The dynamic relationship among NTD/WON exchange rates and the stock prices of Taiwan and Korea

Chien-Hsiu Lin[1], Shinn-Juh Lin[2]

Abstract

This paper investigates the dynamic short-term causal relations and the long-term equilibrium relations with regards to the NTD/WON exchange rate and the stock prices of Taiwan and Korea, which are two important emerging markets in the Asia-Pacific region that have traditionally economic competitors. We specifically include the 1997 Asian financial crisis in our sample, so as to examine how the short-term and long-term relations change after such an event. To do so, we adopt the autoregressive distributed lag (ARDL) model proposed by Pesaran et al. (2001), which allows us to deal with structural breaks easily, and to handle data that have integration of different orders. Our empirical results suggest that the stock price of Korea has had a positive significant impact on the NTD/WON exchange rate; whilst the NTD/WON exchange rate has had a negative significant effect on the stock price of Korea, for the post-crisis period. This implies that after the 1997 Asian financial crisis, the NTD/WON exchange rate became more important in explaining the stock price of Korea, and that the Korean government implemented a currency depreciation strategy to boost its stock market.

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[1] Corresponding author. Department of Money and Banking, National Chengchi University, No. 64, Sec. 2 Zhinan Rd., Wenshan District, Taipei 11605, Taiwan. Email address: clin@nccu.edu.tw

[2] Department of International Business, National Chengchi University, Taipei, Taiwan

1. Introduction

The relationship between stock prices and exchange rates has received a considerable amount of attention from: economists, international investors and policy makers. Theoretically, we can summarize the dynamic relationship between stock prices and exchange rates in the following two forms. The "flow-oriented" models of exchange rates, proposed by Dornbusch and Fischer (1980), focus on the current account balance or the trade balance. These models state that changes in exchange rates affect international competitiveness and thus influence real income and output. Since stock prices can be interpreted as the present value of future cash flows of firms, they react to exchange rate changes. The "stock-oriented" models of exchange rates, proposed by Branson (1993) and Frankel (1983), on the other hand, posit that innovations in the stock market affect aggregate demand through wealth and liquidity effects, thereby influencing money demand (Gavin, 1989.) For example, a decrease in stock prices causes a reduction in the wealth of domestic investors, which in turn leads to a lower demand for money with ensuing lower interest rates. The lower interest rates discourage capital inflows, ceteris paribus, which in turn causes currency depreciation and therefore, exchange rate dynamics may be affected by stock price movements.

On the empirical front, most examinations of the relation between stock markets and foreign exchange markets have focused on the U.S. markets (see Jorion, 1990; Bahmani-Oskooee and Sohrabian, 1992; Amihud, 1993; Bartov and Badnar, 1994; Ajayi and Mougoue,1996, to name a few.) Similar tests have also been performed by Bondnar and Gentry (1993) in relation to the Japanese and Canadian markets. However, for the emerging markets scant literature is available. In this regard, Abdalla and Murinde (1997) showed that exchange rate changes lead stock prices in: India, South Korea, Pakistan and the Philippines, whereas Ajayi, Friedman and Mehdian (1998) found no consistent causal relations between the stock and currency markets in emerging economies. Pan, Fok and Liu (2007) examined dynamic linkages between exchange rates and stock prices for seven East Asian countries, including Hong Kong, Japan, Korea, Malaysia, Singapore, Taiwan and Thailand. They showed a significant causal relation form exchange rates to stock prices for Hong Kong, Japan, Malaysia, and Thailand before the 1997 Asian financial crisis, and a causal relation from the equity market to the foreign exchange market for Hong Kong, Korea and Singapore. Further, while no country shows a significant causality form stock prices to exchange rates during the Asian crisis, a causal relation from exchange rates to stock prices is found for all countries except Malaysia.

This paper complements the empirical literature by studying two important emerging markets in the Asia-Pacific region, namely Taiwan and South Korea. These two countries are traditionally economic competitors, and they share great similarities in their economic developments, not only in terms of industrial structures, but also in terms of their increasing reliance on international trade. Although Taiwan is only the sixth biggest trading partner for Korea, and Korea is the fifth largest trading partner for Taiwan, they are each other’s biggest trading competitors in their major industries, such as the: information, communication and technology sectors. Furthermore, the governments of these two countries have been closely monitoring each other’s currency value to determine whether devaluation is needed, so as to maintain or increase their export competitiveness. It is therefore of great interest to examine the dynamic linkages regarding the New Taiwan Dollar (NTD) and the Korean WON (WON) exchange rate and the stock prices of both Taiwan and South Korea.

