International Journal of Economics and Financial Issues

ISSN: 2146-4138

available at http: www.econjournals.com

International Journal of Economics and Financial Issues, 2017, 7(1), 420-428.

Arbitrage, Covered Interest Parity and Cointegration Analysis on the New Taiwan Dollar/US Dollar FOREX Market Revisited

Kuo-Shing Chen[1]*, Chien-Chiang Lee[2], Chun-Ming Chen[3]

[1]Shih Chien University, Kaohsiung Campus, 200 University Road Neimen, Kaohsiung 84550, Taiwan, [2]Department of Finance, National Sun Yat-Sen University, 70, Lien-hai Road, Kaohsiung 804, Taiwan, [3]Department of Finance, National Sun Yat-Sen University, Taiwan. *Email: t7732129@ebas.gov.tw

ABSTRACT

This study applies interest parity theory including covered interest parity (CIP) to examine the 30-, 60-, 90-, and 180-day maturities for the new Taiwan dollar/US dollar (NTD/USD) foreign exchange (FX) market. In the empirical unit root tests, we find that NTD/USD forward premium and interest rate spread present I(0) property. Empirical results are provided that interest rate differential appears stationary component; imply the stable relationship between Taiwan and USA on monetary policy. Using Taylor (1989)'s covered interest arbitrage model, the empirical results exhibit the absence of excess profit opportunities on new Taiwan dollar (NTD) or US dollar (USD) returns. Additionally, theoretical innovation approach of the cost-of-carry model is considered to evaluate the arbitrage opportunities in FX study. Accordingly, the CIP condition generally continue to hold that almost zero-arbitrage results support FX market efficiency although the Federal Reserve implemented several rounds of quantitative easing after the peak of the 2008 financial crisis. Ultimately, Taiwanese FX market emerges to have been little affected by the increased crisis risks during the turbulent times because of the its limited development and market integration.

Keywords: Covered Interest Parity, Market Integration, Granger Causality Tests, Cost-of-carry Model
JEL Classifications: G1, G12, F32

1. INTRODUCTION

Exchange rate risk presents unavoidable risk, whereas investors' proper usages of forward contracts reduce the risk arising from exchange rate fluctuations. Therefore, those who engage in international activities must be carefully weighed exchange rate risk premium changes to achieve effective hedging purpose, when trying to apply forward contracts to hedge foreign exchange risks. Interest rates reflect the tightness of monetary policy. Central banks utilize them as intermediate targets to achieve certain macroeconomic conditions. According to covered interest parity (CIP) theory, a country's domestic interest rate is linked closely with external rates. To conduct monetary policy, central banks have to take this parity into consideration. Slight deviations from CIP, indicating a looser link between the domestic and the foreign capital markets, are nonetheless typically observed. Saito and Shiratsuka (2001) argue that deviations from parity indicate liquidity constraints in the banking sector, which leads to limited arbitraging and money market segmentation.

The aim of our research is to estimate the presence, scale and causes of deviations from CIP in the Taiwan money market. Ascertaining whether systematic deviations from parity take place is not as easy as it may seem. One of the issues here is choosing proper interest rate measures. During the turmoil crisis times, however, it turned out that offered rates might be confusing, even when related to the most developed markets. Dollar LIBOR is a good example (Michaud and Upper, 2008). Until recently, little attention was paid to actual money market rates, as the offered rates behaved well. The Lehman brothers collapse and subsequent market turmoil showed, however, that offered rates represent market rates poorly, at least in periods of turbulence. The estimations of and explanations for deviations from parity based on these rates may produce either similar or qualitatively different results. The obtained results thus provide additional insight into discussions concerning money market indicator choices. While deviations from parity may attract the attention of monetary authorities, it is unclear why they happen; therefore it is also difficult to understand how to react to them. Intending to clarify the nature of the deviations from parity, we examine three possible sources of such deviations, namely transaction costs, credit risk, and monetary policy.

Moreover, the majority of studies except Skinner and Mason's (2011) are not focused on the question of why such disparities exist. Latter papers have attempted to explain the deviations using equity premium, and the yield curve slope, but these factors have turned out to be insignificant, prompting us to further examine the issue. The methodology of this project is also comprehensive in the three following aspects from previous studies are discussed. First, the paper attributed the asymmetry of the no-arbitrage band to the spreads of risk premiums. This explanation seems reasonable taking into account the fact that quantify easing monetary was announced by the Federal Reserve after November 2008. Second, in this paper, employing Dickey-Fuller (DF)-GLS and Ng-Perron unite root tests show that future spot rates (1987) and forward rates are both I(1). Finally, we employ Engle-Granger two step procedures and Johansen cointegration method to find that future spot rates and forward rates in existence of cointegration relationship, we assume vector autoregression (VAR) model can be used to test Granger causality between future spot rates and forward rates. This work also examines several new empirical findings in the study of CIP.

The organization of this work is as follows. Section 2 reviews the previous literature. Section 3 discusses the relationship between the forward premium, CIP and the cointegration relationship shortly. Section 4 describes the data and the empirical results are shown in this section. The final Section 5 gives conclusions and remarks.

2. LITERATURE REVIEW

2.1. Noticeably CIP Hypothesis

Theoretically, CIP thus means the interest rate differential is equivalent to the forward premium. Several approaches to testing CIP empirically have been applied by researchers. The first general method is based on examination whether an apparent departures from parity (the interest rate differential minus forward premium), actually differs from zero or not (Taylor, 1989; Sarno and Taylor, 2002; Batten and Szilagyi, 2010). Taylor and Tchernykh-Branson (2004) regressed the forward premium on interest rate differential between the U.S. and Russian money market. The study concluded that the small profit opportunities arbitrage into the dollar, but large profit opportunities available claim to arbitrage into the ruble, therefore attributed their findings to risk premiums. Close results were obtained by Skinner and Mason (2011). Indeed, they found that the average deviation from CIP was estimated less than one basis point for 3-month maturities. They did, however, obtain non-stationary generalized autoregressive conditional heteroskedasticity residuals for the latter maturity. The next important question takes into account the persistence of the profitable arbitrage opportunities. While earlier papers such as Fletcher and Taylor (1996) and Fong et al. (2010) reported that long-lived profitable opportunities exist, recent studies demonstrate clearly the opposite. The prior literature investigated the properties of potential deviations from no-arbitrage conditions. In most scenarios, the average duration of CIP was calculated between 20 s and 4 min, Akram et al. (2008).

