E C O N O M I C S B U L L E T I N

Stock Prices and Dividends in Taiwan's Stock Market: Evidence Based on Time-Varying Present Value Model

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Abstract

In this study, we use the newly developed momentum threshold unit root and cointegration tests advanced by Enders and Granger (1998), and Enders and Siklos (2001) to investigate if there is any asymmetric adjustment in long-run prices and dividends in Taiwan¡¦s stock market during June 1991 to February 2005. The empirical results indicate that long-run prices and dividends cointegration relationship holds for the majority of Taiwan¡¦s stock market, but that adjustment mechanism is asymmetric. The results for most industries from the M-TAR cointegration tests attest to the absence of rational bubbles in Taiwan¡¦s stock market. These results have important policy implications for investors.

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1. Introduction

This study investigates whether rational bubbles were present in Taiwan's stock market during June 1991 to February 2005. Financial theory points out that in a well-functioning capital markets, prices and dividends should be related (Brealey and Myers, 1986); the present value of the share should be equal to the dividend stream discounted by the return earned on securities of comparable risk. The occurrence of rational bubbles signifies that no long-run relationship exists between stock prices and dividends. In pursuit of determining if stock prices and dividends are cointegrated, empirical studies have, for the most parts, employed cointegration techniques. According to the present value model, stock prices are fundamentally determined by the discounted value of their future dividends, which derive their value from future expected earnings (e.g., see Campbell, Lo, & Mackinlay, 1997; Cochrane, 2001).

Empirical studies of the validity of present value models have been extensively conducted in the cointegration framework in two approaches. One is based on the assumption of a constant discount rate, predicted that stock prices and dividend levels are attracted to each other in the long-run. It means that they are theoretically cointegrated. If stock prices and dividends follow integrated processes of order 1 then transversality condition holds (Campbell & Shiller, 1987). Alternatively, if the present value model is valid, the time-varying discount rate can be applied instead of a constant one. As a result, the log difference between dividends and prices follows a stationary process (Campbell & Shiller, 1988a, 1988b). From a theoretical perspective, there is no sound reason to assume that economic systems are intrinsically linear (Barnett and Serletis, 2000). In fact, numerous studies have empirically demonstrated that financial time series, such as stock prices, exhibit nonlinear dependencies (see, Hsieh, 1991; Abhyankar et al., 1997).

Recent research has mostly advocated that the relationship between stock prices and dividends may best be characterized by using a nonlinear model. For example, theoretical models for the interaction between arbitrage traders and noise have generally suggested that small and large returns may very well exhibit different dynamics. For example, arbitrageurs must constantly be wary of the possibility of noise traders driving returns further away from equilibrium before correction. Otherwise, from a methodological point of view, if we take the long-run validity of the present value model, the low power of unit root tests in particular, non-linearities, structural breaks and/or outliers are possible candidates for mixed findings.

Consequently, conventional integration and cointegration methods are not appropriate because they assume that a unit root is the null hypothesis and a linear process under the alternative. Therefore, we apply Momentum Threshold Autoregressive (M-TAR) model proposed by Ender & Granger (1998) and Enders & Siklos (2001). These models are equipped to provide the requisite empirical evidence favorable to the validity of the present value by permitting short-run asymmetric stock price adjustment or error correction mechanisms.

Past empirical research show that rational bubbles exist in Taiwan's stock market (Chang, 1988; Lin and Ko, 1993; Sheng and Chang, 2000). Most of them use traditional linear Dickey-Fuller unit root and Engle-Granger cointegration test to improve rational bubbles. This present empirical study contributes significantly to this field of research because, firstly, it determines whether rational bubbles exist in Taiwan's stock market for which we use the M-TAR model of Ender & Granger (1998) and Enders & Siklos (2001). Second, we rely in our paper on a present value model with time-varying expected returns and a general class of processes to model bubble-like deviations from the long-run equilibrium. Third, to the best of our knowledge, this study is the first of its kind to apply the M-TAR technique, which allowing us to draw conclusions in the long-run validity of the present value model and, hence, addresses the question of whether Taiwanese stock prices adhere to fundamentals in the long-run. Finally, investigating the short-run dynamics under the M-TAR approach provides a test concerning the importance of bubble-like processes in stock prices.