More specifically, the main purpose of our study is to investigate fully the dynamic short-term causal relations and the long-term equilibrium relations among NTD/WON exchange rate and the stock prices of Taiwan and Korea for the period from January 1988 to September 2009, covering major industrial restructuring in Korea and Taiwan, as well as the 1997 Asian financial crisis. When undertaking this kind of endeavor, researchers typically require sufficiently long time-series data to obtain robust results. However, one potential problem with long period data sets is that one will get caught up with structural breaks in the observed data. For example, during the sample period that we studied, the 1997 Asian financial crisis had a profound impact on currency valuation (see Erb, Harvey and Viskanta, 1998) and consequently it may well have altered the stock price-exchange rate relations. An ensuing technical problem is that the structural break problem is often empirically indistinguishable from the unit root problem, when applying traditional unit root tests, such as the augmented Dickey-Fuller test. All these problems in the data render traditional econometric techniques, such as the VAR or the co-integration treatments as inapplicable for addressing the proposed research. Therefore, one needs to consider different modeling strategies and thus we adopt the autoregressive distributed lag (ARDL) model, or bounds testing approach, proposed by Pesaran et al. (2001). Two major advantages of the ARDL approach are that it allows us to deal with structural breaks easily, and it can deal with data that have integration of different orders.

**Our empirical results show that for the full sample period, the stock price of Korea has had a positive significant impact on the NTD/WON exchange rate, thereby confirming the validity of the “stock-oriented” model for the full sample period. We then divide the full sample into the pre-crisis (before the 1997) and the post-crisis (after the 1997) periods. We find that during the latter period the NTD/WON exchange rate has had a negative significant impact on the stock price of Korea, indicating that after the 1997 financial crisis, the currency depreciation strategy implemented by the Korean government boosted their nation's economic growth, which led to a prosperous stock market. However, we cannot observe the same for Taiwan, which implies that the Taiwanese government did not use a currency depreciation strategy to maintain its export competitiveness.

The rest of this paper is organized as follows. Section 2 explains the econometric methodology, whereas the empirical results are presented in section 3 and section 4 contains the conclusion.

2. Methodology

2.1 The ARDL Model

In order to examine the dynamic linkage among the NTD/WON exchange rate and the stock prices of Taiwan and Korea, we adopt the autoregressive distributed lag model (ARDL), which is summarized in this section. Suppose an explanatory variable, which is stationary at level, known as I(0), is regressed with another variable, which is nonstationary at level, but is stationary at first-difference, known as I(1), then this will yield a spurious regression, and thereby give a misleading and unreliable conclusion. Therefore, one needs to consider different modeling strategies so as to resolve the order of integration issue for the series and the autoregressive distributed lag (ARDL) model, or bounds testing approach, proposed by Pesaran et al. (2001) is employed, because is able to provide a solution to this problem. That is, the bounds test allows a mixture of I(1) and I(0) variables as regressors, and in other words the order of integration of the relevant variables does not necessarily have to be the same.

To derive our preferred model, we follow the assumptions made by Pesaran et al. (2001) in Case V, that is, unrestricted intercepts and unrestricted trends, so as to be able to write down the model as a general vector autoregressive (VAR) model of order p, in z_t:

$$z_t = \beta + ct + \sum_{i=1}^{p} \phi_i z_{t-i} + \varepsilon_t, t = 1,2,3,...,T \qquad (1)$$

with β representing a (k+1) vector of intercepts (drift) and c denoting a (k+1) vector of trend coefficients. Pesaran et al. (2001) further derived the following vector equilibrium correction model (VECM) corresponding to (1):

$$\Delta z_t = \beta + ct + \Pi z_{t-1} + \sum_{i=1}^{p} \Gamma_i \Delta z_{t-i} + \varepsilon_t, t = 1,2.....,T \qquad (2)$$

where the $(k+1)\times(k+1)$ matrices $\Pi = I_{k+1} + \sum_{i=1}^{p} \Psi_i$ and $\Gamma_i = -\sum_{j=i+1}^{p} \Psi_j, i = 1,2,....,p-1$ contain the long-run multipliers and short-run dynamic coefficients of the VECM. z_t is the vector of variables y_t and x_t respectively.

For the “flow-oriented” model, y_t is an I(1) dependent variable defined as EX_t, the NTD/WON exchange rate; and $x_t = [P_{KRt}, P_{TWt}]$, the stock prices of Korea and Taiwan, is a vector matrix from mixing I(0) and I(1) regressors as already defined with a multivariate identically and independently distributed (i.i.d) zero mean error vector $\varepsilon_t = (\varepsilon_{1t}, \varepsilon'_{2t})'$, and a homoskedastic process. Further, assuming that a unique long-run relationship exists among the variables, the conditional VECM (2) now becomes:

$$\Delta y_t = \beta_{y0} + ct + \delta_{yy} y_{t-1} + \delta_{xx} x_{t-1} + \sum_{i=1}^{p-1} \lambda_i \Delta y_{t-i} + \sum_{i=0}^{p-1} \xi_i \Delta x_{t-i} + \varepsilon_{yt}, t = 1,2,...,T \qquad (3)$$

On the basis of equation (3), the conditional VECM of “stock-oriented” model can be specified as:

$$\Delta EX_t = \beta_0 + c_1 t + \delta_1 EX_{t-1} + \delta_2 P_{KRi,t-1} + \delta_3 P_{TWi,t-1} + \sum_{i=1}^{p} \lambda_i \Delta EX_{t-i} + \sum_{i=0}^{q} \xi_i \Delta P_{KRi,t-i} + \sum_{j=0}^{q} \xi_j \Delta P_{TWi,t-j} + \varepsilon_{EXt}$$

(4)

And the conditional VECM of “flow-oriented” model can be specified as:

$$\Delta P_{KRi,t} = \beta_7 + c_2 t + \delta_4 P_{KRi,t-1} + \delta_5 EX_{t-1} + \delta_6 P_{TWi,t-1} + \sum_{i=0}^{q} \xi_i \Delta EX_{t-i} + \sum_{i=1}^{p} \lambda_i \Delta P_{KRi,t-i} + \sum_{j=0}^{q} \xi_j \Delta P_{TWi,t-j} + \varepsilon_{KRt}$$

(5)

$$\Delta P_{TWi,t} = \beta_{14} + c_3 t + \delta_7 P_{TWi,t-1} + \delta_8 EX_{t-1} + \delta_9 P_{KRi,t-1} + \sum_{i=0}^{q} \xi_i \Delta EX_{t-i} + \sum_{j=0}^{q} \xi_j \Delta P_{KRi,t-j} + \sum_{i=1}^{p} \lambda_i \Delta P_{TWi,t-i} + \varepsilon_{TWt}$$

(6)

where δ_i are the long-run multipliers, β_i are the drifts and ε_t are white noise errors.

Bounds testing procedure

The first step in the ARDL bounds testing approach is to estimate equations (4), (5) and (6) by ordinary least squares (OLS), in order to test for the existence of a long-run relationship among the variables. This is achieved by conducting an F-test for the joint significance of the coefficients of the lagged levels of the variables, i.e., $H_0 : \delta_1 = \delta_2 = \delta_3 = 0$ against the alternative $H_A : \delta_1 \neq \delta_2 \neq \delta_3 \neq 0$. We denote the test which normalize on EX by $F_{EX}\left(EX \mid P_{KR}, P_{TW}\right)$. Two asymptotic critical values bounds provide a test for cointegration when the independent variables are I(d) (where $0 \le d \le 1)$: a lower value assuming the regressors are I(0) and an upper value assuming purely I(1) regressors. If the F-statistic is above the upper critical value, the null hypothesis of no long-run relationship can be rejected irrespective of the orders of integration for the time series. Conversely, if the test statistic falls below the lower critical value, the null hypothesis cannot be rejected. Finally, if the statistic falls between the lower and upper critical values, the result is inconclusive. The computed F-statistic value is compared with the critical values tabulated in table CI(v) of Pesaran et al. (2001).

In the second step, once cointegration is established, the conditional ARDL (p1, q1, r1) long-run model for EX_t can be estimated as:

$$EX_t = \beta_0 + c_1 t + \sum_{i=1}^{p1} \delta_1 EX_{t-i} + \sum_{i=0}^{q_1} \delta_2 P_{KR\,t-1} + \sum_{i=0}^{r1} \delta_3 P_{TWt-1} + \varepsilon_{EXt} \dots \tag{7}$$

The structural lags of the ARDL(p1,q1,r1) are determined by using minimum Schwarz Bayesian Criterion (SBC). In the final step, we obtain the short-run dynamic parameters by estimating an error correction model associated with the long-run estimates, which is specified as follows:

$$\Delta EX_t = \mu + \sum_{i=1}^{p} \lambda_i \Delta EX_{t-i} + \sum_{i=0}^{q} \xi_i \Delta P_{KR\,t-i} + \sum_{j=0}^{q} \xi_j \Delta P_{TWt-j} + \upsilon ecm_{t-1} + \varepsilon_{EXt} \tag{8}$$

Here λ, ξ are the short-run dynamic coefficients of the model's convergence to equilibrium and υ is the speed of adjustment.

2.2 Unit Root Tests

Before we proceed with the ARDL bounds test, we test for stationarity status for all variables so as to determine their order of integration. This is to ensure that the variables are not I(2) stationary and hence avoid spurious results. In this regard, according to Ouattara (2004), in the presence of I(2) variables the computed F-statistics provided by Pesaran (2001) are not valid, because the bounds test is based on the assumption that the variables are I(0) or I(1). Therefore, the implementation of unit root tests in the ARDL procedure might still be necessary in order to ensure that none of the variables is integrated of order 2 or beyond. In this study, we apply two kinds of unit root tests, an ADF test without considering structural breaks and an LM unit root test with structural breaks.

2.2.1 Unit root test without structural break

The unit root test without structural break we use in this study is the familiar augmented Dickey and Fuller (ADF, 1979, 1981) test. The two differencing AR models of ADF can be expressed as having the following forms:

$$\Delta y_t = c + \alpha y_{t-1} + \sum_{i=1}^{p-1} \beta_i \Delta y_{t-i} + \varepsilon_t \tag{9}$$

$$\Delta y_t = c + \alpha y_{t-1} + \delta t + \sum_{i=1}^{p-1} \beta_i \Delta y_{t-i} + \varepsilon_t \tag{10}$$

Model (9) is a model with a constant, whilst model (10) represents a model with both a constant and a trend. The null hypothesis for the ADF test is $H_0 : \alpha = 0$, with the alternative $H_A : -2 < \alpha < 0$. We select the lag length k using the Schwarz Info Criterion.

2.2.2 LM unit root test with structural breaks

A key limitation of the ADF type models is that they do not allow researchers to model the impact of structural changes in the economy. Perron (1989) showed that the ability to reject a unit root decreases when the stationary alternative is true and an existing structural break is ignored. He used a modified Dickey-Fuller unit root test that included dummy variables to allow for one known, or exogenous, structural break. Subsequent papers modified the test to allow for one unknown breakpoint that is determined endogenously from the data. One widely used endogenous procedure is the minimum test of Zivot and Andrews (1992), which selects the breakpoint where the t-statistic testing the null of a unit root is the most negative. Lumsdaine and Papell (1997) continued in this direction and extended the unit root test to include two structural breaks. Both endogenous break tests assume no break under the null. Thus, the alternative hypothesis would include the possibility of a unit root with break(s). Therefore, rejection of the null does not necessarily imply rejection of a unit root per se, but would imply rejection of a unit root without breaks. In the presence of a break under the null, researchers might incorrectly conclude that rejection of the null indicates evidence of a trend-stationary time series with breaks, when in fact the series is difference-stationary with breaks. Nunes, Newbold, and Kuan (1997) and Lee and Strazicich (2001) provided evidence that assuming no break under the null in endogenous break tests causes the test statistic to diverge and leads to significant rejections of the unit root null, when the data-generating process is a unit root with break(s). As a result, we apply the Lee and Strazichch (2003) two-break LM unit root test.

The LM unit root test can be explained using the following data generating process:

$$y_t = \delta' Z_t + X_t, \qquad X_t = \beta X_{t-1} + \varepsilon_t \tag{11}$$

Here, y is a vector containing the NTD/WON exchange rate, and the stock prices of Taiwan and Korea. Z_t consists of exogenous variables and ε_t is an error term that follows the classical properties. Two structural breaks can be considered as follows. Model A allows for two shifts in level and is described by $Z_t = [1, t, D_{1t}, D_{2t}]'$, where $D_{jt} = 1$ for $t \geq T_{Bj} + 1, j = 1,2,$ and 0 otherwise. T_{Bj} denotes the time period when a break occurs. Model C includes two changes in level and trend and is described by $Z_t = [1, t, D_{1t}, D_{2t}, DT_{1t}, DT_{2t}]'$, where $DT_{jt} = t - T_{Bj}$ for $t \geq T_{Bj} + 1, j = 1,2,$ and 0 otherwise. Lee and Strazicich (2003) used the following regression to obtain the LM unit root test statistic:

$$\Delta y_t = \delta' \Delta Z_t + \phi \overline{S}_{t-1} + \mu_t \qquad (12)$$

where $\overline{S}_t = y_t - \hat{\psi}_x - Z_t \hat{\delta}_t$, t=2,…..,T; $\hat{\delta}$ are coefficients in the regression of Δy_t on ΔZ_t; $\hat{\psi}_x$ is given by $y_t - Z_t \hat{\delta}$; and y_1 and Z_1 represent the first observations of y_t and Z_t respectively. The LM test statistic is given by: $\overline{\tau}$ =t-statistic for testing the unit root null hypothesis that $\phi = 0$. The location of the structural break (T_B) is determined by selecting all possible break points for the minimum t-statistic as follows:

$$Inf\tilde{\tau}\left(\overline{\lambda_i}\right) = \underset{\lambda}{Inf}\ \tilde{\tau}\left(\lambda\right), \qquad \text{where } \lambda = \frac{TB}{T}$$

The search is carried out over the trimming region (0.15T, 0.85T), where T is the sample size. Critical values for the two-break models A and C are tabulated in Lee and Strazicich (2003).

3. Empirical Results

3.1 Data

This research is conducted using the NTD/WON exchange rate, the closing Taiwanese Stock Exchange Weighted-price index and the Korea Stock Exchange Composite. Data are collected from the Global Financial Database. The sample period covers from January 1988 to August 2009 and a total of 260 monthly observations are obtained for each variable. The stock price for Taiwan and Korea are taken in logarithmic form times by 100, so as to smooth the time series. Table 1 shows the summary statistics and figure 1 the graphs of the NTD/WON exchange rate and the stock price for both Taiwan and Korea.

[Insert Table 1]

[Insert Figure 1]

3.2 ADF test Results

Table 2 reports the ADF unit root test results for models that include only an intercept, and those containing both an intercept and a trend. According to these results, only the stock price of Taiwan is stationary: the null hypothesis of a unit root is rejected at the 5% level. From the ADF test results, the order of integration for NTD/WON, and the stock prices of Taiwan and Korea are I(1), I(0) and I(1), respectively.

[Insert Table 2]

3.3 LM structural break test results

Table 3 shows the results for the unit root test based on the LM two-structural break procedure. In the Model A, which allows for two shifts in level, the results of the LM test lead to the rejection of the unit root null at the 5% significance level for the NTD/WON exchange rate, but the unit root null for the stock price of Korea and Taiwan cannot be rejected. Therefore, the determination of the order of integration for the NTD/WON, and the stock prices of Taiwan and Korea in Model A are I(0), I(1) and I(1), respectively. For Model C, which includes two changes in level and trend, the outcomes from the LM test allow for the rejection of the unit root null in NTD/WON, and the stock prices of Taiwan and Korea at the 1% level. As a result, the determination of the order of integration for NTD/WON, and the stock prices of Taiwan and Korea in Model C are all stationary.

[Insert Table 3]

3.4 Bounds test for cointegration

In the first step of the ARDL analysis, we test for the presence of long-run relationships in equations (4), (5) and (6) and we use the SBC to select the structural lags for the ARDL-VECM. Following the procedure in Pesaran (1997), we first estimate an OLS regression for the first differences part of equations (4), (5) and (6) and then test for the joint significance of the parameters of the lagged level variables when added to the first regression. The computed F-statistics test the joint null hypothesis that the coefficients of the lagged level variables are zero, i.e. no long-run relationship exists between them. As the 1997 Asian financial crisis is considered as a structural break that may alter the long-run relationship between exchange rate and stock price, we divide the whole sample into two subsamples. One is from January 1988 to June 1997 (pre-crisis period) and the other is from July 1997 to September

2009 (post-crisis period), to test if the long-run relationship among the variables changes due to the financial crisis. Table 4 reports the results of the calculated F-statistics when each variable is considered as a dependent variable (normalized) in the ARDL-OLS regressions.

