th to 13th, 1985. He obtained ten-minute frequency data for both dollar-sterling and dollar-mark for a number of maturities. Even though the data set produced a large number of potential arbitrage opportunities, Taylor (1987) concluded that only one of them would actually be profitable. Once brokerage fees were introduced, then not even this one (out of approximately 3500 opportunities) proves beneficial. However, there is an obvious limitation associated to this study, namely the limited dataset. Taylor (1987) carries on, to point out that the reported deviations from CIP are due to data imperfections, rather than anything else. Since a true deviation from CIP provides a potential profit opportunity, the importance of having "real" data recorded at the same point in time, when an agent could trade, is emphasised.

In Taylor (1989), contemporaneous, mainly trice-daily trading data was used. He considered observations of the spot and forward dollar-sterling rates of 1-, 2-, 3-, 6-, and 12-month maturities, for the five historical periods, where the markets were known to have experienced turbulence. The study includes also a 'calm' period which acts as a control period. In each case the bid and offer prices were recorded, rather than the average middle rate, since in Taylor (1987) it is argued that it is inaccurate to use approximations in such tests. He utilizes

$$\pounds\ \text{Return} = 100\ [S^B / F^O (1 + i^B_{\$}\ (D/360)) - (1 + i^O_{\pounds}\ (D/365)] \qquad (4)$$

to obtain the percentage period return in sterling when arbitraging from sterling to dollar and

$$\$\ \text{Return} = 100[F^B / S^O (1 + i^B_{\pounds}\ (D/365)) - (1 + i^O_{\$}\ (D/360)] \qquad (5)$$

when arbitraging from dollars to sterling. The superscripts B and O denote 'bid' and 'offer' rate while the peculiarly British habit of basing interest payments on a 365-day basis, as opposed to the more usual 360 days is reflected. Both equalities were calculated for all the data points and maturities available, with and without allowances for brokerage fees which he concludes to be of 'tiny magnitude' and the results were not qualitatively affected.

The 1967 devaluation report is characterized by the author as the most stringent test of CIP. Whereas, the data recorded over the 1972 float of sterling, shows a higher degree of disparity between the spot and forward exchange rates than in the corresponding Euro deposit rates. Almost in every case, some profit could have been riskless and persistently earned by arbitraging from sterling to dollars. These results, therefore, indicate an apparent violation of the efficient market hypothesis, with the degree of violation apparently a positive function, both of the amount of turbulence and the maturity considered. The data related to the turbulent periods from late 70s onwards are supportive of not only increased market efficiency but of stronger maturity effect too. This is not only due to the reductions in the size, frequency and persistence of arbitrage opportunities but also due to the increased number of market participants, experience and major information technology advances that have been accomplished.

Karfakis and Moschos (1990) examine the issue of interest rate linkages between Germany and Belgium, France, Ireland, Italy and Netherlands respectively. Monthly data on short-term domestic nominal interest rates are used over the period of April 1979 to November 1988, in order to apply cointegration techniques. Their findings oppose the existence of a long run systematic interest rate relationship between Germany and any of the countries in study. Karfakis and Moschos (1990) credit this result to the nonstationarity of either the expected exchange rate movements or that of the risk premia. At the same time, the Granger causality test implies an unidirectional causality from German interest rates to other European Monetary System (EMS) countries' rates (except for Ireland) pointing towards the German dominance in the EMS. This finding holds, regardless of the spirit and the degree of controls on capital flows.

