



Testing for cointegration with threshold effect between stock prices and exchange rates in Japan and Taiwan

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ABSTRACT

This paper empirically investigates the exchange rate effects of the New Taiwan dollar against the Japanese Yen (NTD/JPY) on stock prices in Japan and Taiwan from January 1991 to March 2008. Our study employs the newly threshold error-correction model (TECM) elaborated by Enders and Granger [Enders, W., Granger, C.W.F., 1998. Unit-root tests and asymmetric adjustment with an example using the term structure of interest rates. *Journal of Business Economics & Statistics* 16, 304–311] and Enders and Siklos [Enders, W., Siklos, P.L., 2001. Cointegration and threshold adjustment. *Journal of Business Economics & Statistics* 19, 166–176], assuming the nature of the relationship between the variables is on the basis of non-linearity. The empirical evidence suggests that there is a long-run equilibrium relationship between NTD/JPY and the stock prices of Japan and Taiwan during the time period investigated. However, an asymmetric threshold cointegration relationship only exists in Taiwan's financial market. Furthermore, we extend our research by taking into account the effect of the U.S. exchange rate specifically on Taiwan's financial market. This research also finds a long-term equilibrium and asymmetric causal relationships between NTD/USD and the stock prices of Taiwan. In addition, the results of TECM Granger-Causality tests show that no short-run causal relationship exists between the two financial assets considered for both countries' cases. However, in the long run a positive causal relationship running from either the Japan or U.S. exchange rate to the stock prices of Taiwan strongly argues for the traditional approach.

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1. Introduction and literature review

It is generally argued that the relationship between exchange rates and stock prices has important implications, especially from the viewpoint of recent large cross-border movement of funds and investments. There are two theories about the dynamic relationship between exchange rates and stock prices – the traditional and portfolio approaches – which have been discussed for a long time, yet have not resulted in any consensus. The traditional approach claims that a depreciation of the domestic currency makes local firms more competitive, leading to an increase in their exports and consequently higher stock prices. This implies a positive correlation between exchange rates (with an American quotation) and

stock prices.² The inference from the above traditional approach suggests that exchange rates lead stock prices.

The portfolio approach, on the contrary, argues that an increase in stock prices induces investors to demand more domestic assets and thereby causes an appreciation in the domestic currency, implying that stock prices lead exchange rates and they are negatively related.^{3,4} The “stock-oriented” model of exchange

² In addition, the theory of the “Uncovered Interest Rate Parity” (UIRP) suggests that the expectations of relative currency values influence the levels of domestic and foreign interest rates. This in turn affects costs of capital and thereby the profitability and price competitiveness of a firm, and consequently the present value (stock price) of a firm may vary.

³ The appreciation of the domestic currency attracts more foreign capital or investments into the domestic market, and this leads to further currency appreciation.

⁴ With a European quotation, the relationship between stock prices and exchange rates of the traditional or portfolio approach is just the reverse.

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rates by Branson (1983) specifies the exchange rate as serving to equate the supply and demand for assets such as stocks and bonds.

Whether empirically or theoretically, many economists have suggested a significant relationship between exchange rates and stock prices, but the results have been quite mixed for the sign and causal direction between exchange rates and stock prices.⁵ Mok (1993) found weak bi-directional causality between stock prices and exchange rates, while Bahmani-Oskooee and Sohrabian (1992) and Nieh and Lee (2001) argued for a bi-directional causality between stock prices and exchange rates in the short run, but not in the long run. In addition, there are some studies that have found very weak or zero association between stock prices and exchange rates (for instance, Franck and Young, 1972; Bartov and Bodnar, 1994; Fernandez, 2006).

There was a tremendous change in the exchange rate of the Japanese Yen (JPY) and the New Taiwan Dollar (NTD) against USD during the period of 1985–1988, which was primarily the consequence of the “Plaza-Louvre intervention accord”. The revaluation of NTD/USD since July 1986 has mainly showed a linked reaction of interference appreciation in JPY/USD since September 1985 as caused by the G-5 “Plaza intervention accord”. The Plaza-Louvre cooperation marked the new era of managing floating exchange rates.

Suggestions to build a Yen Bloc⁶ were first spurred in the early 1990s, in light of great changes in Asian economies. Foreign capital started to flow into the respective Asian countries at accelerating rates in the 1990s. The weight of exports to the United States in total Asian exports decreased significantly since the mid-1980s, as intra-regional trade increased rapidly. On the other hand, the economic influence of Japan in this region has expanded through its trades and investments in the region. Another important domestic factor considered which has contributed to the huge inflows of foreign capital is the far-reaching liberalization of Japan's financial market. Asia may need an international currency to reduce transaction costs and foreign exchange risks in its regional trades and investments, but it is better for the Japanese yen, rather than the US dollar, to fulfill this objective.

Taiwan is a country with a typical island-style economic system, which is highly open to international trade and investment. Thus, the volatility of NTD/JPY may affect both exporters and importers significantly in Taiwan. For an extended period of time, Taiwan experienced a widening trade gap (deficit) with Japan. The main explanation is likely that the majority of Taiwan imports from Japan are more capital-intensive and comparable expensive goods, while the majority of Taiwan exports to Japan are more labor-intensive and cheaper goods. This degenerating condition of a trade imbalance with Japan has remained unchanged so far. Additionally, as an export-oriented country, Taiwan depends heavily on electronics products exported to its major trading partners. Japan, like most of the other Asia-Pacific countries, is a main competitor to Taiwan. For the case when NTD/JPY appreciates, Taiwan exporters may lose their competitiveness in the world markets and their stock prices usually fall. Studies investigating the causal relations and the international transmission between these two financial assets of Japan and Taiwan can be found in Sewell et al. (1996), Chen and Wu (1997), Granger et al. (2000), Pilbeam (2001), and Yau and Nieh (2006).

⁵ For instance, Aggarwal (1981), Soenen and Hennigar (1988), Smith (1992), Bodnar and Gentry (1993), Dropy and Nazarian-Ibrahimi (1994), Choi and Prasad (1995), Prasad and Rajan (1995), Ajayi and Mougoue (1996), Fang and Loo (1996), Abdalla and Murinde (1997), Kwon et al. (1997), Kanas (2000), and Bhattacharya and Mukherjee (2003), among others.

⁶ Yen Bloc refers to a grouping of countries that use the JPY as an international currency and maintain stable exchange rates against the JPY.

Due to the mutual effects of exchange rates and stock prices on each other as mentioned above, it is difficult to predict the overall impact of the varying exchange rate on the stock markets in Taiwan and Japan. Whether it is favorable or unfavorable depends on the entire industrial structure within a country. Studies emphasizing the impact of the exchange rate on stock prices in Taiwan can be found in Wu (1997), Guo and Wu (1998), and Chiao et al. (2001); whereas Choi et al. (1998), He and Ng (1998), Doukas et al. (1999), Caporale et al. (2002), Elyasiani and Mansur (2005), Homma et al. (2005), and Kurihara (2006), among others, studied the relationship between the exchange rate and stock prices in Japan.

In prior empirical studies concerning the exchange rate, the US dollar is mostly utilized as the base currency, while a few studies use the Japanese Yen instead.^{7,8} Because Japan is one of the major trading partners of Taiwan, the NTD/JPY plays a crucial role and may possibly influence Taiwan's economy as well as the local stock market. Therefore, while investigating the relationship or financial transmission between these two countries, it may be more appropriate to consider JPY as the base currency.

It has been suggested more recently that linear conventional time series methodologies fail to consider information across regions. This leads to inefficient estimation and therefore lower testing power. One proposed approach to increase power in testing is to consider non-linear techniques instead. Threshold cointegration was introduced by Balke and Fomby (1997) as a practical method to combine non-linearity and cointegration. In particular, the model allows for non-linear adjustment to long-run equilibrium. Later research based on the concept of threshold cointegration include: Obstfeld and Taylor (1997), Enders and Falk (1998), Enders and Granger (1998), Enders and Siklos (2001), Lo and Zivot (2001), Taylor (2001), and Hansen and Seo (2002).

The main purpose of this study tends to concentrate on the cointegration as well as short-term and long-term causal relationships between the two major financial assets, exchange rates and stock prices, of both countries considered, by employing the newly threshold error-correction model (TECM) elaborated by Enders and Granger (1998) and Enders and Siklos (2001). In order to be more persuading than the traditional vector error-correction model (VECM), we attempt to employ the advanced time-series methodologies assuming that the nature of the causal relationship between the variables is on the basis of non-linearity.

The remainder of this paper is organized as follows. Section 2 describes the data. Section 3 introduces all the methodologies used and analyzes the empirical results. Section 4 concludes this paper.

2. Data

This paper looks at NTD/JPY, NTD/USD, closing Taiwan Stock Exchange Index (TW Stock), and the Nikkei 225 Index (JP Stock). Data are collected from the AREMOS Statistical Data Bank of Taiwan's Ministry of Education. Considering that there may be more fluctuations in daily data, this study adopts monthly data. The sample period runs from January 1991 to March 2008, with a total of 207 monthly observations obtained for each variable. This specific period is chosen due to the fact that the

⁷ Enders and Hurn (1994) believed that using the Japanese Yen as the base currency can be crucial in investigating the macro-fundamental issues, especially among Asian countries.

⁸ The issue examining the dominant power or considering the impact of either the U.S. or Japan on other countries' financial markets can be found in Karolyi and Stulz (1996), Varela and Naka (1997), Sun and Tong (2000), and Durand et al. (2001).

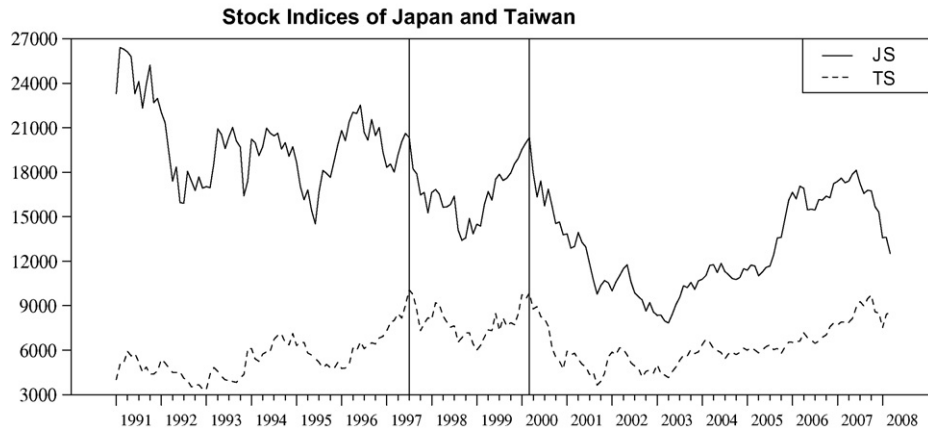


Fig. 1. Stock price movements of Japan and Taiwan.

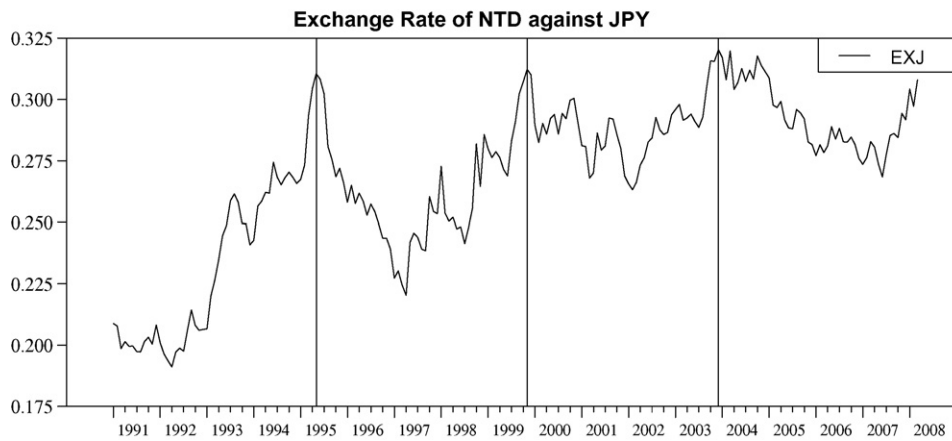


Fig. 2. Exchange rate movement of NTD against JPY.

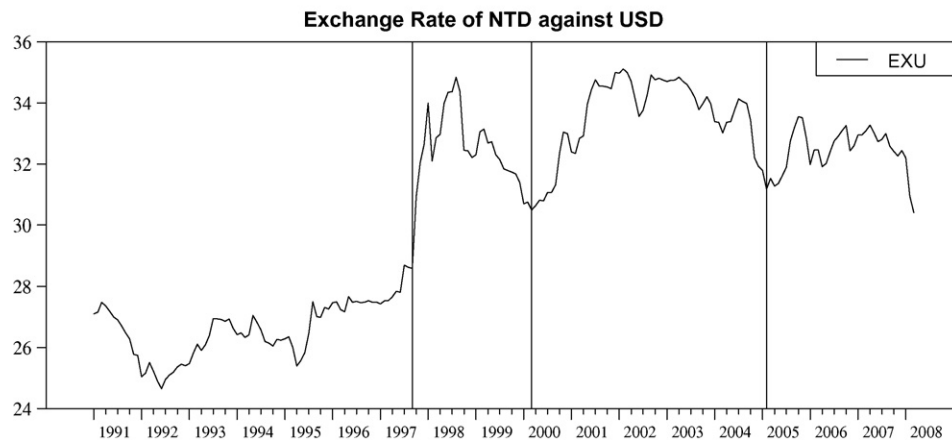


Fig. 3. Exchange rate movement of NTD against USD.

1997 Asian Financial Crisis (AFC) and 2000 Internet bubble happened in the middle of this period, and thus we may capture a full picture before and after the Crisis and the bubble (see Figs. 1 and 2).

We observe from Fig. 1 that both stock indices experienced a similar up-and-down moving pattern, but the volatility of the JP Stock is much higher than that of the TW Stock. The JP Stock is in fact in a downward trend throughout the sample period, and it

experienced dramatic drops before the month of September 1998 when it hit its lowest level of 13,406 from its highest level of 20,604 in June 1997 and from 20,337 to 9775 in the period between March 2000 and September 2001.⁹ Moreover, it is seen clearly from Fig. 2 that, after the AFC, JPY appreciated against NTD up to the year 2000.

⁹ The second serious drop illustrates that the JP stock was heavily hurt during the period of worldwide sell-off from the Internet bubble in the year 2000.

Table 1
Summary statistics of JS, TS, EXJ and EXU.

| | JS | TS | EXJ | EXU |
|------------|----------|-----------|------------|------------|
| Mean | 16174.73 | 6227.74 | 0.2684 | 30.5029 |
| S.D. | 4157.85 | 1542.34 | 0.0325 | 3.3141 |
| Maximum | 26409.22 | 10066.35 | 0.3202 | 35.1120 |
| Minimum | 7831.42 | 3374.56 | 0.1911 | 24.6500 |
| Skewness | 0.0143 | 0.3988 | -0.7907 | -0.2914 |
| Kurtosis | 2.4475 | 2.4778 | 2.8285 | 1.5008 |
| J-B N Test | 2.6399 | 7.8380*** | 21.8256*** | 22.3153*** |

Notes: 1. JS, TS, EXJ and EXU are the symbols for the Nikkei 225 Index, Taiwan Stock Exchange Index, NTD/JPY exchange rate and NTD/USD exchange rate, respectively.
2. S.D. denotes standard error.
3. J-B N Test denotes the Jarque–Bera normality test.
4. *** indicates significance at the 1%, respectively.

Fig. 1 combined with Figs. 2 and 3 also shows that the increase in JP Stock most likely accompanied JPY depreciation (against NTD), whereas the TW Stock increased with NTD depreciation (against JPY or USD). Table 1 presents the summary statistics of the four variables investigated.

3. Methodologies and empirical results

This paper aims to empirically investigate the asymmetric causal relationships between NTD/JPY and the stock prices of Japan and Taiwan, respectively. Furthermore, we extend our research taking into account the effect of the U.S. exchange rate specifically on Taiwan’s financial market. To fully capture the causal relations among variables investigated, our study employs non-linear examinations.

3.1. Conventional linear unit root tests

Among various testing strategies, this paper first tests for “stationarity” of each variable by employing three traditional unit root test techniques: ADF (Dickey and Fuller, 1981), KPSS (Kwiatkowski et al., 1992), and NP (Ng and Perron, 2001).¹⁰ Since the estimation might be biased if the lag length and bandwidth are pre-designated without rigorous determination, based on the “principle of parsimony”, the modified Akaike information criterion (Modified-AIC or MAIC) suggested by Ng and Perron (2001) for the unit root of ADF and NP and the Bartlett kernel based criterion proposed by Newey and West (1994) for PP are utilized to determine the optimal number of lags and optimal bandwidth, respectively.

Table 2 summarizes the results of the three unit root tests, ADF, KPSS, and NP, which show that the null of non-stationarity cannot be rejected for any levels of the series. After first differencing, however, the null is rejected at least at the 5 percent significance level for all series. We thus conclude that all the variables considered in this paper are the I(1) type series.

3.2. Advanced non-linear ESTAR unit root test

There recently is a growing consensus that exchange rates and stock prices might exhibit non-linearities and that conventional unit root tests have lower power in detecting their mean reverting (stationary) tendency. Therefore, this study employs a newly developed “non-linear” stationary test advanced by Kapetanios et al. (2003) (henceforth, KSS) to determine whether the Japan or

U.S. exchange rate, or stock prices of Japan and Taiwan are non-linear stationary.

The KSS non-linear stationary test is alternatively based on detecting the presence of non-stationarity against non-linear but globally stationary exponential smooth transition autoregressive (ESTAR) process:

$$\Delta Y_t = \gamma Y_{t-1} \{1 - \exp(-\theta Y_{t-1}^2)\} + \nu_t, \tag{1}$$

where Y_t is the data series of variables considered, ν_t an i.i.d. error with zero mean and constant variance, and $\theta \geq 0$ is known as the transition parameter of the ESTAR model that governs the speed of transition. We are now interested in testing the null hypothesis of $\theta = 0$ against the alternative of $\theta > 0$. Under the null hypothesis, Y_t follows a linear unit root process, whereas it is a non-linear stationary ESTAR process under the alternative. However, the parameter γ is not identified under the null hypothesis. Kapetanios et al. (2003) used a first-order Taylor series approximation to $\{1 - \exp(-\theta Y_{t-1}^2)\}$ under the null of $\theta = 0$ and approximated Eq. (1) by the following auxiliary regression:

$$\Delta Y_t = \xi + \delta Y_{t-1}^3 + \sum_{i=1}^k b_i \Delta Y_{t-i} + \nu_t, \quad t = 1, 2, \dots, T. \tag{2}$$

The null hypothesis and alternative hypotheses are then expressed as $\delta = 0$ (non-stationarity) against $\delta < 0$ (non-linear ESTAR stationarity).¹¹ Table 3 presents the results of KSS’s (2003) non-linear ESTAR stationary test, which shows that all four variables considered in this paper are I(1) series at least at the 10 percent significant level.

3.3. EG-ES threshold cointegration tests

The findings of the I(1) series for both stock prices of Japan and Taiwan, and the exchange rates of NTD/JPY and NTD/USD enable us to proceed with further long-run equilibrium relationship (cointegration) tests. On the basis of non-linearity, we employ the threshold cointegration techniques elaborated by Enders and Granger (1998) and Enders and Siklos (2001). This is indeed a residual-based two-stage estimation as developed by Engle and Granger (1987). The differences between them are addressed on the formulation of linearity and non-linearity from their second stage of unit root test. The equation is expressed as following in the first stage.

$$Y_{1t} = \alpha + \beta Y_{2t} + u_t, \tag{3}$$

where Y_{1t} and Y_{2t} are two I(1) series of the stock prices and exchange rates, respectively. Here, α and β are estimated parameters and u_t is the disturbance term that may be serially correlated.

The second stage focuses on the coefficient estimates of ρ_1 and ρ_2 in the following regression:

$$\Delta u_t = I_t \rho_1 u_{t-1} + (1 - I_t) \rho_2 u_{t-1} + \sum_{i=1}^l \gamma_i \Delta u_{t-i} + \varepsilon_t, \tag{4}$$

where ε_t is a white-noise disturbance and the residuals, μ_t in (4) are extracted from (3) to be further estimated. Term I_t is the Heaviside indicator function such that $I_t = 1$ if $u_{t-1} \geq \tau$ and $I_t = 0$ if $u_{t-1} < \tau$, where τ is the threshold value. A necessary condition for $\{\mu_t\}$ to be stationary is: $-2 < (\rho_1, \rho_2) < 0$. If the variance of ε_t is sufficiently large, then it is also possible for one value of ρ_j to be between -2 and 0 and for the other value to equal zero. Although

¹⁰ The test statistic of NP test is MZ_t in this paper.

¹¹ The simulated critical values for different K were tabulated in Kapetanios et al. (2003) (Table 1 as of p. 363).

Table 2
The results of conventional linear unit root tests.

| | | JS | | TS | | EXJ | | EXU | |
|------|------------|--------------|------|--------------|------|--------------|------|--------------|------|
| ADF | Level | -2.04[2] | (0) | -2.34[2] | (0) | -2.61[1] | (0) | -0.24[1] | (1) |
| | Difference | -14.71[1]*** | (0) | -14.20[1]*** | (0) | -14.63[1]*** | (0) | -11.80[1]*** | (0) |
| NP | Level | -2.41[2] | (3) | -2.48[2] | (2) | -2.69[3] | (2) | 0.28[1] | (3) |
| | Difference | -14.70[1]*** | (3) | -14.22[1]*** | (6) | -14.63[1]*** | (5) | -11.84[1]*** | (8) |
| KPSS | Level | 0.177[3]** | (11) | 0.167[3]** | (11) | 0.161[3]** | (11) | 0.276[3]*** | (11) |
| | Difference | 0.063[2] | (0) | 0.054[2] | (6) | 0.054[2] | (6) | 0.167[2] | (3) |

Notes: 1. JS, TS, EXJ and EXU are the symbols for the Nikkei 225 Index, Taiwan Stock Exchange Index, NTD/JPY exchange rate and NTD/USD exchange rate, respectively.
2. *** and ** denote significance at 1% and 5% levels, respectively.
3. The critical values for the ADF *t*-statistics are from the MacKinnon (1996) table.
4. The test statistic of the NP test is MZt.
5. The numbers in the brackets indicate model specification. The numbers in the parentheses of ADF and NP is the appropriate lag lengths selected by MAIC, whereas the numbers in the parentheses of KPSS and KPSS are the optimal bandwidths decided by the Bartlett kernel of Newey and West (1994).
6. The model specification is based on the decision procedures suggested by Dolado et al. (1990).
7. The nulls of ADF and NP are I(1), whereas the null of KPSS is I(0).

there is no convergence in the regime with the unit root (i.e., the regime in which $\rho_j = 0$), a large realization of ε_t will switch the system into the convergent regime. Enders and Granger (1998) and Enders and Siklos (2001) both pointed out in either case, that under the null hypothesis of no convergence, the *F*-statistic for the null hypothesis $\rho_1 = \rho_2 = 0$ has a non-standard distribution. The critical values for this non-standard *F*-statistic are tabulated in their paper. Enders and Granger (1998) also indicated that if the sequence is stationary, the least squares estimates of ρ_1 and ρ_2 have an asymptotic multivariate normal distribution.

Eq. (4) is a threshold autoregressive (TAR) model of the disequilibrium error, where the test for threshold behavior of the disequilibrium error is termed the threshold cointegration test for variables in Eq. (3). Assuming the system is convergent, $\mu_t = 0$ can be considered as the long-run equilibrium value of the sequence. If μ_t is above its long-run equilibrium, then the adjustment is $\rho_1\mu_{t-1}$; and if μ_t is below its long-run equilibrium, then the adjustment is $\rho_2\mu_{t-1}$. We test the null of $\rho_1 = \rho_2 = 0$ for the cointegration relationship and the rejection implies the existence of a cointegration relationship between variables. The finding of $\rho_1 = \rho_2 = 0$ enables us to proceed with a further test for symmetric adjustment (i.e., $H_0: \rho_1 = \rho_2$) by using a standard *F*-test. When the coefficients of regime adjustment are equal (symmetric adjustment), Eq. (4) converges the prevalent ADF test. Rejecting both the null hypotheses of $\rho_1 = \rho_2 = 0$ and $\rho_1 = \rho_2$ implies the existence of threshold cointegration and the asymmetric adjustment.

Instead of estimating Eq. (4) with the Heaviside indicator depending on the level of μ_{t-1} , the decay could also be allowed depending on the previous period's change in μ_{t-1} . The Heaviside indicator could then be specified as $I_t = 1$ if $\Delta\mu_{t-1} \geq \tau$ and $I_t = 0$ if $\Delta\mu_{t-1} < \tau$, where τ is the threshold value. According to Enders and Granger (1998), this model is especially valuable when the

Table 3
The results of nonlinear unit root test—KSS test.

| | <i>t</i> -Statistic on δ | |
|-----|---------------------------------|------------------|
| | Level | First difference |
| JS | 0.3294(0) | -2.4836(4)** |
| TS | -1.2858(0) | -3.7593(6)*** |
| EXJ | 0.0341(0) | -1.7783(0)* |
| EXU | 0.1647(0) | -3.5821(3)*** |

Notes: 1. JS, TS, EXJ and EXU are the symbols for the Nikkei 225 Index, Taiwan Stock Exchange Index, NTD/JPY exchange rate and NTD/USD exchange rate, respectively.
2. ***, ** and * denote significance at 1%, 5% and 10% levels, respectively.
3. The numbers in the parentheses are the appropriate lag lengths selected by MAIC (modified Akaike information criterion) suggested by Ng and Perron (2001).
4. The simulated critical values for different *K* were tabulated in Kapetanios et al. (2003) (Table 1 as of p. 363).

adjustment is asymmetric such that the series exhibits more 'momentum' in one direction than the other. This model is termed the momentum threshold autoregressive (M-TAR) model. The TAR model is used to capture a 'deep' cycle process if, for example, positive deviations are more prolonged than negative deviations. On the other hand, the M-TAR model allows the autoregressive decay to depend on $\Delta\mu_{t-1}$. As such, the M-TAR representation may capture 'sharp' movements in a sequence.

In most cases, the value of τ is unknown, and it has to be estimated along with the value of ρ_1 and ρ_2 . By demeaning the $\{\mu_t\}$ sequence, the Enders and Granger (1998) test procedure employs the sample mean of the sequence as the threshold estimate of τ . However, the sample mean is a biased threshold estimator in the presence of asymmetric adjustments.¹² A consistent estimate of the threshold τ can be obtained by employing Chan's (1993) methodology of searching over possible threshold values to minimize the residual sum of squares (RSS) from the fitted model. Enders and Siklos (2001) estimated the threshold value of τ by applying Chan's (1993) methodology and used the same method incorporating the Monte Carlo approach to obtain the *F*-statistics for the null of $\rho_1 = \rho_2 = 0$.^{13,14} As there is generally no presumption as to whether to use the TAR or M-TAR model, the recommendation is to select the adjustment mechanism by a model selection criterion such as the AIC or SBC.

The results of our estimations of threshold cointegration relationships between the NTD/JPY exchange rate and each of the country stock indices (Japan and Taiwan) are illustrated in Tables 4 and 5, respectively. Based on the 'Principle of Parsimony', both AIC and SBC suggest that the most applicable model for variables' adjustment to long-run equilibrium in both countries is M-TART (M-TAR model with threshold value) for Japan and TART for Taiwan, where the threshold values of τ are found to be -0.039 and -0.429, respectively, based on Chan's (1993) method. Table 6 illustrates the result of threshold cointegration tests between the NTD/USD exchange rate and TW Stock. Likewise, TART is found to be the most applicable model with the threshold value of -0.386.

For further analysis, the empirical evidence for the Japanese case in Table 4 shows that the null of no cointegration (\hat{F}_C) is rejected, which indicates the existence of a long-run equilibrium relationship between NTD/JPY and JP stock. However, the null of symmetric adjustment (\hat{F}_A) is not rejected, suggesting that there

¹² For instance, if autoregressive decay is more sluggish for positive deviations of μ_{t-1} from τ than for negative deviations, then the sample mean estimator will be biased upwards.

¹³ The critical values of this non-standard *F*-statistics for testing this threshold cointegration relationship are tabulated in their paper.

¹⁴ For detailed illustrations, please see Enders and Siklos (2001) on page 172.

Table 4

Model specification for Japan (with exchange rate of NTD/JPY).

| | J (TAR) | J (M-TAR) | J (TART) | J (M-TART) |
|----------------|-----------------|-----------------|------------------|------------------|
| $\hat{\rho}_1$ | -0.059(-1.804)* | -0.053(-1.775)* | -0.076(-2.173)** | -0.070(-2.740)** |
| $\hat{\rho}_2$ | -0.038(-1.377) | -0.040(-1.357) | -0.030(-1.143) | -0.002(-0.043) |
| \hat{F}_C | 2.576[0.078]* | 2.500[0.085]* | 3.014[0.051]* | 3.755[0.025]** |
| \hat{F}_A | 0.251[0.617] | 0.099[0.754] | 1.107[0.294] | 2.554[0.116] |
| l | 0 | 0 | 0 | 0 |
| AIC | -24.04 | -23.88 | -24.90 | -26.35 |
| SBC | -17.39 | -17.23 | -18.25 | -19.70 |

Notes: 1. J represents Japan. M-TART indicates momentum-threshold autoregressive model with threshold value.

2. Lag-length (l) selection is based on the Ng and Perron (2001) unit root procedure.3. Numbers in parentheses and bracket are t -statistics and p -value, respectively.4. \hat{F}_C and \hat{F}_A denote the F -statistics for the null hypothesis of no cointegration and symmetry. Critical values are taken from Enders and Siklos (2001).5. The threshold value, τ , of TAR and M-TAR models are 0.148 and -0.039, respectively.

6. The model is specified, based on the 'principle of parsimony' of AIC and SBC, as M-TART model with the threshold value of -0.039.

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

Table 5

Model specification for Taiwan (with exchange rate of NTD/JPY).

| | T (TAR) | T (M-TAR) | T (TART) | T (M-TART) |
|----------------|------------------|------------------|-------------------|-------------------|
| $\hat{\rho}_1$ | -0.050(-1.421) | -0.073(-1.979)** | -0.048(-1.810)* | -0.113(-3.338)*** |
| $\hat{\rho}_2$ | -0.087(-2.384)** | -0.063(-1.812)* | -0.225(-3.003)*** | -0.013(-0.352) |
| \hat{F}_C | 3.850[0.023]** | 3.601[0.029]** | 6.146[0.003]*** | 5.632[0.004]*** |
| \hat{F}_A | 0.519[0.472] | 0.037[0.848] | 4.954[0.027]** | 3.962[0.048]** |
| l | 0 | 0 | 0 | 0 |
| AIC | 90.18 | 90.66 | 85.76 | 86.74 |
| SBC | 96.84 | 97.32 | 92.42 | 93.40 |

Notes: 1. T represents Taiwan. M-TART indicates momentum-threshold autoregressive model with threshold value.

2. Lag-length (l) selection is based on the Ng and Perron (2001) unit root procedure.3. Numbers in parentheses and bracket are t -statistics and p -value, respectively.4. \hat{F}_C and \hat{F}_A denote the F -statistics for the null hypothesis of no cointegration and symmetry. Critical values are taken from Enders and Siklos (2001).5. The threshold value, τ , of TART and M-TART models are -0.429 and -0.008, respectively.

6. The model is specified, based on the 'principle of parsimony' of AIC and SBC, as TART model with the threshold value of -0.429.

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

is no significant threshold cointegration between the two variables considered. On the other hand, the evidence for the Taiwanese case is shown in Table 5 whereby both the null of no cointegration (\hat{F}_C) and symmetric adjustment (\hat{F}_A) are rejected at the 1 percent and 5 percent levels, respectively, suggesting the existence of an asymmetric threshold cointegration relationship between NTD/JPY and TW Stock during the period investigated. The case between TW Stock and the NTD/USD exchange rate is shown in Table 6 whereby both the null of no cointegration (\hat{F}_C) and symmetric adjustment (\hat{F}_A) are rejected at the 1 percent and 10 percent levels, respectively, indicating also that an asymmetric threshold cointegration exists between NTD/

USD and TW Stock. The existence of a long-term equilibrium (cointegration) relationship in the Japanese and Taiwanese markets implies that there has been a force of recovering new equilibrium exchange rate-stock price levels or a co-movement through time.

3.4. TECM Granger-Causality tests

Granger and Lee (1989), Siklos and Granger (1997), Balke and Fomby (1997), and Enders and Granger (1998) examined the possibility of non-linear adjustment in the relationship between or among variables in an asymmetric framework. Enders and Siklos

Table 6

Model specification for Taiwan (with exchange rate of NTD/USD).

| | T (TAR) | T (M-TAR) | T (TART) | T (M-TART) |
|----------------|------------------|------------------|-------------------|-------------------|
| $\hat{\rho}_1$ | -0.043(-1.225) | -0.074(-2.100)** | -0.033(-1.185) | -0.098(-3.178)*** |
| $\hat{\rho}_2$ | -0.083(-2.418)** | -0.053(-1.560) | -0.170(-3.315)*** | -0.005(-0.116) |
| \hat{F}_C | 3.673[0.028]** | 3.417[0.035]** | 6.198[0.002]*** | 5.058[0.007]*** |
| \hat{F}_A | 0.673[0.413] | 0.178[0.674] | 5.564[0.019]** | 3.356[0.068]* |
| l | 0 | 0 | 0 | 0 |
| AIC | 79.66 | 80.16 | 74.80 | 76.98 |
| SBC | 86.32 | 86.82 | 81.45 | 83.63 |

Notes: 1. T represents Taiwan. M-TART indicates momentum-threshold autoregressive model with threshold value.

2. Lag-length (l) selection is based on the Ng and Perron (2001) unit root procedure.3. Numbers in parentheses and bracket are t -statistics and p -value, respectively.4. \hat{F}_C and \hat{F}_A denote the F -statistics for the null hypothesis of no cointegration and symmetry. Critical values are taken from Enders and Siklos (2001).5. The threshold value, τ , of TART and M-TART models are -0.386 and -0.030, respectively.

6. The model is specified, based on the 'principle of parsimony' of AIC and SBC, as TART model with the threshold value of -0.386.

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

Table 7
Estimates of the M-TECM for Japan Stock Price and NTD/JPY.

| | JS | EXJ |
|---|------------------------|----------------|
| Constant | -0.003(-0.613) | 0.002(1.119) |
| JS(-1) | 0.035(0.489) | 0.007(0.187) |
| JS(-2) | 0.007(0.103) | -0.023(-0.674) |
| EXJ(-1) | 0.092(0.145) | -0.024(-0.338) |
| EXJ(-2) | -0.132(-0.905) | 0.062(0.868) |
| Z_{t-1}^+ | -0.045(-1.956)* | -0.016(-1.497) |
| Z_{t-1}^- | 0.002(0.044) | -0.003(-0.230) |
| $H_0: \gamma_1 = \gamma_2 = 0$ | 1.915[0.150] | 1.147[0.032]** |
| $H_0: \theta_1 = \theta_2 = 0$ | 0.622[0.538] | |
| $H_0: \delta_1 = \delta_2 = 0$ | | 0.244[0.784] |
| $H_0: \theta_1 = \theta_2 = \gamma_1 = 0$ | 1.742[0.160] | |
| $H_0: \theta_1 = \theta_2 = \gamma_2 = 0$ | 0.416[0.742] | |
| $H_0: \delta_1 = \delta_2 = \gamma_1 = 0$ | | 1.021[0.384] |
| $H_0: \delta_1 = \delta_2 = \gamma_2 = 0$ | | 0.183[0.908] |
| $H_0: (JS) \gamma_1 = \gamma_2$ | 1.245[0.266] | |
| $H_0: (EXJ) \gamma_1 = \gamma_2$ | | 0.401[0.527] |
| ARCH(4) | 1.222[0.303] | 1.143[0.338] |
| D-W | 1.999 | 2.019 |

Notes: 1. JS and EXJ represent Japan stock index and exchange rate of NTD/JPY, respectively.

- Numbers in parentheses and bracket are t -statistics and p -value, respectively.
- Momentum threshold error-correction model: $\Delta Y_{it} = \alpha + \gamma_1 Z_{t-1}^+ + \gamma_2 Z_{t-1}^- + \sum_{i=1}^{k_1} \delta_i \Delta Y_{1t-i} + \sum_{i=1}^{k_2} \theta_i \Delta Y_{2t-i} + v_t$, where $Y_{it} = (JS_t, EXJ_t)$, $Z_{t-1}^+ = I_t \hat{u}_{t-1}$, $Z_{t-1}^- = (1 - I_t) \hat{u}_{t-1}$, given $I_t = 1$ if $\Delta u_{t-1} \geq -0.039$, $I_t = 0$ if $\Delta u_{t-1} \leq -0.039$ and v_t is a white-noise disturbance.
- Symmetric error-correction model: $\Delta Y_{it} = \alpha + \gamma \hat{u}_{t-1} + \sum_{i=1}^{k_1} \delta_i \Delta Y_{1t-i} + \sum_{i=1}^{k_2} \theta_i \Delta Y_{2t-i} + v_t$.
- ** and * denote significance at the 5% and 10% levels, respectively.

(2001) further developed and elaborated an explicit test for cointegration with asymmetric error correction.

Given the threshold cointegration results found in the previous section, the next step proceeds with the Granger-Causality test using the advanced threshold error-correction model by Enders and Granger (1998) and Enders and Siklos (2001). The M-TECM is expressed as the following:

$$\Delta Y_{it} = \alpha + \gamma_1 Z_{t-1}^+ + \gamma_2 Z_{t-1}^- + \sum_{i=1}^{k_1} \delta_i \Delta Y_{1t-i} + \sum_{i=1}^{k_2} \theta_i \Delta Y_{2t-i} + v_t, \quad (5)$$

where $Y_{it} = (JS_t, EX_t)$ for the Japanese case and $Y_{it} = (TS_t, EX_t)$ for the Taiwanese case, and JS_t , TS_t , and EX_t are symbols for JP stock, TW stock, and NTD/JPY at time t , respectively. Here, $Z_{t-1}^+ = I_t \hat{u}_{t-1}$ and $Z_{t-1}^- = (1 - I_t) \hat{u}_{t-1}$, given $I_t = 1$ if $\Delta u_{t-1} \geq -0.039$, and $I_t = 0$ if $\Delta u_{t-1} \leq -0.039$ for the Japanese case; and $I_t = 1$ if $u_{t-1} \geq -0.429$, $I_t = 0$ if $u_{t-1} \leq -0.429$ for the Taiwanese case. Furthermore, v_t is a white-noise disturbance.

From this formulation, the Granger-Causality tests are employed to examine whether all the coefficients of $\Delta Y_{1,t-i}$ or $\Delta Y_{2,t-i}$ are jointly statistically different from zero based on a standard F -test and/or whether the γ_j coefficients of the error-correction term are significant. Since Granger-Causality tests are very sensitive to the selection of lag length, we apply the AIC criterion to determine the appropriate lag lengths and empirically find that, for both the Japanese and Taiwanese cases, the two lag lengths of k_1 and k_2 are all one (i.e., $k_1 = k_2 = 1$).

Table 7 presents the results of Granger-Causality tests, based on the M-TECM for Japan Stock Index (JS) and NTD/JPY exchange rate (EXJ). They clearly illustrate no short-run causal relationship exists between this two financial assets (insignificant of $H_0: \delta_1 = \delta_2 = 0$ and $\theta_1 = \theta_2 = 0$). In addition, there also exists no causal relationship in the long run when the difference in the previous disequilibrium term is above the threshold value of -0.039 (the insignificance of $H_0: \delta_1 = \delta_2 = \gamma_1 = 0$, $H_0: \theta_1 = \theta_2 = \gamma_1 = 0$, $\delta_1 = \delta_2 = \gamma_2 = 0$, and $H_0: \theta_1 = \theta_2 = \gamma_2 = 0$). The evidence of an insignificant finding of the null

Table 8
Estimates of the TECM for Taiwan Stock Price and NTD/JPY.

| | TS | EXJ |
|---|------------------------|----------------|
| Constant | -0.000(-0.086)* | 0.002(1.093) |
| TS(-1) | 0.076(1.047) | -0.015(-0.569) |
| TS(-2) | 0.113(1.592) | -0.014(-0.537) |
| EXJ(-1) | -0.056(-0.273) | -0.034(-0.464) |
| EXJ(-2) | 0.026(0.127) | 0.057(0.791) |
| Z_{t-1}^+ | -0.048(-1.863)* | 0.0141(1.628) |
| Z_{t-1}^- | -0.209(-3.093) | 0.000(0.000) |
| $H_0: \gamma_1 = \gamma_2 = 0$ | 6.400[0.002]*** | 2.651[0.105] |
| $H_0: \theta_1 = \theta_2 = 0$ | 0.047[0.954] | |
| $H_0: \delta_1 = \delta_2 = 0$ | | 0.302[0.740] |
| $H_0: \theta_1 = \theta_2 = \gamma_1 = 0$ | 1.181[0.318] | |
| $H_0: \theta_1 = \theta_2 = \gamma_2 = 0$ | 3.279[0.022]** | |
| $H_0: \delta_1 = \delta_2 = \gamma_1 = 0$ | | 0.930[0.427] |
| $H_0: \delta_1 = \delta_2 = \gamma_2 = 0$ | | 0.302[0.740] |
| $H_0: (TS) \gamma_1 = \gamma_2$ | 5.009[0.026]** | |
| $H_0: (EXJ) \gamma_1 = \gamma_2$ | | 2.651[0.105] |
| ARCH(4) | 0.682[0.605] | 1.241[0.295] |
| D-W | 1.995 | 2.016 |

Notes: 1. TS and EXJ represent Taiwan stock index and exchange rate of NTD/JPY, respectively.

- Numbers in parentheses and bracket are t -statistics and p -value, respectively.
- Threshold error-correction model: $\Delta Y_{it} = \alpha + \gamma_1 Z_{t-1}^+ + \gamma_2 Z_{t-1}^- + \sum_{i=1}^{k_1} \delta_i \Delta Y_{1t-i} + \sum_{i=1}^{k_2} \theta_i \Delta Y_{2t-i} + v_t$, where $Y_{it} = (TS_t, EXJ_t)$, $Z_{t-1}^+ = I_t \hat{u}_{t-1}$, $Z_{t-1}^- = (1 - I_t) \hat{u}_{t-1}$, given $I_t = 1$ if $u_{t-1} \geq -0.429$, $I_t = 0$ if $u_{t-1} \leq -0.429$ and v_t is a white-noise disturbance.
- Symmetric error-correction model: $\Delta Y_{it} = \alpha + \gamma \hat{u}_{t-1} + \sum_{i=1}^{k_1} \delta_i \Delta Y_{1t-i} + \sum_{i=1}^{k_2} \theta_i \Delta Y_{2t-i} + v_t$.
- ***, ** and * denote significance at 1%, 5% and 10% levels, respectively.

of $\gamma_1 = \gamma_2$ in either financial asset is consistent with the finding of our previous M-TART estimations.

For the adjustment speed towards equilibrium in JP stock and NTD/JPY, Table 7 shows that there are only 0.002 percent and -0.003 percent (the coefficients of Z_{t-1}^-) adjustments, respectively, to revert to the equilibrium when differences in the previous disequilibrium term are in the lower regime (below the threshold value of -0.039). On the other hand, it is statistically significant and approximately -0.045 percent (the coefficient of Z_{t-1}^+) of the deviation in JP Stock and -0.016 percent in NTD/JPY revert to the equilibrium in the higher regime.

Table 8 presents the results of the Granger-Causality tests based on TECM for TW Stock (TS) and NTD/JPY exchange rate (EXJ). They again show that no short-run causal relationship exists between the two financial assets (insignificance of $H_0: \delta_1 = \delta_2 = 0$ and $\theta_1 = \theta_2 = 0$). However, in terms of the long-run situation, a unidirectional causal relationship running from NTD/JPY to TW Stock is found for the regime below the threshold value of -0.429 for u_{t-1} . This can be interpreted as the significance of $H_0: \theta_1 = \theta_2 = \gamma_2 = 0$ and the insignificance of $H_0: \theta_1 = \theta_2 = \gamma_1 = 0$, $\delta_1 = \delta_2 = \gamma_1 = 0$, and $\delta_1 = \delta_2 = \gamma_2 = 0$.

The finding that exchange rates lead the movement of stock prices with a positive sign (by American quotation) implies that the traditional approach may appropriately describe the phenomenon of the price transmission between exchange rates and stock prices in Taiwan's financial market. The traditional approach proposing that NTD depreciation makes Taiwanese firms more competitive leads to an increase in their exports and consequently raises TW Stock. Moreover, the significant finding of the null of $\gamma_1 = \gamma_2$ in TW Stock (at the 5 percent level) is consistent with our previous finding from the TART model, which argues that there exists an asymmetric causal relationship between NTD/JPY and TW Stock.

For the adjustments towards an equilibrium above and below the threshold value of -0.429 in TW Stock and NTD/JPY, Table 8 presents different findings of the point estimates of adjustment coefficients. It is significant that TW Stock adjusts to eliminate

Table 9
Estimates of the TECM for Taiwan Stock Price and NTD/USD.

| | TS | EXU |
|---|-------------------|------------------|
| Constant | −0.003(−0.479) | 0.000(0.441) |
| TS(−1) | 0.099(1.353) | −0.013(−0.962) |
| TS(−2) | 0.125(1.751) | −0.015(−1.151) |
| EXU(−1) | 0.302(0.751) | 0.162(2.186) |
| EXU(−2) | 0.299(0.733) | 0.020(0.272) |
| Z_{t-1}^+ | −0.034(−1.226) | 0.005(1.212) |
| Z_{t-1}^- | −0.174(−3.455)*** | 0.000(0.000) |
| $H_0: \gamma_1 = \gamma_2 = 0$ | 6.742[0.001]**** | 1.468[0.227] |
| $H_0: \theta_1 = \theta_2 = 0$ | 0.672[0.512] | |
| $H_0: \delta_1 = \delta_2 = 0$ | | 1.141[0.321] |
| $H_0: \theta_1 = \theta_2 = \gamma_1 = 0$ | 0.986[0.400] | |
| $H_0: \theta_1 = \theta_2 = \gamma_2 = 0$ | 4.423[0.005]**** | |
| $H_0: \delta_1 = \delta_2 = \gamma_1 = 0$ | | 1.019[0.386] |
| $H_0: \delta_1 = \delta_2 = \gamma_2 = 0$ | | 1.141[0.321] |
| $H_0: (\text{TS}) \gamma_1 = \gamma_2$ | 5.948[0.016]** | |
| $H_0: (\text{EXU}) \gamma_1 = \gamma_2$ | | 0.000(0.000) |
| ARCH(4) | 0.526[0.717] | 7.154[0.000]**** |
| D-W | 1.995 | 1.996 |

Notes: 1. TS and EXU represent Taiwan stock index and exchange rate of NTD/USD, respectively.

2. Numbers in parentheses and bracket are t -statistics and p -value, respectively.

3. Threshold error-correction model: $\Delta Y_{it} = \alpha + \gamma_1 Z_{t-1}^+ + \gamma_2 Z_{t-1}^- + \sum_{i=1}^{k_1} \delta_i \Delta Y_{1t-i} + \sum_{i=1}^{k_2} \theta_i \Delta Y_{2t-i} + v_t$, where $Y_{it} = (\text{TS}, \text{EXU})$, $Z_{t-1}^+ = I_t \hat{u}_{t-1}$, $Z_{t-1}^- = (1 - I_t) \hat{u}_{t-1}$, given $I_t = 1$ if $u_{t-1} \geq -0.386$, $I_t = 0$ if $u_{t-1} \leq -0.386$ and v_t is a white-noise disturbance.

4. Symmetric error-correction model: $\Delta Y_{it} = \alpha + \gamma \hat{u}_{t-1} + \sum_{i=1}^{k_1} \delta_i \Delta Y_{1t-i} + \sum_{i=1}^{k_2} \theta_i \Delta Y_{2t-i} + v_t$.

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

approximately −4.8 percent (the coefficients of Z_{t-1}^+) of a unit negative change in the deviation and −20.9 percent (the coefficients of Z_{t-1}^-) of a unit negative change in the deviation to revert to the equilibrium. On the other hand, there are 1.41 percent and 0.00 percent adjustments in NTD/JPY (the coefficients of Z_{t-1}^+ and Z_{t-1}^-) to revert to the equilibrium, which are not significant.

Table 9 offers the results of the Granger-Causality tests based on TECM for TW Stock (TS) and NTD/USD exchange rate (EXU). They again show that no short-run causal relationship exists between the two financial assets (insignificant of $H_0: \delta_1 = \delta_2 = 0$ and $\theta_1 = \theta_2 = 0$). However, in terms of the long-run situation, a unidirectional causal relationship running from NTD/USD to TW Stock can also be found for the regime below the threshold value of −0.386 for μ_{t-1} . This can be interpreted as the significance of $H_0: \theta_1 = \theta_2 = \gamma_2 = 0$ (at 1 percent level) and the insignificance of $H_0: \theta_1 = \theta_2 = \gamma_1 = 0$, $\delta_1 = \delta_2 = \gamma_1 = 0$, and $\delta_1 = \delta_2 = \gamma_2 = 0$.

The finding that exchange rates lead the movement of stock prices with a positive sign (by American quotation) implies that the traditional approach may appropriately describe the phenomenon of the price transmission between the U.S. exchange rate and stock prices in Taiwan's financial market. Moreover, the significant finding of the null of $\gamma_1 = \gamma_2$ in TW Stock (at the 5 percent level) is consistent with our previous finding of the TART model, which argues that there exists an asymmetric causal relationship between NTD/USD and TW stock.

For the adjustments towards long-term equilibrium above and below the threshold value of −0.386 in TW Stock and NTD/USD, Table 9 presents different findings to the former TW Stock and NTD/JPY case of the point estimates of adjustment coefficients. It is found that TW Stock adjusts to eliminate approximately −3.4 percent (the coefficient of Z_{t-1}^+) of a unit negative change in the deviation from the equilibrium created by the changes in NTD/USD and −17.4 percent adjustment (the coefficient of Z_{t-1}^-) of a unit negative change in the deviation to revert to the equilibrium (significant at the 1 percent level). This implies that, stock prices respond to the innovations in the NTD/USD. The U.S. dollar is the more important factor influencing Taiwan stock prices, especially

below an appropriately estimated threshold. The respective coefficients of Z_{t-1}^+ and Z_{t-1}^- for NTD/USD are 0.5 percent and 0.00 percent adjustments to revert to the equilibrium, which are not significant.

4. Conclusion

This paper aims to empirically investigate the threshold cointegration relationships between the NTD/JPY exchange rate and the stock prices of Japan and Taiwan, respectively. For the appropriate model specifications, it is found that the applicable model for adjustment to the long-run equilibrium between the exchange rates and stock prices are the M-TART for Japan and TART for Taiwan. In addition, TART is also found to be the most applicable model from the result of threshold cointegration tests between NTD/USD exchange rate and stock prices of Taiwan. There exists strong evidence supporting the long-run equilibrium (cointegration) relationships between exchange rates and stock prices of the two countries. This implies that it is possible to predict one market from another for both countries, which seems to violate the efficient market hypothesis.

We extend our research by taking into account the effect of the U.S. exchange rate specifically on Taiwan's financial market. Long-term equilibrium and asymmetric causal relationships are also found between NTD/USD and the stock prices of Taiwan. In addition, the results of TECM Granger-Causality tests show that no short-run causal relationship exists between the two financial assets considered for both countries' cases. This indicates that the movements of exchange rates and stock prices do not have significant impacts upon each other in the short run. However, in the long run, a positive causal relationship running from either the Japan or U.S. exchange rate to the stock prices of Taiwan apparently argues for the traditional approach. Since Taiwan is a small open economy, the prices of most of its exports and imports are set in U.S. dollar, Japanese Yen, or other major currencies in world markets. Therefore, domestic (stock) prices in Taiwan would be strongly influenced by the exchange rates in the long run. Although the economic influence of Japan in Asia has expanded through its trades and investments in the region, the top trading country having a close long-term relationship with Taiwan still is the U.S. Therefore, the U.S. dollar exchange rate may still dominate and play an important role influencing stock prices of Taiwan.

The finding of the threshold effect in Taiwan's financial market implies the predictability of the volatile and unstable exchange rate movements, which probably developed during the 1997 Asian financial crisis period. One should incorporate the possibility of a structural shift (the existence of a threshold) into our model during the different stages of crisis evolution in order to analyze a more accurate assessment of market efficiency. The evidence of the threshold effect with asymmetrical responses in Taiwan's market implies that there has been a force of recovering new equilibrium exchange rate-stock price levels, especially when the exchange rate is significantly undervalued (depreciated) compared to the rationally expected level of exchange rate that is reflected in the lower regime.

The limitation of this paper is that we neglect the movements of interest rates which may exert considerable influence on stock prices. The stock prices basically move inversely with the interest rates, while the exchange rates (domestic currency) move in the same direction of the interest rates. We suggest that research may be extended to the linkage among the three variables of stock prices, exchange rates, and interest rates, as well as the cointegration and causal relationships with them in a future study.

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