[Insert Table 4]

The computed F-statistic $F_{EX}\left(EX \mid P_{KR}, P_{TW}\right)$=5.9919 is higher than the upper bound critical value 5.85 at the 5% level. And $F_{P_{KR}}\left(P_{KR} \mid EX, P_{TW}; post-crisis\right)$=9.2329 is also higher than the upper bound critical value 5.85 at the 5% level. Thus, the null hypotheses of no cointegration are rejected, implying long-run cointegration relationships amongst the variables when the regressions are normalized on EX_t for the whole sample and on P_{KRt} for the post-crisis period. Therefore, based on the "stock-oriented" model, we use EX_t as the dependent variable for the whole sample, while using P_{KRt} as the dependent variable for the post-crisis period according to the "flow-oriented" model.

3.5 ARDL model results for the whole sample

Once we establish that a long-run cointegration relationship exists, equation (7) is estimated using the following ARDL (1, 0, 0) specification. The results obtained by normalizing on the NTD/WON exchange rate $\left(EX_t\right)$, in the long run are reported in Table 5.

[Insert Table 5]

The estimated coefficients of the long-run relationship show that the stock price of Korea has had a positive significant impact on the NTD/WON exchange rate. A 1% increase in stock price of Korea has resulted in about 0.1082E-3% appreciation of the WON against the NTD and this is consistent with the argument suggested by “stock oriented” model. That is, an increase in stock prices causes a growth in wealth of domestic investors, which in turn leads to higher demand for money with ensuring higher interest rates. The higher interest rates encourage capital inflows, which in turn is the cause of currency appreciation. Table 5 also shows that the stock price of Taiwan in period of interest has been insignificantly negatively correlated with the NTD/WON exchange rate.

The results of the short-run dynamic coefficients associated with the long-run relationships obtained from the equation (8) are given in table 6. The signs of the short-run dynamic impacts are maintained to the long-run. However, the stock price of Taiwan is only significant at 18.3% t-probability. The equilibrium correction coefficient (ecm), estimated -.3023E-5 is highly significant, has the correct sign and implies that there has been a fairly rapid of adjustment back to equilibrium after a shock.

From the findings of the long-run relationship and the short-run causality, we conclude that the hypothesis of “stock oriented” model is valid in the Korean case, as there appears to have been a positive relationship and short-run causality running from the stock price of Korea to the NTD/WON exchange rate. However, it looks as though the “stock-oriented” model cannot be applied to Taiwan, because we cannot observe, either a statistically significant long-run or a short-run relationship between the stock price of Taiwan and the NTD/WON exchange rate.

[Insert Table 6]

3.6 The ARDL model results for the post-crisis period

According to the “flow-oriented” model, we estimate the long-run cointegration relationship among variables using the ARDL (1, 10, 2) specification. The results obtained by normalizing on the stock price of Korea, P_{KRt} , in the long run, are reported in table 7.

[Insert Table 7]

The estimated coefficients of the long-run relationship show that the NTD/WON exchange rate has had a negative significant effect on the stock price of Korea, with the estimated elasticity being -4398. This shows that a 1% depreciation of WON against NTD has resulted in a 4398% increase in the stock price of Korea, which is indicative of the currency depreciation strategy carried out by Korea. To compete with Taiwanese exporters, Korea could devaluate its currency against the NTD so as to strengthen its international competitiveness, thus promoting real income and stock price. And the stock price of Taiwan has been significantly positively correlated with the stock price of Korea This can be due to the influence of the common global macroeconomic factor on both countries' stock markets.

The results of dynamic short-run causality among the relevant variables are shown in table 8. We find that the NTD/WON exchange rate of the past 1, 7, 8 and 10 periods are statistically significant to have negatively Granger-caused the stock price of Korea. However, the NTD/WON exchange rate of current, past 3 and 9 periods are statistically significant in terms of having positively Granger-caused the stock price of Korea. The equilibrium correction coefficient (ecm), estimated at -0.17535, is highly significant, has the correct sign and implies a fairly rapid adjustment to equilibrium after a shock. Moreover, approximately 17.5% of disequilibria from the previous year's shock converge back to the long-run equilibrium in the current year.

[Insert Table 8]

4. Conclusion

This study has employed the bounds testing (ARDL) approach to cointegration to examine the long-run and short-run relationships among the NTD/WON exchange rate and the stock prices of Taiwan and Korea, which are two important emerging markets in the Asia-Pacific region, and are traditionally economic competitors. We specifically included the 1997 Asian financial crisis in our sample to examine how the short-term and long-term relations changed with financial crisis. The bounds test suggested that there existed long-run cointegration relationships amongst the variables when the regressions were normalized on the NTD/WON exchange rate for the whole sample and on the stock price of Korea for the post-crisis period.

Our empirical results suggest that the stock price of Korea has had a positive significant impact on the NTD/WON exchange rate; whilst the NTD/WON exchange rate has had a negative significant impact on the stock price of Korea for the post-crisis period. The result suggests that an increase in stock price in Korea causes a growth in wealth of Korean investors, which in turn leads to a higher demand for money, thereby ensuring higher interest rates and these higher interest rates encourage capital inflows, which in turn result in the WON's appreciation. The results for the post-crisis period imply that, after the 1997 Asian financial crisis, the NTD/WON exchange rate became more important in explaining the stock price of Korea, and suggest that the Korean government implemented a currency depreciation strategy to boost its stock market.

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Table 1: Summary statistics for the NTD/WON exchange rate, and the stock price for both Taiwan and Korea

	NTD/WON exchange rate	The stock price of Korea	The stock price of Taiwan
Mean	0.0318	5.2111	5.5289
Median	0.0322	5.1311	5.5559
Std. Dev.	0.0045	0.4831	0.2841
Skewness	-0.0019	0.4408	-0.3241
Kurtosis	2.3907	2.5045	2.6600

Table 2: ADF test results

	α	δ	k	probabilities
NTD/WON	-0.0226	----	0	0.4230
[C]	[-1.6963]*			
NTD/WON	-0.0343	-1.23E-06	0	0.5362
[C, T]	[-2.1121]**	[-1.2570]		
Stock price of	-0.0789	----	0	0.0070
Taiwan [C]	[-3.5699]***			
Stock price of	-0.0825	8.59E-05	1	0.0330
Taiwan [C, T]	[-3.5857]***	[0.2637]		
Stock price of	-0.0130	----	0	0.7201
Korea [C]	[-1.0906]			
Stock price of	-0.0430	0.0003	0	0.4008
Korea [C, T]	[-2.3580]**	[2.1605]**		

Note: α is the coefficient on the one-period lagged variable, while δ is the coefficient on the time trend. [C] represents a model with a constant, while [C, T] represents a model with both a constant and a trend. k is the optimal lag length selected using the Schwarz Info Criterion.

*, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Table 4: Bounds test for cointegration analysis

Dep. Var.	**F-statistic**	**Outcome**
$F_{EX}\left(EX \mid P_{KR}, P_{TW}\right)$	5.9919	Cointegration
$F_{P_{KR}}\left(P_{KR} \mid EX, P_{TW}\right)$	4.2876	No cointegration
$F_{P_{TW}}\left(P_{TW} \mid EX, P_{KR}\right)$	3.2309	No cointegration
$F_{EX}\left(EX \mid P_{KR}, P_{TW}; pre-crisis\right)$	1.4569	No cointegration
$F_{EX}\left(EX \mid P_{KR}, P_{TW}; post-crisis\right)$	3.7969	No cointegration
$F_{P_{KR}}\left(P_{KR} \mid EX, P_{TW}; pre-crisis\right)$	1.6155	No cointegration
$F_{P_{KR}}\left(P_{KR} \mid EX, P_{TW}; post-crisis\right)$	9.2329	Cointegration
$F_{P_{TW}}\left(P_{TW} \mid EX, P_{KR}; pre-crisis\right)$	2.8731	No cointegration
$F_{P_{TW}}\left(P_{TW} \mid EX, P_{KR}; post-crisis\right)$	2.2931	No cointegration

Notes: Critical values are cited from Pesaran et al. (2001), Table CI(v), Case V: Unrestricted intercept and unrestricted trend. Lower bound I(0)=4.87 and upper bound I(1)=5.85 at the 5% significance level.