Frankel (1991) believes that the constant global trend of financial markets integration during the 1980's had all but eradicated short-term interest differentials for major industrialized countries. He studies at a set of 25 countries and uses the forward rate data, in order to decompose the real interest differential -the left hand side. This is the broadest measure of barriers to international capital mobility, according to Frankel (1991), and is given by the country premium minus the currency premium. This is:

$$r - r^* = (i - i^* - fd) - (fd - \Delta p^e + \Delta p^{e*}) \qquad (6)$$

where the first term on the right hand side is the CIP. Frankel (1991) calls it the political or country premium because it encapsulates all barriers to financial market integration across national boundaries. Such barriers are: transactions costs, information costs, capital controls, tax laws that discriminate by country of residence, default risk, and risk of future capital controls. He describes CIP as "... an unalloyed criterion for capital mobility in the sense of the degree of financial market integration across national boundaries". (Frankel, 1991, p,230 and Frankel, 1992, p.197) By studying a panel of 25 countries (in country-group comparisons of the measures of real interest differential), it is safely concluded that "Only the country premium has been eliminated; this means that only covered interest differentials are small."(Frankel, 1992, p.201) He also suggests that, even in such a case, large differentials in real interest rates will not be eliminated.

Koedijk and Kool (1992) are not only interested in how the European Monetary System has functioned in practice, but also on whether Germany holds a dominant role or not. They employ nominal interest and inflation behaviour in order to explore the timing and speed of monetary convergence. For the period in study from March 1979 to September 1989 Koedijik and Kool (1992) apply a modified version of the principle components analysis to reveal that diverging movements in inflation and interest rates have always existed and still exist between Germany, the Netherlands and the United Kingdom on one side; and Belgium, France and Italy on the other. Their overall conclusion on German dominance over EMS implies that this is not and has never been the case. However, they do confirm the key role played in terms of general monetary stance in the European Union.

Katsibris and Miller (1993) challenge Karfakis and Moschos' (1990) argument. They undertake their analysis further by examining cointegration, not only between German interest rate and other EMS rates, but also between U.S. and EMS rates. By including the U.S. interest rate variable to the bilateral cointegration and Granger causality tests, Katsibris and Miller's (1993) results reject the hypothesis of the German dominance and independence within the EMS and propose the importance of causality from the U.S. interest rate to the EMS members' rates. On the whole they support the notion of increased financial integration.

Holmes and Pentecost (1999) are examining the degree of financial integration in the EU, by stressing out the importance of the risk premia in the determination of the interest rate differentials. In order to encapsulate the different elements of the integration process, they utilize two alternative econometric techniques. These are the cointegration analysis and the time-varying method that assist in the measurement of both the level and the degree of financial integration respectively. They divide their sample period (March 1979 — August 1992) into two subperiods, based on the number of realignments in the ERM. By employing covered and nominal three-month TB rates for six members of the European Community, they provide evidence of increasing financial integration. The use of covered interest rate differentials is advocated to be 'superior' to nominal rates, as greatest integration is captured by the faster convergence of covered interest rates.

In the process of real interest parity examination across the G-7 economies, Fujii and Chinn (2001) consider both ex ante and ex post real interest movements for various maturities of financial instruments. They are interested in both the short (up to one year) and the long (5 and 10 years) time horizons. Overall, the paper suggests that real interest parity holds better at long than at short horizons. However, those more positive results related to the long-term yields are obtained at an additional cost that takes the form of various shortcomings and distortions. However, they do suggest that capital mobility is more appropriately measured by long term instruments. This 'judgment' can also be further justified on the view postulated by Eijffinger and Lemmen (2001), who argue that governments perceive short term capital flows to be more harmful to the economy than long term ones —and thus impose more strict controls on capital flows. Fujii and Chinn's (2001) view covered interest differentials as a manifestation of 'political risk', caused either by the existing controls on capital or the possibility of imposing new ones. The argument is carried on further, to point out that the absence of exchange risk premium postulates 'perfect capital substitutability'. For the countries in study, the results suggest that departures on the basis of covered interest parity are essentially eliminated for almost every country but Canada.

Holmes (2001) provides us with some new evidence in favour of covered interest parity. He studies the countries of the European Union along with three non-European countries from 1983 to 1998. For the purposes of his research, he divides his study era into two sub segments, from 1983:3 to 1990:4 and from 1990:5 to 1998:12. The reason for doing so lays on searching the effect that capital controls impose on CIP. In order to measure such effects, Holmes (2001) is searching for unit roots in the covered interest differentials with respect to Germany. Apart from using the conventional augmented Dickey Fuller test, he also applies a new method of panel data unit root tests, the T-bar test. The author's results obtained by this new method are more supportive of CIP than the ones of the conventional ADF tests. Finally, the paper points out that the relaxation of the remaining capital controls have helped to confirm CIP in terms of onshore interest rates, regardless of the turbulence experienced during the early 1990s and increased the overall level of financial integration.

Summarising the various researches we accept that presence of controls on capital, apart from interfering with covered interest parity, increases transaction costs and, consequently, the width of the 'natural band'—as argued by Frankel and Levinch (1977) , Dooley and Isard (1980), Otani and Tiwari (1981), Nellis (1982), Holmes (2001). Furthermore CIP is the appropriate measure of financial integration, (Frankel (1991, 1992), Nellis (1982), Katsibris and Miller (1993), Holmes and Penetecost (1999) and Holmes (2001).

Data and Econometric Methodology

This study employs monthly series collected from Datastream, which in turn obtains them from the International Financial Statistics. The series include three-month and six-month Treasury Bill and Eurocurrency rates as well as spot and forward exchanges rates with respect to the United States dollar for Canada, France, German, Japan and U.K. The period under consideration starts from January 1986 and ends on December 1998. In contrast to the majority of the existing literature, we choose United States as our home country and not Germany. Additionally, the starting and ending dates are not arbitrarily chosen; the reasoning for both these dates lays in the absence of time series data outside this period. It is only in the latter case where we can justify this absence: due to the introduction of a single European currency on 1 January, 1999.

Econometric Methodology

Over the past decades a notable number of studies have focused on the potential nonstationarity of important macroeconomic variables. Nowadays, the unit root tests are the typical method adopted in empirical analysis. Our econometric methodology utilizes two types of unit root tests namely the augmented Dickey Fuller test and the panel data test developed by Tm, Pesaran & Shin (2003). Moreover we divide our sample period into two subperiods in order to observe the effect of capital controls on the achievement of CIP.

While there are many findings of unit roots using the conventional ADF test, the test is advocated to suffer from power deficiency against near stationary alternatives. Therefore researchers responded to this problem by employing panel data unit root tests in order to increase power in testing for unit roots. Not only Im et al. (2003) but also Levin and Lin (1993) were amongst the first ones to provided a solution by exploiting the asymptotic theory and finite sample properties of ADF tests of panel data. Several recent papers use the panel data tests and report much stronger rejections of the null hypothesis. Both panel unit root tests are extensively used to study the validity of purchasing power parity (PPP).

The key motivation for the development and relevance of the panel unit root tests is, that the power of the test boosts as the number of panel series compared increases. The panel approach utilizes more observations and takes advantage of the cross-country variation of the data. This provides an advantageous insight on the power of the test over the standard unit root tests that are based on individual time series. As O'Connell (1998) advocates that several studies on PPP fail to control for cross-sectional dependence in the data. This failure can raise dramatically the significance level of tests to as much as 50 percent. He argues that cross-sectional dependence by and large result in serious power bias. Luintel (2001) uses the T-bar test to study PPP due to that reason. Namely the failure of most studies to allow for serial correlation and cross-sectional dependence to power loss and size bias. He advocates that demeaning reduces dramatically the magnitude of cross-sectional dependence.

Although Levin and Lin (1993) provide critical values for panel unit root tests, fail to incorporate either autocorrelation or cross-sectional correlation. Papell (1997) considers serial correlation and shows that the Levin and Lin's (1993) finite sample critical values are low by between 3 and 11 percent. He also suggests that panel unit root tests with heterogeneous intercepts are equivalent to including country-specific dummy variables. O'Connell (1998) on the other hand recommends the use of time dummies for removing the most serious form of cross-sectional correlation occurring in the panels.

Hunter and Simpson (2001) employ a panel unit test - attributed to Hadri (2000)- of 12 real exchange rates that accounts for heterogeneous serial dependence which can be corrected by using a non-parametric kernel based method. Their overall suggestion on PPP is that "pooling time series appropriately and then testing the null of stationarity goes some way to support the proposition that real exchange rates are stationary" (Hunter and Simpson: 2001, p.5)

The existence or absence of power against alternatives where a subset of the series is stationary has important consequences for empirical study. Karlsson and Lothgren (2000) found that the power of the panel data test increases monotonically with: (1) an increase in the number of country series in the panel; (2) an increase time-series dimension T in each individual series and (3) an increased proportion d of stationary series in the panel.

Let us now consider the application of our test. Since, CIP is an equilibrium condition based on riskless arbitrage then, its differential will be equal to null at any point in time. We can define the deviations from covered interest parity as:

$$(f-s)_{it} + (i^* - i)_t = y_{it} \tag{7}$$

where f is the natural logarithm of the forward exchange rate, s is the natural logarithm of the spot exchange rate and we have used the approximation i = ln(1+ i) and i* = ln(1+ i*) i.e. continuously compounding interest rates. The covered interest rate differential is given by y where i = 1, 2, ...,N countries and t = 1, 2, ...,T observations. This is the variable we are testing for stationarity.

The Augmented Dickey-Fuller test for stationarity has been expanded to panel data tests for stationarity under certain models that allows for a range of heterogeneity, as is the Im et al. (2003). If we assume that the covered differential is generated by a first order autoregressive process we can write:

$$y_{it} = a_i + \beta_i y_{i,t-1} + \varepsilon_{it} \tag{8}$$

this can also be written as:

$$\Delta y_{it} = a_i + \gamma_i y_{i,t-1} + \varepsilon_{it} \tag{9}$$

where $\Delta y_{it} = y_{it} - y_{i,t-1}$ and $\gamma_i = (\beta_i - 1)$. The null hypothesis in all panel data unit root tests is that each series in the panel contains a unit root, i.e. H_0: $\gamma_i = 0$ for every i. The formulation of the alternative hypothesis is somewhat more ambiguously specified as Karlsson and Lothgren (2000) argue. The alternative for the Im et al. (2003) is that at least one of the individual series in the panel is stationary as opposed to that of LL's alternative where all individual series in the panel are stationary. So, the alternative is expressed as H_1: $\gamma_i < 0$, $i = 1, 2, ..., N_1$, $\gamma_i = 0$, $i = N_1 + 1, N_1 + 2, ..., N$. In order to allow for correlation across the panel Im et al. assume that the error term can be decomposed in two random components:

$$\varepsilon_{it} = \theta_t + \nu_{it} \tag{10}$$

where θ_t is a time-specific common effect which specifies the degree of dependency across the series, and ν_{it} is an independently distributed idiosyncratic random effect. As O' Connell (1998) argues, wrongly assuming identically and independently distributed disturbances can have significant effects on size and the power of the test. To remove the impact of the common effect θ_t, Im et al. (2003) propose demeaning by subtracting the cross-section means from the observed data. In this manner we obtain the demeaned regression:

$$\Delta \tilde{y}_{it} = \tilde{a}_i + \tilde{\gamma}_i \tilde{y}_{i,t-1} + \tilde{\xi}_{it} \tag{11}$$

where $\tilde{\gamma}_i = (\tilde{\beta}_i - 1)$. After allowing for serially correlated errors within a heterogeneous panel we can rewrite the above equation as:

$$\Delta \tilde{y}_{it} = \tilde{a}_i + \tilde{\gamma}_i \tilde{y}_{i,t-1} + \sum_{k=1}^{q_i} \varphi_{ik} \Delta \tilde{y}_{it-k} + \tilde{\xi}_{it} \tag{12}$$

where $\tilde{y}_{it} = y_{it} - 1/N \sum_{j=1}^{N} y_{jt}$. We apply this model that forms the T bar test in order to test the covered interest differentials.

Finally we should mention that failure to guarantee the white noise property for our residuals can alter the Dickey-Fuller distribution.