The framework of the remainder of this paper is as follows. In section 2, we provide the theoretical background. Section 3 briefly describes the M-TAR unit root and cointegration test of Enders and Siklos (2001). Section 4 presents the data we use in our study and our empirical results are shown in Section 5. Finally, Section 6 concludes the paper.

2. Present Value Model

This paper investigates whether a long-run relationship exists between dividends and prices using a cointegration methodology. The framework for our study is a present value model which relates the real stock price, P_t, to its discounted expected future real dividends, D_t, using either a constant or a time-varying expected return (or discount rate). In particular it has been applied to test present value models for stock prices:

$$P_t = \frac{1}{(1+R)} E_t (P_{t+1} + D_{t+1}), \qquad 0 < (1+R)^{-1} < 1 \tag{1}$$

where E_t denotes the conditional expectations operator, P_t denotes the real price at time t, D_t is the time t real dividend, R is the expected real return (assumed constant). If the transversality condition holds, then the real stock price is equal to the fundamental value P_t. Following Campbell and Shiller (1987), it implies:

$$P_t - \frac{D_t}{R} = \left(\frac{1}{R}\right) E_t \left[\sum_{i=1}^{\infty} \left(\frac{1}{1+R}\right)^i \right] \Delta D_{t+i} \tag{2}$$

where Δ denotes first differences. If both (real) stock prices and dividends are non-stationary, then under a no-bubbles assumption such that the right-hand-side of (2) is stationary ($I(0)$), P_t and D_t will be cointegrated with the cointegrating vector equal to $\left[-1, 1/R\right]$.

When the relation between prices and returns are nonlinear, stock price behavior should be time-varying. If we still use the assumption of constant return, it will yield estimated errors. Campbell and Shiller (1988a, 1988b) proposed a log-linear approximation of the present value framework, which enables the investigation of stock prices' behavior under any model of expected returns. It leads to the following present value equation:

$$p_t = \frac{\phi}{1-\lambda} + E_t\left[\sum_{i=1}^{\infty} \lambda^i ((1-\lambda)d_{t+i} - r_{t+i})\right] \tag{3}$$

where p_t denotes the log of real stock price, d_t the log of the dividend payment, and r_t the log of the time-varying discount rate. ϕ and λ are linearizatiom parameters.

Rewriting Eq. (3) in terms of the log dividend-price ratio, we yield:

$$d_t - p_t = -\frac{\phi}{1-\lambda} + E_t\left[\sum_{i=1}^{\infty} \lambda^i (-\Delta d_{t+i} + r_{t+i})\right] \tag{4}$$

Given that changes in the log dividend and the discount rate follow process, then the log stock price and the log dividends are cointegrated with the cointegrating vector $\left[1,-1\right]$ and the log dividend-price ratio is a stationary process (see Cochrane & Sbordone, 1988; Craine, 1993).

When expected returns vary over time, the present value model does not generally imply the existence of a stationary relationship between the integrated level variables P_t and D_t. In contrast, cointegration tests that rely on the log dividend-price ratio are valid in the presence of time-varying expected returns. If there are no long-run relationships between stock prices and dividends, it means there exist rational bubbles in Taiwan's stock market Taiwan's stock market may have rational bubbles. Consequently, our empirical investigation is based on the testable implications of the present value model (4) with time-varying expected returns.

Moreover, the findings contained in Ender and Granger (1998) and Enders and Siklos (2001) demonstrate the low power properties of conventional test approaches in the presence of asymmetric departures from the long-run equilibrium. The findings make clear that M-TAR's design captured certain types of asymmetric adjustment behavior needed to obtain deeper insights into the characteristics of the log dividend-price ratio and stock price behavior.

3. Testing for Threshold Adjustment

3.1 M-TAR unit-root tests and dividend-price ratio

The standard Dickey-Fuller (1979) test assumes a unit root as the null hypothesis and a symmetric adjustment process under the alternative. However, the implicit assumption of linear adjustment is problematic. If adjustment to the long-run value of log dividend-price ratio is asymmetric, the standard unit-root test and its corresponding error correction representation may entail a misspecification error. A formal way to quantify an asymmetric adjustment process as a generalization of the Dickey-Fuller test is given by the MTAR model proposed by Ender & Granger(1998) and Enders & Siklos (2001):

$$\Delta(d-p)_t = I_t\rho_1(d-p)_{t-1} + (1-I_t)\rho_2(d-p)_{t-1} + \sum_{i=1}^{I}\gamma_i\Delta(d-p)_{t-i} + \varepsilon_t \tag{5}$$

where the indicator variable is defined as:

$$I_t = \begin{cases} 1, & if \ \Delta(d-p)_{t-1} \geq \tau \\ 0, & if \ \Delta(d-p)_{t-1} \leq \tau \end{cases} \tag{6}$$

where ε_t is a white-noise disturbance and the residuals, I_t is the Heaviside indicator function such that $I_t = 1$ if $\Delta(d-p)_{t-1} \geq \tau$ and $I_t = 0$ if $\Delta(d-p)_{t-1} \leq \tau$, where τ is the threshold value. A necessary condition for { $\Delta(d-p)_{t-1}$ } to be stationary is: $-2 < (\rho_1, \rho_2) < 0$. If the variance of ε_t is sufficiently large, 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 there is no convergence in the regime with the unit-root (i.e., the regime in which $\rho_j = 0$), large realization of ε_t will switch the system into the convergent regime. Enders and Granger (1998) and Enders and Siklos (2001) both point out in either case, under the null hypothesis of no convergence, the *F*-statistic for the null hypothesis $\rho_1 = \rho_2 = 0$ has a nonstandard distribution. The critical values for this non-standard *F*-statistic are tabulated in their paper. Enders and Granger (1998) also showed that if the sequence is stationary, the least squares estimates of ρ_1 and ρ_2 have an asymptotic multivariate normal distribution.

According to Enders and Granger (1998), this model is especially valuable when adjustment is asymmetric such that the series exhibits more ‘momentum’ in one direction than the other. This model is termed Momentum-Threshold Autoregressive Model (M-TAR). The M-TAR model allows the autoregressive decay to depend on $\Delta(d-p)_{t-1}$. As such, the M-TAR representation can capture ‘sharp’ movements in a sequence.

In the most general case, the value of τ is unknown, it needs to be estimated along with the value of ρ_1 and ρ_2. By demeaning the $(d-p)_t$ 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. For instance, if autoregressive decay is more sluggish for positive deviations of $\Delta(d-p)_{t-1}$ from τ than for negative deviations, the sample mean estimator will be biased upwards. A consistent estimate of the threshold τ can be obtained by using Chan’s (1993) method of searching over possible threshold values to minimize the residual sum of squares from the fitted model. Enders and Siklos (2001) applied Chan's methodology to a Monte Carlo study to obtain the F-statistic for the null hypothesis of $\rho_1 = \rho_2 = 0$ when the threshold τ is estimated using Chan's procedure. The critical values of this non-standard F-statistic for testing the null hypothesis of $\rho_1 = \rho_2 = 0$ are also tabulated in their paper. As there is generally no presumption as to use M-TAR model, the recommendation is to select the adjustment mechanism by a model selection criterion such as the AIC.

The M-TAR model sets up the null hypothesis of a unit root in the log dividend-price ratio, that is, $H_0 : \rho_1 = 0$, $H_0 : \rho_2 = 0$, and $H_0 : \rho_1 = \rho_2 = 0$. The distributions for these statistics are non-statistics and non-standard. Enders & Granger (1998) and Enders & Siklos (2001) used simulation to get critical values. If the null hypothesis is rejected, the null hypothesis of symmetric adjustment is $H_0 : \rho_1 = \rho_2$. If we cannot reject the null hypothesis $H_0 : \rho_1 = \rho_2$, we can conclude in favor of a linear and symmetric adjustment in the log dividend-price ratio.

3.2 M-TAR Cointegration Tests

In this paper, we employ the threshold cointegration technique advanced by Enders and Siklos (2001) to test for stock index price and dividends with asymmetric adjustment in Taiwan Stock Exchange Capitalization Weighted Stock Index (TAIEX) and seven industries.[1] This test involves a two-stage process. In the first stage, we estimate a long-run equilibrium relationship of the form:

$$P_t = \alpha_0 + \alpha_1 D_t + u_t \tag{7}$$

where P_t and D_t represent the logarithm of stock price index and dividends respectively, and u_t is the stochastic disturbance term. The second stage focuses on the OLS estimates of ρ_1 and ρ_2 in the following regression:

$$\Delta u_t = I_t \rho_1 u_{t-1} + (1 - I_t) \rho_2 u_{t-1} + \sum_{i=1}^{l} \gamma_i \Delta u_{t-i} + \varepsilon_t \tag{8}$$

where ε_t is a white-noise disturbance and the residuals, μ_t, in (7) are extracted to (8) to be further estimated. I_t is the Heaviside indicator function such that $I_t = 1$ if $\Delta u_{t-1} \geq \tau$ and $I_t = 0$ if $\Delta u_{t-1} \leq \tau$, where τ is the threshold value. For the case of cointegration, let ϕ and ϕ^* be the *F*-statistics for testing the null hypothesis of $\rho_1 = \rho_2 = 0$ under the M-TAR representation. The distribution of ϕ and ϕ^* are determined by the number of variables in the cointegrating relationship. Enders & Siklos (2001) and Enders & Dibooglu (2002) showed that the power of ϕ^* test exceeds that of the Engle-Granger test for a reasonable range of asymmetry, while the power of ϕ-statistic increases relative to Engle-Granger (1987) test when the degree of asymmetry increases.

4. Data

[1] The industries are included Cement, Foods, Plastics & Chemicals, Textile, Electric & Machinery, Construction and Finance.

We analyze the monthly data for stock price index (P_t) and dividends (D_t) taken from Taiwan Economic Journal (TEJ) database during the June 1991 to February 2005 period. The data begin from June 1991 since dividend data are available from this period. Our empirical analysis focuses on Taiwan's group stock price indices, which are TAIEX, Cement, Food, Plastics & Chemicals, Textile, Electric & Machinery, Construction and Finance. Otherwise, we use Consumer Price Index (CPI) to deflate stock price index and dividends. The purpose is that we can get real price and dividends.

5. Empirical Results

As a first step, we test TAIEX and seven industries' log dividend-price ratio using the M-TAR specifications using the threshold $\tau = 0$, respectively reported in Table 1. Diagnostic statistics and the values of the AIC are used to select appropriate lag changes. From Table 1 we can only find that the Textile industry is estimated with adjustments using M-TAR. It means that in other industries, prices do not follow their fundamental values. But in Table 2 using the Chang (1993) method to find the threshold τ , we can find the null hypothesis of no convergence is rejected because the log dividend-price ratio is stationary with asymmetry adjustment. The industries include TAIEX, textile, electric & machinery, construction and finance. Hence, our empirical evidence generally supports the majority of all industries with long-run validity of the present value model with time-varying expected returns for the Taiwan's stock market. Furthermore, the majority of cases shows that ρ_1 and ρ_2 are statistically significantly mixed. The absolute value of parameter ρ_2 is higher compared to the estimated ρ_1 coefficient, except the Construction and Finance industry. The *F*-statistic rejects the null hypothesis of symmetric adjustment, expect for the cement industry. Hence, it is reasonable to conclude that the log dividend-price rates are stationary, and the adjustment mechanisms are asymmetric.

Table 1 *Estimated adjustment equations using momentum threshold unit test with zero threshold*

Industry	ρ_1	ρ_2	Φ_μ [1]	$\rho_1 = \rho_2$ [2]	AIC	Lags	Q(4)
Asymmetric adjustment with $\tau = 0$							
TAIEX	0.018	-0.021	1.851	3.702**	91.729	1	3.419
Cement	-0.013	0.008	0.476	0.809	216.393	3	0.819
Foods	0.009	-0.014	0.487	0.924	189.522	5	0.141
Plastics & Chemicals	0.017	-0.021	1.067	2.093	214.375	2	0.839
Textile	0.041**	-0.054**	4.141**	8.028***	262.934	2	1.143
Electric & Machinery	0.003	-0.013	0.339	0.422	175.529	4	0.731
Construction	0.001	-0.026	0.959	0.964	300.144	1	4.155
Finance	-0.011	0.005	0.191	0.259	210.242	6	0.054

Note: *, **, *** indicate significance levels at 10%, 5% and 1% respectively.

[1]Entries in this column are the *F*-statistics for the null hypothesis $\rho_1 = \rho_2 = 0$. This test follows a non-standard distribution so the test statistics are compared with critical values reported by Enders and Granger (1998).

[2] the numbers reported in this column are *F*-statistics of symmetric adjustment.

Table 2 *Estimated adjustment equations using momentum threshold unit test with consistent estimate of the threshold*

Industry	ρ_1	ρ_2	Φ_μ [1]	$\rho_1 = \rho_2$ [2]	AIC	Lags	τ	Q(4)
Asymmetric adjustment with τ =threshold								
TAIEX	0.021**	-0.038**	3.971**	7.943***	87.559	1	-0.03000	1.000
Cement	-0.013	0.026	1.015	1.886	215.268	3	-0.05635	0.583
Foods	-0.013	0.040	1.617	3.184*	187.191	5	-0.00824	0.357
Plastics & Chemicals	0.013	-0.047*	1.906	3.772**	212.685	2	-0.05227	0.517
Textile	0.057***	-0.096***	10.807***	21.339***	250.435	2	-0.02260	0.186
Electric & Machinery	0.011	-0.073***	3.792**	7.317***	168.509	4	-0.10200	0.142
Construction	-0.067**	0.004	3.041*	5.101**	296.007	1	0.12541	2.106
Finance	0.0419*	-0.028*	3.025*	5.923***	204.397	6	-0.06957	0.168

Note: *, **, *** indicate significance levels at 10%, 5% and 1% respectively.

[1]Entries in this column are the *F*-statistics for the null hypothesis $\rho_1 = \rho_2 = 0$. This test follows a non-standard distribution so the test statistics are compared with critical values reported by Enders and Granger(1998).

[2]the numbers reported in this column are *F*-statistics of symmetric adjustment.

Table 3 reports the application of the Engle-Granger procedure to equation (7). For each industry the lag length was selected using the Akaike Information Criteria (AIC). The Engle-Granger cointegration test results indicate that the null of no cointegration can be rejected. The outcome is the same as claiming rational bubbles are existent in the Taiwan stock market (Chang, 1988; Lin and Ko, 1993; Sheng and Chang, 2000) when they used traditional linear Dicky-Fuller test. The absence of a long-run relationship between prices and dividends in these initial tests might be attributed to the employment of linear tests for mean reversion. There are in fact asymmetries in any adjustment toward fundamental values with respect to positive and negative shocks. Moreover, these tests for symmetric cointegration have low power against a background of asymmetric adjustments. Therefore, we pursue threshold cointegration tests. The results of the threshold cointegration test with zero threshold are shown in Table 4. The null hypothesis of $\rho_1 = \rho_2 = 0$ can be rejected for five industries. These results indicate that rational bubbles do not exist for most industries. Thus, the relationship between prices and dividends generally fails, assuming linear adjustment or allowing for asymmetric adjustment using a threshold value of zero. Given the presence of measurement errors and/or adjustment costs, there is no reason to presume that the threshold is equal to zero. As shown in Table 5, widespread support for the theory is found when Chan's method is used to obtain a consistent estimate of thresholds. The MTAR model uses the AIC model to select criterion. We find there is strong evidence of no rational bubbles between the prices and dividends, except in foods and finance industries. A major difference from the results previously reported in Table 3 indicates that the case for cointegration is substantially strengthened when asymmetries are accounted for. In addition, whenever rational bubbles do not exist, the null hypothesis of symmetric adjustment is also rejected. The tests support the prediction under time-varying present value models that the following five industries are cointegrated: TAIEX, Cement, Plastics & Chemicals, Textile, Electric & