International Journal of Economics and Finance; Vol. 6, No. 10; 2014
ISSN 1916-971X E-ISSN 1916-9728
Published by Canadian Center of Science and Education

Study on Synergistic Fluctuation of Exchange Rate between Renminbi and New Taiwan Dollar

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Received: July 11, 2014 Accepted: July 17, 2014 Online Published: September 25, 2014

doi:10.5539/ijef.v6n10p55 URL: http://dx.doi.org/10.5539/ijef.v6n10p55

Abstract

According to the methods such as Johansen Cointegration Test, Error Correction Model (ECM) and Granger Causality Test, the empirical result in this paper shows the launching of the “Cross-Strait Currency Clearing Mechanism” prominently increase long-term equilibrium, long/short-term interaction and lead-lag relationship of the exchange rate between Renminbi (RMB) and New Taiwan Dollar (TWD). To sum up, it is proved that implementation of *Memorandum on Cross-strait Currency Clearing Cooperation* and the policy of “Cross-Strait Currency Clearing Mechanism” remarkably multiplies a positive synergistic fluctuation of the exchange rate between cross-Strait currencies in causality. It is suggested that transaction in U.S. Dollars decrease and transaction in RMB increase for cross-Strait economy and trade, investment and fund dealings.

Keywords: cointegration, Error Correction model (ECM), cross-strait currency clearing mechanism, Renminbi (RMB), New Taiwan Dollar (TWD)

1. Introduction

Since the cross-Strait trade had first surpassed 50 billion U.S. Dollars in 2002, it achieved 162.2 billion U.S. Dollars in 2012 which accounted for 40% of the Taiwan international trade amount. However, the common used currency between both sides was U.S. Dollars. After the launching of the “Cross-Strait Currency Clearing Mechanism” in January 2013, Taiwanese corporations actively use RMB for trade settlement. The scholar Cao and Lee (2013) considered no necessity of using U.S. Dollar for the cross-Strait trade and fund dealings in the future, which saved corporations considerable transaction costs. Besides, people will have access to RMB in the cross-Strait investment, trade, tourism and financial interflow. Thus, the paper attempts to investigate the synergistic fluctuation of exchange rate between RMB and TWD upon the launching of the Cross-Strait Currency Clearing Mechanism from the development of RMB in Taiwan as well as with VAR and ECM models.

The conversion of RMB from/into TWD began on October 3, 2005. The trial program concerned with daily conversion of 20,000 RMB in Kinmen-Matsu Region that 20,000 established a foundation for the cross-Strait currency exchange. On May 21, 2008, the “draft amendment to the Cross-Strait People's Relation Act” had been passed in Taiwan as a legal basis for legitimate conversion of RMB in Taiwan before the Cross-Strait Currency Clearing Mechanism was signed. However, it was “one-way conversion” of RMB into TWD. On June 30, 2008, the conversion of RMB into TWD was available throughout Taiwan. 19 banks and their branches were approved to handle the business of purchasing and selling RMB. As RMB supply by Taiwan’s banks was getting stable, all banks and some companies (Vigor Kobo, Regent) were ratified to handle “two-way conversion” of TWD into RMB.

As the volume of trade and the amount of investment on both sides across the Taiwan Strait had been rising, TWD could not be directly converted from/into RMB, and fund had been transferred indirectly through U.S. Dollar resulting in double cost of currency exchange, the cross-Strait currency clearing was launched in December 2012. As of February 2013 since launch, trade settlement, deposit and transaction amount of RMB in Taiwan greatly increased. China’s “Administrative Rules on Pilot Program of Renminbi Settlement of Cross-border Trade Transactions” was announced and taken effect officially on July 1, 2009, so RMB trade settlement was available in ASEAN countries and Hong Kong. On February 3, 2012, the “Notice of the Relevant

Issues Pertaining to Administration over Enterprises Engaging in RMB Settlement of Export of Goods" was also released to comprehensively open up the cross-border Renminbi business of current account that skyrocketed RMB trade settlement. According to the People's Bank of China, RMB trade settlement in 2012 reached 2.94 trillion RMB which was 41.3% greater than that in 2011 of 2.08 trillion RMB. The amount in the first half of 2013 achieved 2.05 trillion RMB (Figure 1). The ratio of the cross-border RMB trade settlement in China's total foreign trade volume continued to rise from 0.43% in the first quarter of 2010 to 13% in the second quarter of 2013.

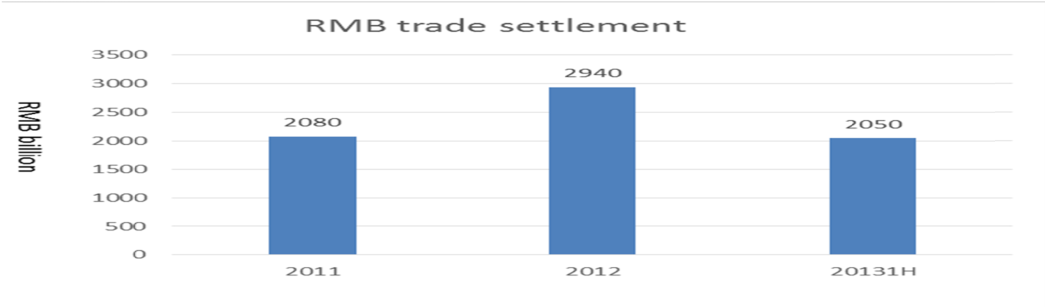

Figure 1. 2011–2013 cross-border RMB trade settlement business

Source: The People's Bank of China.