Consequently, in order to ensure that the residuals are approximately white noise we determine the lag length of the individual ADF regressions according to the Said and Dickey (1983) $T^{1/3}$ rule. The reason for doing so is because we have monthly data and this can otherwise lead to moving average processes in the residuals. In other words we allow a good approximation for any autoregressive moving-average processes that may be present in the data.

Results and their Interpretation

Given that are searching for unit roots, not only on the three month but also the six month covered interest differentials, we test both the Treasury bill and Eurocurrency rates. In order to study the effects of controls on capital, we divide the sample period into two subperiods. The first one is from January 1986 to April 1990, when capital controls were still in place, while the latter is from May 1990 to December 1998 and is characterized by less restricted movement of capital. The reason for choosing 1990:4 to divide our sample period is coherent on the basis that this date is documented as a significant one where all remaining controls were removed within ERM.

Table 1: ADF unit root test: Deviations from CIP, the three-month case

THREE - MONTH TREASURY BILL RATES				
	No Trend		With Trend	
	1986:6–1990:4	**1990:5-1998**	**1986:6–1990:4**	**1990:5-1998**
Canada	- 3.465**	- 3.304**	- 3.378*	- 3.389*
France	- 2.700*	- 4.666***	- 2.728	- 4.678***
Germany	- 1.459	- 3.068**	- 1.320	- 3.347*
Japan	- 1.785	- 1.425	- 1.832	- 2.093
U.K.	- 2.806*	- 2.183	- 2.702	- 1.849
THREE - MONTH EUROCURRENCY RATES				
Canada	- 3.456**	- 3.937***	- 3.809**	- 3.910**
France	- 3.157**	- 4.302***	- 3.714**	- 4.408***
Germany	- 1.645	- 4.516***	- 2.570	- 4.504***
Japan	- 2.757*	- 4.820***	- 2.970	- 5.020***
U.K.	- 3.263**	- 2.949**	- 3.340*	- 2.944

Notes: ***, ** and * denote rejection of the null of non stationarity at the 1, 5 and 10% level of significance respectively.

Canada was one of the first countries that abolished its capital controls and thus the CIP is invariably fulfilled in both subperiods and for both rates as seen in table 1. Although Germany on the other hand removed its controls on capital as early as 1981, the first subperiod is characterised by the violation of the CIP, not only for the TB rates, but also for the Eurocurrency rates. These results can be supported by arguing that there has been a fair deal of time since Germany abolished capital controls, and thus the first period acted as a transition one. Additionally, one can claim the fact that Germany was not reunited until the early 1990s and its reunification caused a major asymmetric shock in the EU. This probably explains why Germany had a more permissive attitude towards capital inflows, rather than outflows, and also may have imposed a political risk in the sense of prospective capital controls, which led to deviations from CIP. The reverse findings are true for the second subperiod, indicating an increase in financial integration among U.S. and Germany. For the U.K. and Japan, the three months covered interest differential appears unable to accept the alternative at the 5% level of significance in both subperiods. France on the other hand, which was one of the last countries to abolish capital controls in the early 1990s, fails to confirm CIP in the first subperiod while the results are much stronger and indicate zero interest differentials.

The main 'image' in the first subperiod of table 1, is failure of rejecting the null at the 5% level of significance, while for the second subperiod the situation is reversed. This may be due to further relaxation of capital controls. Additionally the use of Eurocurrency rates favours CIP better than the national rates. This is consistent with the studies of Aliber (1973), Frankel and Levinch (1977), Nellis (1982), Taylor (1989) and Holmes (2001) whose results obtained by using Euro-currency interest rates always point towards less covered interest departures and thus higher market efficiency.

Table 2: ADF unit root tests: Deviations from CIP, the six-month case

SIX - MONTH TREASURY BILL RATES				
	No Trend		With Trend	
	1986:6–1990:4	**1990:5-1998**	**1986:6–1990:4**	**1990:5-1998**
Canada	- 3.721***	- 2.497	- 3.688**	- 2.202
France	- 3.038**	- 3.346**	- 3.314*	- 4.246***
Germany	- 2.528	- 2.919**	- 2.479	- 2.764
Japan	- 2.200	- 1.338	- 2.335	- 1.849
U.K.	- 4.189***	- 2.6O8*	- 4.423***	- 2.199
SIX - MONTH EUROCURRENCY RATES				
Canada	- 3.329**	- 3.508**	- 3.438*	- 3499**
France	- 3.040**	- 3.580***	- 4.054**	- 4.217***
Germany	- 3.090**	- 3797***	- 3390*	- 4.346***
Japan	- 2.285	- 5.003***	- 2.369	- 4,957***
U.K.	- 3.147**	- 3.232**	- 3.517**	- 3.911**

Once again the Eurocurrency market is in support of CIP in table 2, since these assets are by virtue more comparable in terms of their characteristics. More specifically, we address the political risk associated to the asset, which, since it is issued under the same jurisdiction bears identical risks. It is only in the case of Japan, in the first subperiod, that we fail to reject the null at any level of significance. For the second subperiod, the results for Japan are so strong that the alternative of stationarity is accepted for all the levels of significance. Moving in to the analysis of the six-month TB rates we observe something awkward in the case of Canada and the U.K. The interest differential is stationary in the first subperiod, but not in the second. This finding is likely to be either because the covered interest parity is indeed violated, or due to the low power of the ADF. In France's case we note that the alternative is accepted at the 5% level of significance. Since capital controls interfere with interest parity, we should not expect the CIP to be upheld in the first subperiod where the controls are still in place. We can most likely support this finding on the view that governments consider short-term capital flows more harmful than the long-term ones. The results for Germany do not bring up any surprises, since the interest differential contains unit root during 1986:1-1990:4 but not in the second subperiod. This leads us to the conclusion of increased market efficiency, thus a higher degree of integration with the U.S. Once again Japan rejects the alternative of stationarity for both subperiods. This may be due to a series of 'incidents'. Firstly there was a change in the monetary policy of Japan during the late 1980s where an artificial depreciation took place, while there was a series of banking crises in the early 1990s which may interfere with CIP.

Given that ADF power is low when time spam is short, it is important to determine whether failure to reject the unit root null is caused by the low power of the unit root test in small samples, or whether it cannot be rejected since it is indeed the correct hypothesis. The results of the panel unit root test are reported in table 3. Apart from treating the whole sample of countries as a single group we also divide it further into two subgroups. Group 1 includes Canada and Japan while group 2 consists of France, Germany and U.K. The results obtained in both subperiods and for all groups confirm CIP in the case of Eurocurrency rates. Now, for the TB rates the results do not point out the existence of a unit root in any group but the first one. This comes along with Karlsson and Lothgren (2000) who illustrate that for a given proportion of stationary series the panel becomes more powerful when we increase the time-series dimension rather than a corresponding increase in the number of countries.

Table 3: Panel data unit root tests: Deviations from covered interest parity with U.S., the three-month case

Group 1 : **Japan, Canada**				
	Treasury bill rates		**Eurocurrency rates**	
	1986:6–1990:4	1990:5-1998	1986:6–1990:4	1990:5-1998
t-Bar	- 3.296***	- 2.433*	- 3.658***	- 4.117***
Group 2: **France, Germany & U.K.**				
t-Bar	- 2.446**	- 3.866***	- 3.153***	- 4.819***
Group 3: **Canada, France, Germany, Japan & U.K.**				
t-Bar	- 3.320***	- 3.716***	- 3.172***	- 4.362***

Overall we can suggest that both the onshore and offshore CIP is upheld with the three-month data. An interesting feature in table 3 is that onshore differentials are more stationary for the first subperiod while, the offshore differentials appear to be by far more stationary in the second subperiod than in the first. Additionally, for the whole sample of countries and for the first subperiod, we accept the alternative at any level of significance. This is noteworthy since the univariate tests indicated only one stationary series at the 5% level of significance. Clearly this is due to the power of the T-bar test, which utilizes the demeaned series. In other words, the test is so powerful that it rejects the null for the whole sample.

Table 4: Panel data unit root tests: Deviations from covered interest parity with U.S., the six-month case

Group 1 : **Japan, Canada**				
	Treasury bill rates		Eurocurrency rates	
	1986:6–1990:4	**1990:5-1998**	**1986:6–1990:4**	**1990:5-1998**
t-Bar	- 2.552*	- 1.847	- 2.622*	- 3.725***
Group 2: **France, Germany & U.K.**				
t-Bar	- 3.882***	- 2.845***	- 3.361***	- 4.134***
Group 3: **Canada, France, Germany, Japan & U.K.**				
t-Bar	- 3.054***	- 3.260***	- 2.847***	- 3.490***

Studying the six-month case, the results obtained in table 4 with Eurocurrency rates are in favour of CIP for one more time. Obviously, we are unable to reject the null in the case of the first group between 1986 — 1990:4. This is not to a surprise since both series are nonstationary. For the TB rates, the results of the panel test favours CIP in contrast to the conventional ADF tests in all cases but group 1. Therefore, we can suggest that the onshore CIP is impaired and this is confirmed as well with the three-month rates. In addition and according to our findings we may claim that financial integration among group 1 and the U.S. is stronger in the first subperiod than in the second subperiod since the null is not rejected at any level of significance.

The findings for group 1, as explained earlier within the ADF results, may be due to the early 1990's crisis that occurred in Japan. Batten et al. (2007) using daily time series for UCD/YEN from 1983 to 2005, find evidence that considerable CIP arbitrage opportunities have persisted in the YEN forward market, which tend to be one way and favour those able to borrow U.S. dollars. According to the study, it was not before 2000 that those deviations could be eliminated and the reasoning is coherent with numerous studies pointing out that CIP arbitrage possibilities are significantly reduced when real time information becomes available. Namely, '… the effects of electronic trading using Reuters D2000 and EBS trading platforms and connected product-pricing systems, […] have improved the operational efficiency of foreign exchange markets' (Batten et al., 2007, p.420). Additionally, one could claim that financial integration can in turn be increased due to the recent use of electronic trading and pricing.

Conclusion

The validation of CIP implies zero arbitrage opportunities and in turn efficiency of capital markets and integration amongst them. Nevertheless we were careful in the choice of our data set, since the comparability criterion had to be satisfied in order to proceed to the test. This means that the pairs of securities were identical in all respects except of currency of denomination. We applied the conventional augmented Dickey Fuller test and compared it with a new methodology developed by Tm, Pesaran and Shin (2003). While the first one suffers from power deficiency when the time span is short, the latter one is a powerful test for detecting unit roots due to the exploitation of the cross-country variations of the data in estimation. By dividing our sample period in two subperiods we found that deviations from covered interest parity within the U.S. were unable to reject the null hypothesis of nonstationarity, when an ADF test was used in most of the cases. After demeaning our data, we apply the T-bar test developed by Im, et al. (2003) which simultaneously accounted for cross-sectional dependence and dynamic heterogeneity. Using such a procedure, the cases of onshore and offshore interest rates have been investigated. The panel unit root test, however, provide us with results that strongly favour the alternative in contrast to the ADF tests. The interesting feature lies on the fact that the ERM crisis did not affect the offshore interest rates and the relaxation of capital controls yield better results for the six month rates rather than the three month ones. At the same time Eurocurrency rates always provide us with results that favour CIP. Overall, when both national financial markets are deregulated and international capital flows are liberalized, returns on comparable financial assets traded in domestic and foreign markets are equalised and thus the interest differentials are stationary, pointing out financial market efficiency and thus integration amongst those countries.

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[1] The reference to Richardo is found in Frenkel and Levinch (1975). Unfortunately the book was not found in any library and thus we can not be confident if those were his exact words.