Table 5: Estimated long run coefficients by normalizing on the NTD/WON exchange rate using the ARDL approach

ARDL (1, 0, 0) selected based on SBC. Dependent variable is EX_t **.**

Regressor	Coefficient	Standard Error	T-Ratio	T-Probability
C	-.4420E-4	.011639	-.0037971	.997
Trend	-.8182E-4	.1137E-4	-7.1958***	.000
P_{KRt}	.1082E-3	.1753E-4	6.1750***	.000
P_{TWt}	-.2609E-4	.1955E-4	-1.3342	.183

*** denotes a 1% significance level.

Table 6: Error correction representation by normalizing on the NTD/WON exchange rate for the selected ARDL model

ARDL (1, 0, 0) selected based on SBC. Dependent variable is EX_t **.**

Regressor	Coefficient	Standard Error	T-Ratio	T-Probability
C	-.5121E-5	.0013485	-.0037973	.997
Trend	-.9480E-5	.2244E-5	-4.2240***	.000
ΔP_{KRt}	.1254E-4	.2890E-5	4.3399***	.000
ΔP_{TWt}	-.3023E-5	.2264E-5	-1.3353	.183
ecm(-1)	-.3023E-5	.023885	-4.8508***	.000

ecm = EX_t -.1082E-3* P_{KRt} + .2609E-4* P_{TWt} + .4420E-4*C+ .8182E-4*Trend

R-Squared =.094576 R-Bar-Squared =.079672 F-stat. F(4, 243) =6.3456[.000]
S.E. of Regression =.9419E-3 RSS =.2156E-3 DW-statistic =1.9806
Akaike Info. Criterion =1373.6 Schwarz Bayesian Criterion =1364.8

Table 7: Estimated long run coefficients by normalizing on the stock price of Korea using the ARDL approach

ARDL (1, 10, 2) selected based on SBC. Dependent variable is P_{KRt} .

Regressor	Coefficient	Standard Error	T-Ratio	T-Probability
C	-26.7380	103.4051	-.25857	.796
Trend	1.4198	.13178	10.7746***	.000
EX_t	-4398.0	2034.1	-2.1621**	.032
P_{TWt}	.78436	.20499	3.8263***	.000

*** (**) denotes the 1% (5%) significance levels.

Table 8: Error correction representation by normalizing on the stock price of Korea for the selected ARDL model

ARDL (1, 10, 2) selected based on SBC. Dependent variable is P_{KRt} .

Regressor	Coefficient	Standard Error	T-Ratio	T-Probability
C	-4.6886	18.3468	-.25555	.799
Trend	.24897	.052352	4.7558***	.000
ΔEX_t	1111.3	498.8618	2.2277**	.028
ΔEX_{t-1}	-618.8378	529.6470	-1.1684	.245
ΔEX_{t-2}	-662.2493	534.8062	-1.2383	.218
ΔEX_{t-3}	1816.4	504.7787	3.5984***	.000
ΔEX_{t-4}	1226.0	507.9157	2.4137**	.017

ΔEX_{t-5}	1732.8	523.4676	3.3103***	.001
ΔEX_{t-6}	2567.4	516.2529	4.9732***	.000
ΔEX_{t-7}	1286.8	527.2792	2.4404**	.016
ΔEX_{t-8}	143.6071	536.3958	.26773	.789
ΔEX_{t-9}	2055.4	562.6576	3.6530***	.000
ΔP_{TWt}	.59188	.071297	8.3017***	.000
ΔP_{TWt-1}	.18127	.072669	2.4945**	.014
ecm(-1)	-.17535	.038993	-4.4971***	.000

ecm = P_{KRt} + 4398.0* EX_t -.78436* P_{TWt} + 26.7380*C -1.4198*Trend

R-Squared =.62534 R-Bar-Squared =.57887 F-stat. F(14, 131) =15.3793[.000]
S.E. of Regression =6.7133 RSS =5813.8 DW-statistic =1.9674
Akaike Info. Criterion =-493.1244 Schwarz Bayesian Criterion =-518.4851

Figure 1: Graphs showing the NTD/WON exchange rate and the stock price of both Korea and Taiwan, for the period January 1988 to August 2009