2.2. Deviations from CIP Explanations

The previous investigations into CIP have estimated the no-arbitrage band due to transaction costs for the major traded currencies and revealed that that excess profit opportunities are not infrequent Clinton (1988); Skinner and Mason's (2011); Taylor and Tchernykh-Branson (2004); Hutchison et al. (2012). The recent financial turmoil attracted attention to counterparty risks affecting CIP. All these studies found that this risk significantly influenced deviations from CIP condition including a compensation for liquidity and credit risk. There is some evidence that deviations from CIP depend on turbulence in financial markets. Consequently, the existence of political risk can potentially influence CIP conditions. Due to financial integration is not complete, possible explanations of CIP violations are agents not considering all countries' assets as similar and also the unperfected markets and liquidity constraints, Ferreira and Andreia (2015). Some countries such as Greece, Ireland, Italy, Portugal or Spain in Eurozone, and Korean appear some derivations of CIP, similar results are found for the debate when analyzing CIP differentials, see for example, Ferreira (2011); Suh and Kim (2016). The work by Al-Loughani and Moosa (2000) suggested another approach to testing for CIP debate. Authors reported on holding CIP and agreement between the sample data and cointegration-based approaches. Gurvich et al. (2010) argue however, in favor of CIP, as cointegration between the rates is observed. Their extremely weak CIP hypothesis seems to be explained by focusing mainly on the consequences of FX market liberalization. The cointegration technique is also conveniently extended to test for the across-country market efficiency that the spot exchange rate series of several currencies are examined for cointegration (Baillie and Bollerslev, 1989; Aroskar et al., 2004). The finding of cointegration in an across-country setting implies market inefficiency as a cointegrated system indicates predictability of one currency from another currency.

3. CIP THEORY AND MARKET EFFICIENCY

Due to the level of international interest rates in financial markets are different from each other currencies, it would induce generate interest arbitrage activities. In order to avoid losses on currency exchange rate changes, utilizing the foreign currencies are covered by future receivables to avoid foreign-exchange risk at interest arbitrage activities, namely the covered interest arbitrage. Through such risk-free interest arbitrage activities, will make the spot foreign currency appreciation, long-term foreign currency depreciation. When the effect of the interest rate differential is offset by the premium of the forward foreign currency, the funds will cease to move at the equilibrium state.The equilibrium is well known the risk-free interest rate parity while the international interest rates differential is equal to the forward rate premium or the magnitude of discount. If D is the number days to maturity of the forward and deposit contracts, this process is described as below.

3.1. Covered Interest Arbitrage Mechanism

Suppose $S^b(S^a)$ represent the NTD against the USD spot bid (ask) exchange rate, $F^b(F^a)$ for the NTDs long-term bid (ask) exchange rate $i_\$^B\left(i_\$^o\right)$ for USD deposits (loan) interest rate, $i^B(i^0)$ for the NT deposit (loan) interest rate.

1. One unit NTD are borrowed after D days in Taiwan required repaying the principal and interest yield $\left[\left(1+i^{0}\times\frac{D}{365}\right)\right]$. The borrowing TWD convert to $\frac{1}{S^{a}}$ USDs, invest and buy the dollar forward foreign exchange hedging in the U.S. The gross returns with D days to maturity are received at: $\left[\frac{F^{b}}{S^{a}}\left(1+i_{\$}^{B}\times\frac{D}{360}\right)\right]$.

When the Formula (1) holds, the no-arbitrage condition is satisfied on the market.

$$\left[\frac{F^{b}}{S^{a}}\left(1+i_{\$}^{B}\times\frac{D}{360}\right)=\left(1+i^{0}\times\frac{D}{365}\right)\right] \quad (1)$$

By borrowing one dollar (per one currency unit) with D days to maturity in the U.S., and repay the dollar loan, required the principal and interest obtained $\left[\left(1+i_{\$}^{0}\times\frac{D}{360}\right)\right]$.

The one borrowing dollar converts into NTDs and invest in Taiwan while considering hedging via the bid of dollar foreign exchange forward. After D days, the gross return of dollar is available to $\left[\frac{S^{b}}{F^{a}}\left(1+i^{B}\times\frac{D}{365}\right)\right]$.

When the Formula (2) holds, imply the absence of arbitrage opportunities when deviations from parity are small compared to transaction costs.

$$\left[\frac{S^{b}}{F^{a}}\left(1+i^{B}\times\frac{D}{365}\right)=\left(1+i_{\$}^{0}\times\frac{D}{360}\right)\right] \quad (2)$$

According to the interest-free arbitrage model Taylor (1989). If the interest rate parity theory holds, there should be covered interest arbitrage in the market. Using the arbitrage model consider the bid-ask spreads are arbitrage from USDs to NTD. If the following inequality holds, then unprofitable CIP holds, and imply the absence of arbitrage opportunities when deviations from parity are small compared to transaction costs.

The return of borrowing NTD which convert to USD deposits is available to:

$$\left[\frac{F^{b}}{S^{a}}\left(1+i_{\$}^{B}\times\frac{D}{360}\right)-\left(1+i^{0}\times\frac{D}{365}\right)\right]<0 \quad (3)$$

In this case, the covered arbitrage from the NTD to USD, CIP arbitrage is not profitable under condition.The return of borrowing dollars which convert to TWD deposits is available to:

$$\left[\frac{S^{b}}{F^{a}}\left(1+i^{B}\times\frac{D}{365}\right)-\left(1+i_{\$}^{0}\times\frac{D}{360}\right)\right]<0 \quad (4)$$

The above Formulas (3) and (4) show that there are no probability of risk-free arbitrage in the market but also imply that the financial market and the foreign exchange market are efficient. The arbitrageurs cannot be covered arbitrage process to obtain additional profits. On the contrary, vice versa applies.

3.2. Theoretical Framework Setup

Assuming S_t is a spot foreign exchange rate and f_t is a forward exchange rate. Interest rate differential and forward premium (f_p) are described by (6) and (7). In other words, the typical CIP thus express that the interest rate differential is equivalent to the forward premium, which could be written as:

$$f_{t,k}-s_{t}=i_{t,k}-i_{t,k}^{*} \quad (5)$$

$$\frac{1+i_{t,k}}{1+i_{t,k}^{*}}\approx i_{t,k}-i_{t,k}^{*} \quad (6)$$

Where s_t is the log spot exchange rate at time t, Hence $f_{t,k}$ represents the log forward rate of s for a contract expiring k periods in the future, $i_{t,k}$ denotes the k-period yield on the domestic currency asset, and $i_{t,k}^{*}$ represents the corresponding yield (i.e., the nominal interest rate) on the foreign currency asset. The LHS of Equation (5) is so called risk-free arbitrage condition that holds regardless of investor preferences.

$$f_{t,k}-s_{t}=\ln F_{t}-\ln S_{t}=\frac{F_{t}}{S_{t}}-1=f_{p} \quad (7)$$

By rearranging and approximating (6), the typical used expression for CIP is calculated**:**

$$f_{t,k}-s_{t}=\left(\frac{i_{t,k}-i_{t,k}^{*}}{1+i_{t,k}^{*}}\right) \quad (8)$$

When the theoretical exchange rate of the futures is deviation from the actual exchange rate, there exists arbitrage opportunities in the FX market. At this moment, investor can achieve risk free profits through arbitrages. The cost-of carry model can be presented as:

$$F_{t}=S_{t}e^{(r-d)(T-t)} \quad (9)$$

Where r is the risk free interest, d is the dividend yield and $(T-t)$ is the time to expiry of the futures contract respectively, at time t. In Equation (9). Assuming that both r and d are constants, and they are rather far away from the futures contracts maturities. After logarithmic computation, the deviations from Equation (9) give basis (b_t) and is obtained:

$$b_{t}=\ln F_{t}-\ln S_{t}=f_{t}-s_{t}=(r-d)(T-t)=\delta \quad (10)$$

Where δ is the cost of carrying. Arbitrage opportunities can be derived by leveraging the nonequilibrium relationship between the exchange rate difference of spots and futures, as long as all the costs of carrying are taken into consideration. Throughout this paper, we conclude that the basis (the difference between spots and futures) is equal to forward premium and examine this arbitrage relationship using both Engle Granger two-step procedure and Johansen cointegration test. If the (log) spot and forward rate series are both I(1), but cointegrated, then according to the Engle-Granger Representation Theorem. The short run

Table 1: Test for CIP

Panel A:

$$\text{NTD return} \Rightarrow \left[\frac{\text{forward bid}}{\text{spot ask}}\left(1+\text{USD deposit interest rate}\times\frac{n-day}{365}\right)-\left(1+\text{NTD loan interest rate}\times\frac{n-day}{360}\right)\right]$$

Panel B:

$$\text{USD return} \Rightarrow \left[\frac{\text{spot bid}}{\text{forward ask}}\left(1+\text{NTD deposit interest rate}\times\frac{n-day}{360}\right)-\left(1+\text{USD loan interest rate}\times\frac{n-day}{365}\right)\right]$$

Sample period	Market days							
	Panel A: The average returns on borrowing NTD, and covered arbitrage by deposit in USD (days)				Panel B: The average USD returns on borrowing USD, and covered arbitrage by deposit in NTD (days)			
	30	6	90	180	30	60	90	180
2005.1.1-2008.3.18	−0.2151230 (100.00)	−0.4164919 (100.00)	−0.6255386 (99.93)	−1.2797850 (100.00)	−0.0509904 (86.06)	−0.1016355 (86.13)	−0.0858679 (78.50)	0.0082789 (41.32)
2008.3.19-2014.11.30	−0.2463984 (100.00)	−0.4813939 (100.00)	−0.7475730 (100.00)	−1.4633360 (100.00)	−0.0536901 (81.61)	−0.1050701 (80.41)	−0.1325548 (75.88)	−0.2386800 (53.46)

Due to missing data, the 10 days interest rate of commercial paper represent 60 days, and 2-month deposit interest rates represent 1 month, ( ) Number in parentheses indicates the ratio of negative returns. CIP: Covered interest parity

behaviour of the two processes in error correction model (ECM) form can be written as:

$$\Delta s_t = \mu_1 + \alpha_1 b_{t-1} + \sum_i^k \phi_{1k}\Delta s_{t-k} + \sum_i^k \theta_{1k}\Delta f_{t-k} + \varepsilon_{1t} \quad (11)$$

$$\Delta f_t = \mu_2 + \alpha_2 b_{t-1} + \sum_i^k \phi_{2k}\Delta s_{t-k} + \sum_i^k \theta_{2k}\Delta f_{t-k} + \varepsilon_{2t} \quad (12)$$

Where $b_{t,}$ is straightforward interpretation of the ECM term. Since $b_{t,}$ is also a measure of future rate misalignment i.e., the magnitude deviation of the previous period's futures price from real-valued. Where α_1, α_2 denote the estimated coefficient indicating that whenever the futures is mispriced relative to spot. As far as the lagged difference terms in (11) and (12) are concerned in the empirical work. Where φ_{1k}–φ_{2k} and θ_{1k}–θ_{2k} denote respective coefficients; Δ is difference operator; and ε_{it} is white-noise error term.

4. METHODOLOGY AND EMPIRICAL RESULTS

4.1. Data Description

To conduct our analysis, we use daily FX data which the source of the spot and forward USD exchange rate is mainly from the first commercial bank's clients, and the AREMOS (Economic Statistics Database of the Ministry of Education), respectively. Through above framework, empirical data which are obtained by some selected variables that are associated with the relationship between interest rate and foreign exchange rate are presented in Appendix 1. The sample period for observed data is covered from January 01, 2005 to November 30, 2014. The exchange rates provide spot exchange rate and the 30-, 60-, 90-, and 180- day of the NTD/USD dollar forward exchange rate, and the corresponding future spot exchange rate (i.e., spot rate as of the contract maturity). The observations summarize 2,597 data and deferred to next business day if the selected days are closed. The forward exchange rate F_{tk} and S_t^1 spot exchange rates are calculated as the average of the bid/ask FX rates.

4.2. The Covered Interest Arbitrage Test

This paper attempts to divide samples period in two subperiods including Pre- and post-crisis periods and the March 2008 presidential election in Taiwan as the cutoff point, the changing dynamics of the relations among China, Taiwan, and the USA. From Table 1, in 180-day market, the average returns on borrowing NTD, and covered arbitrage by deposit in USD appear negative. The average rate of return pre and pro Financial Crisis Timeline are shown as 41.32% and 53.46%, respectively, more arbitrage opportunities arise. Meanwhile, the remaining 30-, 60-, 90- days there are tiny arbitrage opportunities appearance, or even negligible before or after global financial crisis. The rate of 180-day return is greater than 30-, 60-, 90-day returns so that the long-term exists greater probability of arbitrage opportunities than the short- term, as similar findings to Taylor (1989) results. The longer term interest rates exhibit more risk than short-term interest rates, and those risk premium also increases. The CIP theory seems to hold due to the results in the lower profit opportunities. Similar conclusions were discovered by Fletcher and Taylor (1996) based on data concerning long-term contracts. Transaction costs prevent arbitrage when deviations from parity are small.

4.3. Classical Unit Root Tests

As the series usages in Equation (8) are generally non-stationary, methodologies could not utilize ordinary (Granger, Newbold, 1974) least squares estimation to avoid bias test and spurious regression. We examine whether the non-stationary nature of the misalignment is described by a stationary, but interrupted process

1 Given the monthly sample data usage may lead to missing information ignored the speculative arbitrage on short-term market. Therefore, on market efficiency test issue, this paper adopts the natural logarithm in advance to calculate the exchange rate to forbear the Siegel's Paradox.

or by a constant non-stationary process. The following Tables 2 and 3 present the results by the DF-GLS and Ng-Perron unit root test.The DF-GLS and Ng-Perron unit root are more capability of validation methods than augmented Dickey–Fuller (ADF) (ADF Dickey and Fuller, 1979, 1981) and Phillips-Perron (PP) unit root technique to examine the corresponding future spot and forward exchange rates. All variables are not rejected a unit root null hypothesis, that is, variables are non-stationary series in the most of the cases. Table 2 gives the results of the risk premiums and spreads for each period using the DF-GLS and Ng-Perron unit-root tests which show that unit root test involving both constant and time trend terms, each variable does reject the null hypothesis of unit root, represented as I(0) stationary series.

Table 3 summarizes the results of the DF-GLS and Ng-Perron unit root test for the first-order difference among the variables. The same results are obtained by the both.

Unit root test approaches indicating towards the robustness of the finding. As shown in Table 3, also exhibits the variables

Table 2: Unit root test for spot, 30-, 60-, 90-, 180-day forward exchange rate in the level

DF-GLS test				Ng-Perron test statistics			
				MZ_α	MZ_t	MZ_α	MZ_t
n-market day	Variable	τ_u	τ_τ	τ_u		τ_τ	
30-Day	S_t	−0.729 (3)	−1.995 (8)	−1.595 (3)	−0.7318 (3)	−11.798 (6)	−2.358 (6)
	$St+_k$	−0.8498 (3)	−1.5127 (10)	−1.8326 (3)	−0.848 (3)	−12.71 (5)	−2.372 (5)
	$f_{t,k}$	0.4718 (3)	−1.3311 (3)	0.4063 (3)	0.4681 (3)	−4.181 (3)	−1.3286 (3)
	$f_{t,k}-S_t$	−50.96 (3)**	−51.09 (3)***	−1315.94 (3)***	−25.65 (3)***	−1315.8 (3)***	−25.61 (3)***
	$\left(\frac{i_{t,k}-i^*_{t,k}}{1+i^*_{t,k}}\right)$	−2.78 (1)***	−2.88 (1)***	−15.5 (1)***	−2.78 (1)***	−16.66 (1)***	−2.88 (1)***
60-Day	S_t+_k	−0.806 (3)	−1.426 (10)	−1.6803 (3)	−0.80442 (3)	−9.035 (6)	−1.954 (6)
	$f_{t,k}$	0.01374 (3)	−2.091 (3)	0.01492 (3)	0.01192 (3)	−9.299 (3)	−2.79 (3)
	$f_{t,k}-S_t$	−49.84 (3)***	−50.62 (3)***	−1302.26 (3)***	−25.51 (3)***	−1302.9 (3)*	−25.52 (3)***
	$\left(\frac{i_{t,k}-i^*_{t,k}}{1+i^*_{t,k}}\right)$	−2.4 (1)**	−3.265 (1)**	−15.93 (1)*	−2.85 (1)**	−22.59 (1)**	−3.48 (1)***
90-Day	S_t+_k	−0.6303 (3)	−1.9144 (5)	−1.144 (3)	−0.629 (3)	−17.414 (3)	−2.825 (3)
	$f_{t,k}$	−1.567 (3)	−2.506 (12)	−5.606 (3)	−1.5625 (3)	−12.22 (10)	−2.428 (10)
	$f_{t,k}-S_t$	−50.32 (3)***	−50.6 (3)***	−1289.89 (3)***	−25.39 (3)***	−1289.9 (3)***	−25.4 (3)***
	$\left(\frac{i_{t,k}-i^*_{t,k}}{1+i^*_{t,k}}\right)$	−2.45 (1)**	−2.1 (1)**	−14.35 (1)***	−2.45 (1)**	−16.73 (1)***	−2.81 (1)**
180-Day	S_t+_k	−0.8495 (3)	−1.943 (6)	−1.813 (3)	−0.8477 (3)	−11.039 (5)	−2.198 (5)
	$f_{t,k}$	−0.4536 (3)	−1.914 (5)	−0.75 (3)	−0.4508 (3)	−8.163 (5)	−1.896 (5)
	$f_{t,k}-S_t$	−21.38 (3)***	−47.22 (3)***	−689.72 (3)***	−18.57 (3)***	−1246.9 (3)***	−24.96 (3)***
	$\left(\frac{i_{t,k}-i^*_{t,k}}{1+i^*_{t,k}}\right)$	−2.01 (1)**	−3.35 (1)***	−12.14 (1)**	−2.01 (1)**	−14.08 (1)*	−2.36 (1)**

***Significant at the 1% level, **significant at the 5% level,*significant at the 10% level. Where τ_u contain intercept, ττ include intercept and trend, ( ) Number of lags selected by Schwartz (1978) Info criterion are shown in parentheses, DF-GLS τ_u: Asymptotic critical values: 1%-2.56, 5%-1.94%, 10%-1.62, see Elliott et al.(1996); Ng-Perron τ_τ: Asymptotic critical values: 1%-3.48, 5%-2.89%, 10%-2.57, τ_u: Asymptotic critical values, see Ng-Perron (2001, Table 1) MZ_α: 1%-13.8, 5%-8.1%, 10%-5.7, MZ_t: 1%-2.58, 5%-1.98%, 10%-1.62, τ_τ: Asymptotic critical values MZ_α: 1% -23.8, 5% -17.3%, 10% -14.2, MZ_t: 1% -3.42, 5% -2.91%, 10% -2.62 ,see Ng-Perron (2001, Table 1)

Table 3: Unit root test for spot, 30-, 60-, 90-, 180-day forward exchange rate (in the first difference)

DF-GLS test				Ng-Perron test statistics			
				MZ_α	MZ_t	MZ_α	MZ_t
n-market day	Variable	τ_u	τ_τ	τ_u		τ_τ	
30-Day	S_t	42.898***	−42.88***	−1712.52***	−29.26***	−1287.41***	−25.37***
	S_{t+k}	−42.769***	−42.844***	−1252.14***	−25.02***	−1223.37***	−24.73***
	$f_{t,k}$	−38.74***	−38.67***	−1435.69***	−26.79***	−2181.88***	−33.03***
60-Day	S_{t+k}	−42.65***	−42.63***	−1236.34***	−24.86***	−1207.86***	−24.58***
	$f_{t,k}$	−39.304***	−39.30***	−1235.08***	−78.58***	−495.53***	−15.74***
90-Day	S_{t+k}	−36.782***	−41.01***	−1975.54***	−31.43***	−1393.17***	−26.40***
	$f_{t,k}$	−43.32***	−43.32***	−1023.19***	−22.62***	−933.71***	−21.61***
180-Day	S_{t+k}	−41.441***	−41.797***	−1193.29***	−24.42***	−1161.21***	−24.09***
	$f_{t,k}$	−40.48***	−40.42***	−298.26***	−12.21***	−94.71***	−6.881***

***Significant at the 1% level, **significant at the 5% level, *significant at the 10% level, DF-GLS and the critical values τ_u, τ_τ of MZ_α, MZ_t refer to Table 2 obtained from the first difference are stationary series applying the DF-GLS and Ng-Perron (Ng, Perron,2001) unit root test. The 30-, 60-, 90-, 180-day exchange rates follow the I(1) series because the variable must be stationary sequence in the parameter estimation prediction. The result indicates that Taiwan's interest rate policy follows the U.S. and its money policy maintain a stable relationship with U.S.The Fed has influence not only on the world but also deeply affect on Taiwan. Based on the above empirical results are summarized as follows:

1. Where regression with the intercept trend τ_u, the regression with the intercept and time trends τ_τ, the unit root test are employed to examine whether the exchange rate data follow the stationary series or not.The results show that the exchange rate data are not stationary, and the original data after taking the first difference was stationary.
2. From Table 2, the risk premium and the difference in the two countries are I(0) indicate that interest rate spread stability so that presents the CIP theory the existence of holding. This is consistent with the results of Wu et al. (2001) using the Im-Pesaran-Shin test to support the UIP theory with a unit root test for euro interest rates.

4.4. The Engle-Granger Two-step Cointegration Analysis

To gain further insight by eliminating the nonstationary components in spot and forward exchange rate. Then, the Engle-Granger approach is a two-step procedure involving the residual-based test on the specified cointegrating regression model. To analyze the relationship between the FX variables, the Engle-Granger cointegration analysis is applied to the approach regarding with the econometric implications of estimating Equation (8). Table 4 depicts the test for the various days with the future spot exchange rate and forward exchange rate. The null hypothesis of the unit root is rejected at 1% level, except for the single term of 180-day in KPSS test. The rest of the unit root tests exhibit I(0) behaviour, this draws our attention to the conclusion that the future spot and forward exchange rate exists a co-integration relation in the long run.

4.5. Johansen Maximum Likelihood Estimation Cointegration Test

Before starting with the estimation of the cointegration Equation (8), we examined the series for the presence of unit root. Based on the results of the unit root test, the time series are strongly non-stationary at level but when taking the first differences, the time series become stationary. The variables present I(1) sequence by unit root test, so to further determine whether there is a long-term stability of the relationship among the variables. Thus, we employ the Johansen cointegration test and maximum characteristic root test to examine the number of co-integration vectors. Since the number of laggards will directly affect the results of the cointegration test, it is necessary to determine the optimal number of lag was selected using Schwartz Info criterion. In this study, we apply the VAR model to determine the optimal number of lagged order, and the Ljung-Box Q-test to test the 6, 12 order residuals, at 5% significant level for the serially uncorrelated. If the residuals are series uncorrelation, the numbers of lags increase gradually until the residuals follow the white noise process. Table 5 could be observed that H_0 r = 0 is rejected, indicating that there is at least one cointegration vector between the future spot and forward exchange rate variables as confirmed by both trace statistic and max-Eigenvalue. The null

Table 4: Engle-Granger cointegration analysis for the ($\hat{\varepsilon}_t$) of S_{t+k} and $f_{t,k}$

n-market day	Level					
	ADF		PP		KPSS	
	τ_u	τ_τ	τ_u	τ_τ	τ_u	τ_τ
30-Day	−11.96 (3)***	−11.966 (3)***	−50.787***	−36.62***	−1.39 (0)***	−1.037 (0)***
	−8.575 (9)***	−8.57 (9)***			−0.313 (8)***	−0.234 (8)***
60-Day	−8.872 (3)***	−8.88 (3)***	−23.744***	−28.30***	0.182 (0)**	−0.194 (0)***
	−5.19 (9)***	−5.17 (9)***			0.169 (8)***	−0.3795 (8)***
90-Day	−10.11 (3)***	−10.46 (3)***	−27.54***	−33.70***	−1.17 (0)***	−0.13 (0)***
	−3.432 (9)***	−5.327 (9)***			−0.11 (8)***	−0.628 (8)***
180-Day	−5.745 (3)***	−5.998 (3)***	−13.81***	−28.26***	3.02 (0)	6.344 (0)
	−3.104 (9)***	−3.068 (9)			1.774 (8)	0.869 (8)

***Significant at the 1% level, see Phillips, Perron (1988); **significant at the 5% level, *significant at the 10% level, the critical values refer to Mackinnon, 1991. ADF and PP τ_u: Asymptotic critical values: 1% -3.43, 5% -2.86, 10% -2.567; ( ) lag in brackets, τ_τ: Asymptotic critical values: 1% -3.96, 5% -3.41, 10% -3.12, KPSS τ_u: Asymptotic critical values: 1% -0.739, 5% -0.463, 10% -0.347; ( ) lag in brackets, τ_τ: Asymptotic critical values: 1% -0.2160, 5% -0.146, 10% -0.119, see Kowalewski-Phillips-Schmidt-Shin (1992, Table 1)

Table 5: Johansen cointegration test

n-market day	Hypothesized number of CE (s)	Eigen value	Trace statistic	5% Critical value	1% Critical value	Max-Eigen statistic	5%Critical value	1% Critical value
30-Day	$r \leq 0$	0.064419	177.8593**	15.41	20.04	174.9935**	14.07	18.63
	$r \leq 1$	0.001090	2.8658	3.76	6.65	2.865838	3.76	6.65
60-Day	$r \leq 0$	0.028039	77.22011**	15.41	20.04	74.0019**	14.07	18.63
	$r \leq 1$	0.001236	3.219021	3.76	6.65	3.219021	3.76	6.65
90-Day	$r \leq 0$	0.03397	94.53202**	15.41	20.04	89.02867**	14.07	18.63
	$r \leq 1$	0.002134	5.503351	3.76	6.65	5.503351	3.76	6.65
180-Day	$r \leq 0$	0.011366	32.44090**	15.41	20.04	28.55405**	14.07	18.63
	$r \leq 1$	0.001555	3.886849	3.76	6.65	3.886849	3.76	6.65

*.**Denotes significant at the 5%, 1% level, respectively see the critical values of table 5, the CVs cite from Osterwald-Lenum (1992)

hypothesis: H_0 $r \leq 1$ are not rejected. It indicates in presence of a cointegration vector for the variables set between the future spot and forward exchange rates, and the cointegration vector contains constant terms. As shown in Table 5, the each period of exchange rate are rejected H_0: r = 0 and accept H_0: $r \leq 1$, so there is at least a integration vector in NTD/USD FX market and the equilibrium exists a long-run cointegration relationship.

4.6. The Granger Causality Test Results

The Granger causality test also is applied to interpret the P-value of F statistics test (95% confidence interval) in Table 6. Null hypothesis of the 30-, 60-day spot exchange rate show no-Granger-causality relationship between the forward exchange rate (P-value approximately to 0.00). Therefore, the null hypothesis of no-Granger-causality is rejected, indicates the future spot exchange rate on the forward exchange rate in presence of the causality relationship. In addition, we find statistically significant Granger causality from future spot exchange rate to forward exchange rate. The 30-, 60-day spot and forward exchange rates have the feedback causal relationship. At the spot FX of 90. 180-day, The null hypothesis that futures spot exchange rate S_{t+90} fails to cause forward rate f_{90} is rejected at P-value (i.e., 0.00 or close to zero). Consequently, the findings present the existing evidence of the Granger causality relationship between spot and forward exchange rate in the180-day case. The forward rate is provided Granger causality relationship with the spot exchange rate. Therefore, the 30-, 60-, 90-, and 180-day spot and forward exchange rate display the feedback causality relationship. The spot exchange rates are observed to keep ahead the forward exchange rate illustrating that the foreign FX market appears efficiency factor, the past spot exchange rate information fully reflected in the future spot and forward exchange rate[2]. On the other hand, the forward exchange rate lead future spot exchange rate, which explains that the forward rate regarded as forecast indicators may exist.

4.7. Impulse Response Analysis

In this case, the usage of exchange rate vector $y_t = \left[s_{t+k}, f_{t,k}\right]'$ applies the concept of VAR model impulse response (Sims ,1980) due to the volatility of changes over time have characteristics more in line with the properties of financial assets. Obviously, as illustrated in Figure 1, the greatest impact on impulse response to a Cholesky 1% shock exists at the 1 lag, after 4 lag the gradually appear slowing down response over time, and its response end in approximately 0. The market reaction to the new information is completed immediately response within 6 lags. In other words, the future spotexchange rates, which one standard deviation of the innovation, have influence on the forward exchange rate, especially significant at 2 lags. The spot and forward exchange rate are interfered by the variables' effect noise proceed until the

Table 6: Pairwise Granger causality tests

Null hypothesis: H_0: A⇏B H_0: B⇏A	VAR lag	F-statistic	Probability
$S_{t+30} \nRightarrow f_{30}$	(2)	47.1471	0.000***
$f_{30} \nRightarrow S_{t+30}$		138.371	0.000***
$S_{t+60} \nRightarrow f_{60}$	(5)	32.6646	9.8E-15***
$f_{60} \nRightarrow S_{t+60}$		70.0348	0.000***
$S_{t+90} \nRightarrow f_{90}$	(7)	109.711	0.000***
$f_{90} \nRightarrow S_{t+90}$		33.4269	4.7E-15***
$S_{t+180} \nRightarrow f_{180}$	(1)	22.9498	1.3E-10***
$f_{180} \nRightarrow S_{t+180}$		16.0972	1.1E-07***

H_0: A⇏B imply A don't Granger cause B, F-statistic denote Wald test statistic, ( ) Number of lags in brackets by VAR model, the lag order is chosen accordingly to white-noise disturbances with the simplicity principle, ***significant at the 1% level, **significant at the 5% level, *significant at the 10% level. VAR: Vector autoregression

6^{th} lag tends to disappearance, and terminate the convergence to zero level. The same reaction are affected by four cases days FX market, indicate that the foreign exchange market efficiency still holds.

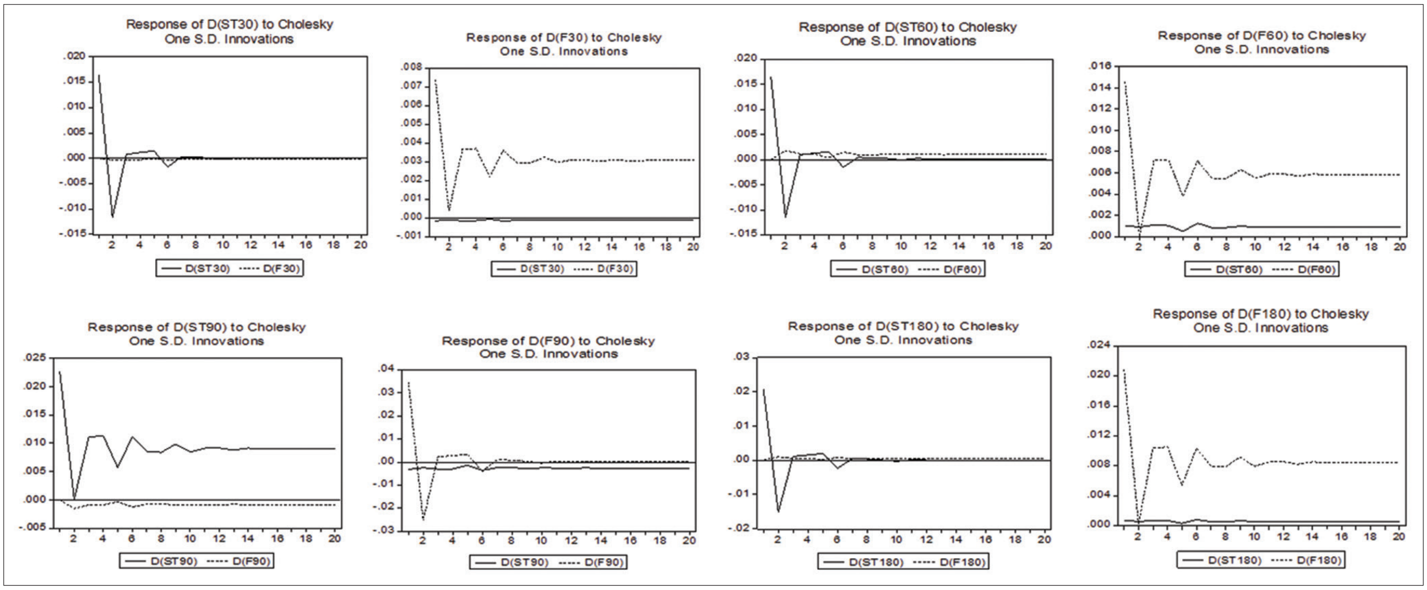
5. CONCLUDING REMARKS

Previous CIP studies related to Taiwan do not provide exhaustive discussion of this issue. We conclude that the evidence on presence and sources of deviations is ambiguous. In this study, we analyze the validation of CIP implying the tiny 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. By dividing our sample period in two subperiods we found that deviations from CIP within the Taiwan were unable to reject the null hypothesis of nonstationarity, when an ADF test was used in most of the cases.In this paper, the results of Taylor's (1989) risk-free arbitrage model and DF-GLS and Ng-Perron unit-root tests, which examine the foreign exchange market efficiency in Taiwan and the exchange rate parity are as follows: First, the DF-GLS and Ng-Perron unit root test show risk premium and the spread between the two countries possessed I(0) property. Second, the money policy maintain a stable relationship between the interest rates of two countries, showing the CIP hypothesis, similar to Johansen and Juselius (1992) found that the nominal interest rate spread is stable in the UK for interest rate parity. That is, if the spread is stable in the long run, then the hypothesis that the interest rate parity holds.

The exchange rate with the forward exchange rate market information seems to be fully utilized at this time cannot expect any change in exchange rates, but the cointegration relationship is one of the necessary conditions for efficient markets, followed by shock response analysis of spot and forward exchange rate market. The impact on the shock response is roughly the similar with each other, indicating that the FX market still has some efficiency factor. The Granger causality test find that the spot exchange rate and the forward exchange rate have a reciprocal influence on each other. Overall, when both international capital flows are liberalized and FX markets are deregulated, returns on comparable financial instruments transacted in home and foreign markets are equalized. Therefore, the interest differentials are

2 If this is non-stationary (equivalently unit root), it indicates that past values can forecast future values. When a series follows a random walk, previous shocks have an ongoing impact on the current values of the time series. As a result, outcomes are widely recognized that the exchange rate misalignment involves unexploited information which can be utilized for unusual excess profits. The available information is not efficiently usage (Giannellis and Papadopoulos, 2009).

Figure 1: Graph of the impulse response to cholesky one SD innovations ±2 SE. The spot and forward exchange rates are interrupted by the variables spontaneous noise, notation of ST30 represents the log of the future spot exchange rate with 30-day settlement period, and the same expression at the other day of notations



stationary, pointing out the financial market efficiency and thus integration among two countries.

In study of the foreign exchange market efficiency, it is discussed whether the forward exchange rate is unbiased. The purpose of exchange rate forecasting, in addition to the government for future reference to determine the trend, but also provide business decision investment, financing and product pricing decisions (Oh and Lee, 2016). At the same time, the Taiwanese monetary authorities should reduce the intervention of domestic monetary policy to maintain market efficiency.

REFERENCES

Schwarz, G. (1978), Estimating the dimension of a model. Annals of Statistics, 6(2), 461-464.

Akram, Q.F., Rime, D., Sarno, L. (2008), Arbitrage in the foreign exchange market: Turning on the microscope. Journal of International Economics, 76, 237-253.

Al-Loughani N.E., Moosa I.A. (2000), Covered interest parity and the relative effectiveness of forward and money market hedging, Applied Economics Letters, 7(10),673-675.

Aroskar, R., Sarkar, S.K., Swanson, P.E. (2004), European foreign exchange market efficiency: Evidence based on crisis and non-crisis periods. International Review of Financial Analysis, 13(3), 333-347.

Baillie, R.T., Bollerslev, T. (1989), Common stochastic trends in a system of exchange rates. The Journal of Finance, 44(1), 167-181.

Batten, J.A., Szillagyi, P.G. (2010), Is covered interest parity arbitrage extinct? Evidence from the spot USD/Yen. Applied Economics Letters, 17, 283-287.

Clinton, K. (1988), Transactions costs and covered interest arbitrage: Theory and evidence. Journal of Political Economy, 96(2), 358-370.

Dickey, D.A., Fuller, W.A. (1979), Distribution of the estimators for autoregressive time series with a unit root. Journal of American Statistical Association, 74, 427-431.

Dickey, D.A., Fuller, W.A. (1981), Likelihood ratio statistics for autoregressive time series with a unit root. Econometrica, 49, 1057-1072.

Elliott, G., Rothenberg, T.J., Stock, J.H. (1996), Efficient tests for an autoregressive unit root. Econometrica, 64, 813-836.

Engle R F, Granger C W J. (1987), Cointegration and error correction representation,estimation and testing. Econometrica, 55, 251- 276.

Ferreira, P. (2011), Monetary integration in the European Union. Journal of Emerging Market Finance, 10, 93-120.

Ferreira, P., Andreia, D. (2015), Revisiting covered interest parity in the European Union: The DCCA approach. International Economic Journal, 29(4), 597-615.

Fletcher, D., Taylor, L.W. (1996), Swap covered interest parity in long-date capital market. The Review of Economics and Statistics, 78(3), 530-538.

Fong, W., Valente, G., Fung, J. (2010), Covered interest rate profits: The role of liquidity and credit risk. Journal of Banking and Finance, 34, 1098-1107.

Giannellis, N., Papadopoulos, A.P. (2009), Testing for efficiency in selected developing foreign exchange markets: An equilibrium-based approach. Economic Modelling, 26(1), 155-166.

Granger, C.W.J., Newbold, P. (1974), Spurious regression in econometric. Journal of Econometrics, 2, 111-120.

Gurvich, E., Lebedinskaya, E., Simachev, Y., Yakovlev, A. (2010), Russia country report. In: Bertelsmann, S., editor. Managing the Crisis. A Comparative Assessment of Economic Governance in 14 Economies. Gütersloh: Bertelsmann Stiftung. Available from: http://www.eeg.ru/files/managcris_en.pdf.

Hutchison, M., Kendall, J., Pasricha, G., Singh, N. (2012), Indian capital control liberalization: Evidence from NDF markets. IMF Economic Review, 60(3), 395-438.

Im, K.S., Pesaran, M.H., Shin, Y. (1995), Testing for Unit Roots in Heterogeneous Panels. Working Paper, University of Cambridge.

Johansen, S., Juselius, K. (1990), Maximum likelihood estimation and inference on cointegration with applications to the demand for money. Oxford Bulletin of Economics and Statistics, 52, 169-210.

Johansen, S., Juselius, K. (1992), Testing structural hypothesis in a multivariate cointegration analysis of the PPP and the UIP for UK. Journal of Econometrics, 53, 211-244.

Kwiatkowski, D., Phillips, P.C.B., Schmidt, P., Shin, Y. (1992), Testing the null-hypothesis of stationary against the alternative of a unit root. Journal of Econometrics, 54, 159-178.

Mackinnon, J.E. (1991), Critical values for cointegration tests. In: Engle, R.F., Granger, C.W.J., editors. Long Run Economic Relationships. Oxford: Oxford University Press. p267-276.

Michaud, F.L., Upper, C. (2008), What drives interbank rates? Evidence from the LIBOR panel. BIS Quarterly Review, 3, 47-58.

Ng, S., Perron, P. (2001), Lag length selection and the construction of unit root tests with good size and power. Econometrica, 69, 1519-1554.

Oh, D.Y., Lee, H. (2017), LM cointegration tests allowing for an unknown number of breaks: Implications for the forward rate un biasedness hypothesis. Applied Economics, 49(12), 1194-1203.

Phillips, P.C.B., Perron, P. (1988), Testing for a unit root in time series regression. Biometrika, 75, 335-346.

Saito M, Shiratsuka S. (2001), Financial crises as the failure of arbitrage: implications for monetary policy. Monetary and Economic Studies, 239-270.

Sarno, L., Taylor, M.P. (2002), The Economics of Exchange Rates. Cambridge, England and New York: Cambridge University Press.

Sims, C.A. (1980), Macroeconomics and reality. Econometric, 48, 1-48.

Skinner, F.S., Mason, A. (2011), Covered interest rate parity in emerging markets. International Review of Financial Analysis, 20(5), 355-363.

Suh, S., Kim, Y.J. (2016), Covered interest parity and arbitrage paradox in emerging markets: Evidence from the Korean market. Pacific-Basin Finance Journal, 38, 161-176.

Taylor, M.P. (1989), Covered interest arbitrage and market turbulence. The Economic Journal, 99, 376-391.

Taylor, M.P., Tchernykh-Branson, E. (2004), Asymmetric arbitrage and default premiums between the U.S. And Russian financial markets. IMF Staff Papers, 51, 257-275.

Wu, J.L., Chen, S.L. (2001), Mean reversion of interest rates in Eurocurrency markets. Oxford Bulletin of Economics and Statistics, 63, 459-473.

APPENDIX

Appendix 1: Variables description and data list

Sample description	Source of data
NTD/USD 30-, 60-, 90-, 180-day forward bid exchange spot rate	AREMOS Economic Statistics Database (Taiwan Economic Data Center) International Financial Statistics Market The first commercial bank's daily exchange rate transaction data
NTD/USD 30-, 60-, 90-, 180-day forward ask exchange spot rate	Taiwan Economic Journal
USD foreign currency 1, 3, 6 months deposit interest rates	AREMOS Economic Statistics Database (Taiwan Economic Data Center) International Financial Statistics Market (USFIN)
1, 3, 6 months NTD deposit interest rates	$s_t = \dfrac{\log(S^{ask} + S^{bid})}{2}$ S_t: The average spot exchange rate quotation $f_{t,k} = \dfrac{\log(F_k^{ask} + F_k^{bid})}{2}$ $f_{t,k}$: The average forward exchange rate quotation
10-, 30-, 90-, and 180-day of commercial paper interest rate	
30-, 60-, 90-, and 180-day LIBOR interest rates	

s_{t+k} represents the log of the future spot exchange rate at time t, with k day i.e.,, the 30-, 60-, 90-, 180-day settlement period