In the first nine months of 2013, the RMB trade settlement in Taiwan through Taipei Branch of the People's Bank of China was 173 billion (Figure 2). According to the Ministry of Commerce of the People's Republic of China, it was estimated from the cross-Strait trade volume of 149.2 billion RMB for January to September 2013 that the ratio of RMB trade settlement in Taiwan achieved 19% indicating an upcoming effect of the Cross-Strait Currency Clearing Mechanism on RMB trade settlement.

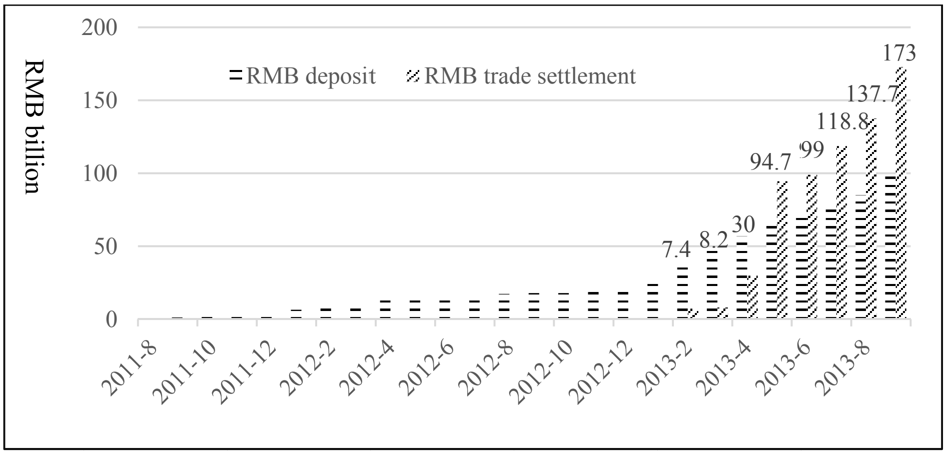

Figure 2. 2011-September 2013, RMB deposit and trade settlement in Taiwan

Source: The Central Bank of Taiwan 2013.11.

Taiwan in August 2011 allowed the Offshore Banking Unit (OBU) of banks to handle offshore RMB business. In December 2012, Do-Mestic Banking Unit (DBU) started to offer the service of RMB deposit and trade settlement which reached 98.7 billion RMB in the first nine months of 2013 (Figure 2). The amount of RMB deposit was second only to USD deposit. In the future, the former will increase along with the amount of trade settlement that expands RMB fund. The remittance rose from17.3 billion RMB in February to 290.2 billion RMB in September accumulatively. Moreover, the volume of foreign exchange transactions for RMB against USD in Taiwan from February to September reached 570.6 billion USD. The RMB fund went to China as well as to Luxemburg, Singapore, France, Japan, Germany, Italy and Australia and so on. This tells the importance of RMB in Taiwan with regard to the volume of foreign exchange transactions. Also, there are six

RMB-denominated Formosa Bonds issued totaling to 3.9 billion RMB.

The paper aims to investigate the correlation and the dynamic relationships between two currency markets involving RMB and TWD after implementation of the Cross-Strait Currency Clearing Mechanism. Implementation of the Currency Clearing Mechanism means a significant reformation to the exchange rate policy in China and Taiwan that changes ways of the cross-Strait fund dealings. This may make an impact on the exchange rate of RMB and TWD which show dynamic relationship, and even change the long-term exchange rate policy of TWD to USD. That the relationship between TWD and RMB will be changed accordingly is the focal point discussed in this paper. August 31, 2012 that the *Memorandum on Cross-strait Currency Clearing Cooperation* was signed by both sides and December 11 that the “Cross-Strait Currency Clearing Mechanism” was officially taken effect are the two divides. Sample data selected are divided into three periods including the period before signature of the *Memorandum on Cross-strait Currency Clearing Cooperation*, the period before and the period after implementation of the “Cross-Strait Currency Clearing Mechanism”. Sequence estimation is adopted to investigate and compare the correlation and synergistic fluctuation between RMB and TWD.

2. Literature Review

Prior to the launching of the Cross-Strait Currency Clearing, RMB circulation in Taiwan was limited. When studying the issue pertaining to the exchange rate of RMB and TWD, scholars discussed chiefly rationality of monetary value or factors influencing exchange rate with the purchasing power parity model. For example, Hui and Li (2009) discovered, with OCA index, the cross-Strait trade connection and change in export effectively stabilized exchange rate fluctuation of RMB against TWD. Feng and Jin (2012) analyzed the cause affecting exchange rate fluctuation of RMB against TWD based on 2005–2009 monthly exchange rate in China and Taiwan in addition to the correlation among the cross-Strait trade, money supply and interest rate by using Cointegration Test and Granger Causality Test. Pan (2013), according to 1994–2012 labor productivity, trade condition, money supply and economic situation, found long-term disequilibrium of exchange rate between RMB and TWD from empirical studies.

King and Wadhwani (1990) and Wang (2011) mentioned financial assets in different markets may cause volatility transmission. To investigate synergistic fluctuation of exchange rate in different markets, the analysis shall emphasize one-way or two-way spillover effect among markets and contagion effect among markets. Engle and Kozicki (1993) and Harvey (1995) proposed synergistic ARCH factor to test fluctuation of exchange rate among different markets. When there was synergistic factor in different markets, exchange rate would simultaneously fluctuate.

Since the launching of the cross-Strait currency clearing mechanism in February 2013, the amount of trade settlement, deposit, cross-Strait remittance and volume of foreign exchange transactions has all risen, which means the cross-Strait exchange rates meet. However, literature on synergistic fluctuation of exchange rate between RMB and TWD was few overseas and in Taiwan except Ito (2010), Subramanian and Kessler (2012) and Mo (2013). Taiwan’s literature on synergistic fluctuation of exchange rate of TWD mostly discussed synergistic fluctuation between TWD and USD. For instance, Huang (1995) by using Error Correction Model (ECM) analyzed long-term stationary equilibrium for TWD against USD during 1984–1993 and found anticipation of ECM better than that of Random Walk. Lee (1996) revised the theory of purchasing power parity and adopted multivariate cointegration test and Vector Autoregression Model (VAR) to investigate long-term synergistic fluctuation of relative exchange rate, interest rate and price for Taiwan and America during 1980–1995. Wu, Huang, Wang and Wu (2012) planned to use Balassa-Samuelson effect along with Markov switching model for discussion about stationary exchange rate between TWD and USD during 1980–2010.

Ito (2010) with currency basket model tested the influence of USD and RMB on fluctuation of exchange rate for Indonesian Rupiah (IDR), Indian Rupee (INR), Korean Won (KRW), Malaysian Ringgit (MYR), Philippines Peso (PHP), Singapore Dollar (SGD), Thai Baht (THB), New Taiwan Dollar (TWD) and Vietnamese Dong (VND). The result showed that from 2005 to 2008, in a currency basket, RMB had greater effect than USD on fluctuation of IDR, MYR and SGD with a result of 0.467, 0.436 and 0.49 separately. However, its influence on TWD was 0.33 only, smaller than the influence of USD. Subramanian and Kessler (2012) based on the data from July 2010 to August 2012 re-tested change in importance of RMB against other Asian currencies. The result demonstrated, except IDR, that INR, KRW, MYR, PHP, SGD, THB and TWD were greatly influenced by RMB and fluctuated. Meanwhile, the weight of influence on TWD increased from 0.33 to 0.61. According to the weekly data from January 2006 to the end of 2009 about TWD and RMB, Mo (2013) with Bayesian econometric approach and Threshold variables discovered from empirical research a slight influence of RMB on TWD, but TWD showed no remarkable influence on RMB.

3. Methodology

In the paper: (1) Based on Augmented Dicky-Fuller (ADF) proposed by Dickey and Fuller (1979, 1981), the unit root test is carried out on variables selected for exchange rate between RMB and TWD to observe if two exchange rate variables are stationary, namely, without unit root; (2) Cointegration test. If the two exchange rate variables are not stationary and in the same integrated order, cointegration test shall be performed. Based on Johansen's (1990, and 1994) five Vector Autoregression Models (VAR), long term equilibrium between the two exchange rate variables is checked; (3) After cointegration test, if the result shows no cointegration, Sims's (1980) Vector Autoregression Model will be adopted for the test of short term interaction between exchange rates; if cointegration exists, Granger's (1988) VAR model is applied along with Error Correction Model (ECM) for error correction of long term equilibrium between cointegration variables to test short term interaction between exchange rates; (4) Finally, VAR model or ECM model is used for lead-lag Granger Causality Test.

3.1 Empirical Model

Below is an equation for TWD and RMB hypothesized in this paper:

$$Y_{i,t} = f(Y_{i,t}) \quad i = 1, 2 \tag{1}$$

That is, $Y_{1,t} = f(Y_{1,t}, Y_{2,t})$ and $Y_{2,t} = f(Y_{1,t}, Y_{2,t})$.

$Y_{1,t}$ indicates the real effective exchange rate of RMB against USD; $Y_{2,t}$ is the real effective exchange rate of TWD against USD. $Y_{1,t}$ and $Y_{2,t}$ are the two exchange rate variables before signature of the *Memorandum on Cross-strait Currency Clearing Cooperation* and implementation of "Cross-Strait Currency Clearing Mechanism".

3.2 Method of Empirical Analysis

Research methods adopted in this paper include: (1) ADF unit root test; (2) Cointegration test; (3) Vector Autoregression Model or estimation with Error Correction Model; (4) Causality test, which are explained separately as below:

3.2.1 Unit Root Test

In the process of ADF test, regression estimation is performed on a sequence with one period lag to variables and differential lag of variables. The regression equation of the test is as follows:

$$y_t = a_0 + \beta_1 y_{t-1} + \sum_{i=1}^{\rho-1} \gamma_i \Delta y_{t-i} + a_1 T + \varepsilon_t \tag{2}$$

From the above equation, it is known that $\beta_1=1$ indicates y_t is of unit root. On the contrary, $\beta_1 \neq 1$ means y_t is without unit root. If the sequence y_t passes ADF test that the hypothesis (H_0) cannot be rejected, the sequence shall be differentiated and applied to the above ADF model to test if it is a stationary sequence. Below is the adjustment:

$$\Delta y_t = a_0 + \delta_1 y_{t-1} + \sum_{i=1}^{\rho-1} \gamma_i \Delta y_{t-i} + a_2 T + \varepsilon_t \tag{3}$$

In the equation, $\delta_1 = \beta_1 - 1$, $\Delta y_t = y_t - y_{t-1}$ demonstrate the sequence y_t is a new sequence performed with first difference. If new sequenceΔy_t rejects hypothesis, it is accepted that new sequence is stationary.

Besides, ADF test with an advanced AR (p) model estimates period lag of difference for an optimal model. To settle the issue, Engle and Yoo (1987) and Reimers (1992) suggested take Schwarz's (1978) SBC (Schwarz Bayesian Information Criterion) as the criterion for determination of model selection. SBC index is calculated as follows:

$$SBC = \text{T}\ln(\text{SSR}) + N\ln(\text{T})$$

T is total samples, ln(SSR) is SSR (sum square of residual; residual sum of squares) picking the value of natural log, and N is the number of parameters to be estimated.

3.2.2 Johansen Cointegration Test

Maximum Likelihood Estimation proposed by Johansen (1990 and 1994) is adopted in this paper to test cointegration among variables. Gaussian VAR model and hypotheses for Johansen's five error correction multivariables are tested as follows:

Model 1, no trend in Vector Autoregression Model and no intercept in cointegration equation:

$$H_0(r): \ \Delta X_t = \Gamma_1 \Delta X_{t-1} + \ldots\ldots + \Gamma_{k-1}\Delta X_{t-(k-1)} + \alpha\beta' X_{t-1} + \psi D_t + \varepsilon_t \tag{4}$$

Model 2, no trend in Vector Autoregression Model but cointegration equation with intercept:

$$H_1^*(r): \ \Delta X_t = \Gamma_1 \Delta X_{t-1} + \ldots\ldots + \Gamma_{k-1}\Delta X_{t-(k-1)} + \alpha(\beta', \beta_0)(X'_{t-1}, 1)' + \psi D_t + \varepsilon_t \tag{5}$$

Model 3, Vector Autoregression Model with linear trend and cointegration equation with intercept:

$$H_1(r): \ \Delta X_t = \Gamma_1 \Delta X_{t-1} + \ldots\ldots + \Gamma_{k-1}\Delta X_{t-(k-1)} + \psi D_t + \alpha\beta' X_{t-1} + \mu_0 + \varepsilon_t \quad (1990) \tag{6}$$

Model 4, linear trend exists in both Vector Autoregression Model and cointegration equation:

$$H_2^*(r): \ \Delta X_t = \Gamma_1 \Delta X_{t-1} + \ldots\ldots + \Gamma_{k-1}\Delta X_{t-(k-1)} + \alpha(\beta', \beta_1)(X'_{t-1}, t)' + \mu_0 + \psi D_t + \varepsilon_t \tag{7}$$

Model 5, Vector Autoregression Model with two trends and cointegration equation with linear trend:

$$H_2(r): \ \Delta X_t = \Gamma_1 \Delta X_{t-1} + \ldots\ldots + \Gamma_{k-1}\Delta X_{t-(k-1)} + \alpha\beta X_{t-1} + \mu_0 + \mu_1 t + \psi D'_t + \varepsilon_t \tag{8}$$

In the empirical analysis, the above five Vector Autoregression Models are used at the same time to test cointegration ranks among exchange rate variables. The maximum critical value of characteristic root equation is obtained after checking Osterwald-Lenum's (1992) critical value table. For selection of a suitable model, according to Nieh and Lee (2001) 's Decision Rule, null hypotheses of the above five models are arranged in order and sieved from left to right and from top to bottom until null hypotheses are not rejected. The testing order determined for models is:

$$H_0(0) \rightarrow H_1^*(0) \rightarrow H_1(0) \rightarrow H_2^*(0) \rightarrow H_2(0) \rightarrow H_0(1) \rightarrow H_1^*(1) \rightarrow H_1(1) \rightarrow H_2^*(1)$$
$$\rightarrow H_2(1) \rightarrow \ldots\ldots \rightarrow \ldots\ldots \rightarrow H_0(k-1) \rightarrow H_1^*(k-1) \rightarrow H_1(k-1)$$
$$\rightarrow H_2^*(k-1) \rightarrow H_2(k-1)$$

When cointegration test is performed, if the lag period selected is too long, over-parameterization may occur that causes inefficient estimation. If the lag period selected is too short, parsimonious parameterization may happen resulting in error of estimation. Therefore, it is necessary to select an optimal lag period, and SBC index is applied for the selection.

3.2.3 Vector Autoregression Model (VAR) and Error Correction Model (ECM)

Sims (1980) believed the empirical result from estimation by a model established based on priori theory is unable to manifest a joint process from all economic variables. Hence, Vector Autoregression Model (VAR) is proposed that is especially based on the characteristic of sample data itself. All economic variables in an empirical model are regarded as endogenous variables; the optimal lag period of variables is selected as explanatory variable for lag of variables covers all related information. Thus, general VAR (n) model can be described as below:

$$Y_t = \alpha + \sum_{i=1}^{n} \beta_i Y_{t-i} + \varepsilon_t \tag{9}$$

In the equation, Y_t comprises (n×1) vector which is a linearly stochastic process of jointly covariance stationary. Meanwhile, Y_{t-1} is (n×1) vector composed of i lag periods of Y_t vectors. β_t is (n×n) coefficient matrix regarded as a propagation mechanism. ε_t, a structural disturbance, is (n×1) one-step ahead forecast error that can be seen as a random innovations. Σ is (n×n) covariance matrix. SBC rule is adopted as well for selection of an optimal lag period.

According to "Granger Representation Theory" posed by Engle and Granger (1987), when cointegration exists among variables and in observing the correlation among the variables, test cannot be performed only on variables and the influence of lag values of other variables on current variables. The adjustment to long term disequilibrium must be taken into consideration. Granger (1988) pointed out that at least one previous disequilibrium term exists in cointegration, so Error Correction Model (ECM) must be adopted in replacement of VAR model for investigation of the correlation among variables.

3.2.4 Granger Causality Test

In every financial and economic theoretical model, the correlation among variables is often deduced under different hypotheses. However, lead-lag relationship among variables is seldom confirmed. Granger (1969) was the first to propose defining lead-lag relationship from predicatability, and with dual-factor VAR model explaining the causality among variables. Suppose two variable series for time sequence Y_t and X_t. The defined information is gathered as below:

$$\Delta Y_t = \alpha_{10} + \sum_{i=1}^{p} \alpha_{1i} \Delta Y_{t-i} + \sum_{j=1}^{q} \beta_{1j} \Delta X_{t-j} + \varepsilon_{yt} \tag{10}$$

$$\Delta X_t = \alpha_{20} + \sum_{i=1}^{p} \alpha_{2i} \Delta Y_{t-i} + \sum_{j=1}^{q} \beta_{2j} \Delta X_{t-j} + \varepsilon_{xt}$$

By testing significance of the above four coefficients (α_{1i}, α_{2i}, β_{1j}, β_{2j}) in this paper, lead-lag relationship among variables can be determined. First, (1) if $\beta_{1j} \neq 0$ and $\alpha_{2i} = 0$, this means X_t leads Y_t (or Y_t lags behind X_t); (2) if $\alpha_{2i} \neq 0$ and $\beta_{1j} = 0$, this indicates Y_t leads X_t; (3) if $\beta_{1j} = 0$ and $\alpha_{2i} = 0$, this demonstrates Y_t and X_t are mutually independent; (4) if $\beta_{1j} \neq 0$ and $\alpha_{2i} \neq 0$, this means two-way causal Feedback exists between Y_t and X_t.

4. Result

4.1 Source of Materials and Description

To compare synergistic fluctuation of exchange rate between RMB and TWD before and after signature of the *Memorandum on Cross-strait Currency Clearing Cooperation* and implementation of the Cross-Strait Currency Clearing Mechanism, sample data are divided into: 123 materials during May 1, 2012 and August 31, 2012 before signature of the *Memorandum on Cross-strait Currency Clearing Cooperation*; 102 materials during September 1, 2012 and December 11, 2012 after signature of the *Memorandum on Cross-strait Currency Clearing Cooperation* until implementation of the Cross-Strait Currency Clearing Mechanism; and, 140 materials during December 12, 2012 and April 30, 2013 after implementation of the Cross-Strait Currency Clearing Mechanism. The data are sourced from "AREMOS Economic Statistics Database" of the Computer Center, Ministry of Education, Taiwan.

Table 1 shows basic statistics for the real effective exchange rate of RMB to TWD. Jarque-Bera (J-B) statistics reveal that the real effective exchange rates of two currencies at a significant level of 1 % do not conform to normal distribution. ARCH-LM also shows the exchange rate of the two currencies at a significant level of 5 % have heteroscedasticity variance. Ljung-Box Q statistics indicate that TWD at a significant level of 1 % has autocorrelation of residual, but RMB does not.

It is observed from the movement of RMB exchange rate during 1996 and 2005 (Figure 3) that China authority carried out fixed exchange rate system and foreign exchange control. The exchange rate was fixed at 1 USD against 8.2–8.4 RMB. On July 21, 2005, managed floating exchange rate system began to take effect that allowed limited appreciation and depreciation of RMB while gradually lifted the ban on foreign exchange control. The exchange rate increased from 1 USD for 8.2–8.4 RMB to 1 USD for 6.2–6.5 RMB. The floating exchange rate system executed in Taiwan made sharper change in exchange rate than RMB (Figure 4).

Table 1. Basic statistics for variables

	Exchange rate of RMB to USD (RMB)	Exchange rate of TWD to USD (TWD)
Mean	7.6041	30.7257
Max.	8.7300	35.1120
Min.	5.2221	24.6500
Std. Dev	1.0177	3.1534
Skewness	-1.1640	-0.4587
Kurtosis	2.9185	1.7209
Jarque-Bera	54.270***	24.778***
	(0.000)	(0.000)
ARCH(4)	2.8267**	2.9383**
	(0.033)	(0.028)
L-B Q (24)	0.48	14.73***
	(0.484)	(0.000)
Obs.	*365*	*365*

Note. 1. *, **, *** individually indicate rejection of null hypotheses at significant levels of 10%, 5% and 1%.2. Jarque-Bera is a statistic for normal testing. In the equation $JB = \frac{T-n}{6}\left(s^2 + \frac{1}{4}(K-3)^2\right)$, s indicates coefficient of skewness, k means coefficient of kurtosis, n is the number of parameters to be estimated in a model, and T refers to total samples.3. ARCH (p) heteroskedasticity tests (ARCH-LM test) LM statistics. 4. L-B Q indicates Ljung-Box Q statistics; Obs. total samples.

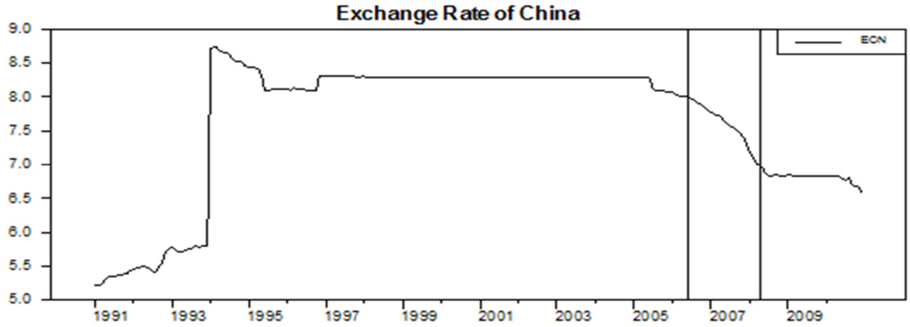

Figure 3. The movement for the real effective exchange rate of RMB to USD (1990–2010)

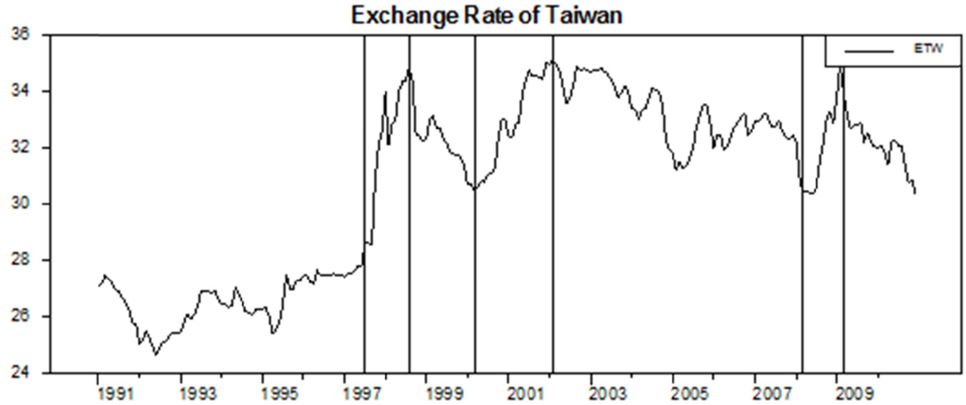

Figure 4. The movement for the real effective exchange rate of TWD to USD (1990–2010)

4.2 Unit Root Test

The result of ADF unit root test (Table 2) shows, at a significant level of 10 %, a null hypothesis of the level with unit root cannot be rejected. That is, two exchange rates are not stationary. However, the data performed with first difference reject unit root indicating the value of first difference for two currencies is stationary. It is known from the result of unit root test that the exchange rate of RMB adopted in the paper as well as the exchange rate of TWD are both I (1) sequence.

Table 2. ADF unit root test

	Level	First Difference
RMB	-2.2480 (0)	-15.0894(0)***
TWD	-1.6098 (1)	-12.7300(12)***

Note. 1. *** means rejection of null hypotheses at a significant level of 1%. () is an optimal lag period of difference determined by minimum SBC. 2. The critical values of ADF at 10%, 5% and 1% are -2.570, -2.860 and -3.430 separately. 3. ADF null hypothesis is unit root exists and the sequence is not stationary.

4.3 Johansen Cointegration Test

The result in Table 3 (1) reveals, at a significant level of 5 %, during May 1, 2012 and August 31, 2012 before signature of the *Memorandum on Cross-strait Currency Clearing Cooperation*, the test results of Model 1 and Model 2 do not have cointegration vector. Model 3 to Model 5 have a group of cointegration vector individually. The result in Table 4 (2) shows, in the transition during September 1, 2012 and December 11, 2012 after signature of the *Memorandum on Cross-strait Currency Clearing Cooperation* until implementation of the Cross-Strait Currency Clearing Mechanism, Model 1 has three groups of cointegration vector; Model 2 has one group of cointegration vector; Model 3 has two groups of cointegration vector; Model 4 and Model 5 have one group of cointegration vector separately. The result in Table 4 (3) tells during December 12, 2012 and April 30, 2013 after official implementation of the Cross-Strait Currency Clearing Mechanism, Model 1 to Model 4 have three groups of cointegration vector separately while Model 5 has four groups of cointegration vector.

According to the above results, cointegration of the exchange rate between RMB and TWD was weak before signature of the *Memorandum on Cross-strait Currency Clearing Cooperation*. As the *Memorandum on Cross-strait Currency Clearing Cooperation* was signed and the "Cross-Strait Currency Clearing Mechanism" was carried out, cointegration of the exchange rate between RMB and TWD was getting stronger. Based on the above result, signature of the *Memorandum on Cross-strait Currency Clearing Cooperation* and implementation of the "Cross-Strait Currency Clearing Mechanism" truly advanced cointegration between the cross-Strait currencies.

Table 3. Johansen cointegration test

	Model 1 H_0		Model 2 H_1^*		Model 3 H_1		Model 4 H_2^*		Model 5 H_2	
Rank	$T_0(r)$	$C_0(5\%)$	$T_1^*(r)$	$C_1^*(5\%)$	$T_1(r)$	C_1 (5%)	$T_2^*(r)$	$C_2^*(5\%)$	T_2 (r)	$C_2(5\%)$
(1) 2012, 5, 1 ~ 2012, 8, 31 ; T = 123										
r = 0	39.363	40.175	40.929	54.079	74.339	47.856	70.941	63.876	62.067	55.246
r≤1	23.737	24.276	23.304	35.193	28.458	29.797	41.649	42.915	34.362	35.011
r≤2	10.403	12.321	7.800	20.262	21.777	15.495	19.212	25.872	12.288	18.398
r≤3	2.738	4.130	3.376	9.165	2.401	3.841	5.064	12.518	2.851	3.842
(2) 2012, 9, 1 ~ 2012, 12, 11 ; T = 102										
r = 0	57.579	40.175	55.867	54.079	67.629	47.856	67.147	63.876	56.993	55.246
r≤1	34.779	24.276	33.085	35.193	35.941	29.797	25.916	42.915	24.161	35.011
r≤2	15.183	12.321	14.575	20.262	15.431	15.495	6.692	25.872	4.941	18.398
r≤3	3.357	4.130	6.930	9.165	3.326	3.841	2.921	12.518	1.316	3.842
(3) 2012, 12, 12 ~ 2013, 4, 30 ; T = 140										
r = 0	60.251	40.175	75.899	54.079	69.931	47.856	92.436	63.876	89.675	55.246
r≤1	26.551	24.276	37.582	35.193	29.848	29.797	51.353	42.915	48.736	35.011
r≤2	15.772	12.321	22.581	20.262	18.891	15.495	26.353	25.872	25.759	18.398
r≤3	2.613	4.130	4.056	9.165	0.080	3.841	4.890	12.518	4.464	3.842

Note. 1. A significant level of 5% is selected for models. On the basis of Nieh and Lee's (2001) principles to model, null hypotheses are rejected from left to right and from bottom to top, and until null hypotheses are not rejected in order to select an optimal Johansen cointegration model for long-term movement. 2. The critical value refers to Osterwald-Lenum (1992). 3. Rank means the hypothesized number of cointegration vector; T indicates the number of sample; selection of optimal lag period refers to SBC.

4.4 Estimation of Error Correction Model (ECM)

According to the result of Johansen cointegration test, cointegration exists between RMB and TWD. It is suggested signature of the *Memorandum on Cross-strait Currency Clearing Cooperation* and implementation of the "Cross-Strait Currency Clearing Mechanism" enhance cointegration and synergistic fluctuation in exchange rate between two currencies. It is also indicated that Error Correction Model (ECM) must be used to test long/short-term interactions of two exchange rates in three periods. As to ECM for two exchange rates, variables with independent variables lagging 2 periods at most are applied to ECM to observe the influence of lag of independent variable on two exchange rates and its significance.

Table 4 (1) to Table 4 (3) found the ECM coefficients of two exchange rates in three periods are of long term causality relationship. In addition, from the first period to the third period, significance of error correction coefficient in EMC model for two exchange rates is intensifying, same as cointegration.

To observe short interaction between two exchange rates in Table 4 (1), on the other hand, the exchange rate of TWD with one period lag (ΔNTD_{t-1}) has outstandingly negative effect (-0.0677) at a significant level of 10 % on current exchange rate of RMB (ΔRMB_t). However, TWD with two period lag (ΔNTD_{t-2}) shows no remarkable influence. RMB with one period lag (ΔNTD_{t-1}) has notably positive effect (0.0068) at a significant level of 10 %

on current exchange rate of TWD (ΔNTD_t), but RMB with two period lag (ΔNTD_{t-2}) has no remarkable influence.

TWD with one and two period lag in Table 4 (2) has outstandingly negative effect (-0.0160 and -0.2987) at a significant level of 5 % on current exchange rate of RMB. RMB with one and two period lag has remarkably positive effect (0.0021 and 0.0734) at a significant level of 5 % on current exchange rate of TWD.

It is known from Table 4 (3) that after official implementation of the Cross-Strait Currency Clearing Mechanism, the exchange rate of TWD with one and two period lag shows notably positive influence (0.0379) at a significant level of 1% and remarkably negative effect (-0.5062) at a significant level of 5 % on current exchange rate of RMB separately. On the other hand, the exchange rate of RMB with one and two period lag has remarkably negative effect (-0.0031) at a significant level of 1% and outstandingly positive influence (0.0179) at a significant level of 5 % on current exchange rate of TWD separately.

It is also discovered from the above result that, with signature of the *Memorandum on Cross-strait Currency Clearing Cooperation* and implementation of the "Cross-Strait Currency Clearing Mechanism", from the first period to the third period, the short interaction between exchange rates of RMB and TWD has been progressively intensified, similar to cointegration and long-term causality relationship between the two currencies. The outcome reveals again that signature of the *Memorandum on Cross-strait Currency Clearing Cooperation* and implementation of the "Cross-Strait Currency Clearing Mechanism" absolutely increase synergistic fluctuation of the cross-Strait exchange rates.

Table 4. Estimation of error correction model

Empirical models:	$RMB_t = f(RMB_{t-1}, NTD_{t-1})$ ΔRMB_t	$NTD_t = f(RMB_{t-1}, NTD_{t-1})$ ΔNTD_t
(1) 2012, 5, 1 ~ 2012, 8, 31		
cons tan*t*	-0.1123	0.0803
	-0.591	-0.317
error correction term	0.0051*	0.0012**
	-0.071	-0.048
ΔRMB_{t-1}	0.0617**	0.0068*
	-0.011	-0.085
ΔRMB_{t-2}	0.0130**	0.0036
	-0.049	-0.191
ΔNTD_{t-1}	-0.0677*	0.1994***
	-0.063	-0.003
ΔNTD_{t-2}	0.1597	0.0636**
	-0.206	-0.022
(2) 2012, 9, 1 ~ 2012, 12, 11		
cons tan*t*	0.0625	0.0026
	-0.573	-0.718
error correction term	0.1263**	0.0066**
	-0.027	-0.011
ΔRMB_{t-1}	0.1283***	0.0021**
	-0.006	-0.022
ΔRMB_{t-2}	-0.2046*	0.0734*
	-0.053	-0.056
ΔNTD_{t-1}	-0.0160**	0.2527***
	-0.016	-0.002
ΔNTD_{t-2}	-0.2987**	0.0953***
	-0.023	-0.014
(3) 2012, 12, 12 ~ 2013, 4, 30		
cons tan*t*	-0.1123	0.0701
	-0.253	-0.334
error correction term	0.0043***	0.0012***
	-0.003	-0.008
ΔRMB_{t-1}	0.1083***	-0.0031***

	-0.008	-0.008
ΔRMB_{t-2}	0.0875**	0.0179**
	-0.016	-0.021
ΔNTD_{t-1}	0.0379***	-0.4332***
	-0.006	-0.007
ΔNTD_{t-2}	-0.5062**	0.0999**
	-0.011	-0.019

Note. *, **, *** indicate separately rejection of null hypotheses at significant levels of 10%, 5% and 1%; the value within ( ) is p value.

4.5 Granger Causality Test

Error Correction Model is then used to test the lead-lag relationship between the exchange rates of RMB and TWD in three periods (Granger Causality Test). It is found from Table 4 (1) to Table 4 (3) that variables of two exchange rates in three periods significantly show two-way causality or two-way causal feedback has been gradually intensified, similar to cointegration, long-term causality and short-term interaction. The outcome proves again that signature of the *Memorandum on Cross-strait Currency Clearing Cooperation* and implementation of the "Cross-Strait Currency Clearing Mechanism" surely increase synergistic fluctuation of the cross-Strait exchange rates. Table 5 and 6 have short-term lead-lag causality for two exchange rates in three periods.

Table 5. Granger causality test

Null Hypothesis	F-Statistic	p-value	Existence of causality
(1) 2012, 5, 1 ~ 2012, 8, 31			
TWD does not lead RMB	2.70162*	0.074	Yes
RMB does not lead TWD	3.26512*	0.057	Yes
(2) 2012, 9, 1 ~ 2012, 12, 11			
TWD does not lead RMB	3.44300**	0.022	Yes
RMB does not lead TWD	5.75411**	0.016	Yes
(3) 2012, 12, 12 ~ 2013, 4, 30			
TWD does not lead RMB	6.11326***	0.009	Yes
RMB does not lead TWD	6.56121***	0.007	Yes

Note. *, **, *** indicate separately rejection of null hypotheses at significant levels of 10%, 5% and 1%.

Table 6. Granger causality

(1) 2012, 5, 1 ~ 2012, 8, 31	TWD ＝＞ RMB
	RMB ＝＞ TWD
(2) 2012, 9, 1 ~ 2012, 12, 11	TWD ＝＞ RMB
	RMB ＝＞ TWD
(3) 2012, 12, 12 ~ 2013, 4, 30	TWD ＝＞ RMB
	RMB ＝＞ TWD

Note. Symbol "≠＞" means "Granger causality does not exist"; symbol "＝＞" indicates "Granger causality exists".

5. Conclusion and Suggestion to Policy

Signature of the *Memorandum on Cross-strait Currency Clearing Cooperation* and implementation of the "Cross-Strait Currency Clearing Mechanism" are investigated through methods such as Johansen cointegration test, Error Correction Model (ECM) and Granger causality test. It is found through empirical study that cointegration between the exchange rate of RMB and TWD is significantly enhanced, and proved that long/short-term synergistic fluctuation and causality between the exchange rates on both sides are increased. According to the above empirical result, it is suggested that Taiwan authority, Taiwanese corporations, the financial industry and people appropriate adjust to currency transaction, reserve and distribution in the future. Our suggestion is as below:

(1) Increase RMB assets for foreign exchange reserve in Taiwan to decrease the risk of exchange rate fluctuationTaiwan has up to USD 406.6 billion of foreign exchange reserve, but over 50% of the asset allocation

are U.S. Treasury Bond. When the exchange rate of USD greatly fluctuates, foreign exchange reserve is likely to be affected. The Central Bank of the Republic of China (Taiwan) shall increase the allocation of RMB to foreign exchange reserve to diversify the risk of centering on USD. (2) TWD shall gradually increase the weight of RMB with reference to basket of currencies to lower exchange rate fluctuationThe weight of RMB shall be added to the basket of currencies that TWD index keeps a close watch on to lower the risk of exchange rate fluctuation. This not only prevents export-oriented companies in Taiwan from deterioration in export competitiveness, but assists Taiwanese corporations in exchange rate hedge to increase Taiwan's export order. (3) The cross-Strait trade is directly settled in RMB to decrease the risk of exchange rate. The cross-Strait trade relations become closer after the launching of the currency clearing. In terms of business, trade, investment and even fund dealings, trade settlement in RMB instead of USD or a currency in a third place saves considerable costs of exchange and transaction, enhances synergistic fluctuation and efficiency of the exchange rate between the cross-Strait currencies, and strengthens the status of RMB in international payment.(4) Financial industry increases financial commodity and strives for development of offshore renminbi center in Taiwan. An official start of RMB remittance business in Taiwan is of different meaning for Taiwan. For Taiwanese who share the same language and race with China, using RMB is absolutely not a tool only which involves friendliness as well. This is why people and companies are glad to have deposit, trade settlement and remittance in RMB since RMB related business began in early 2013 in Taiwan.

With enlarging RMB pool, the financial industry can keep developing all sorts of financial commodities relative to RMB that help Taiwan financial industry make good use of TWD deposit. As dynamic relationship between TWD and RMB is strengthened, Taiwan financial industry actively develops financial commodities estimated in RMB that raises asset value reserve of investors, increases the opportunity of being an offshore renminbi center that Taiwan actively strives for after Hong Kong, and facilitates internationalization of RMB.

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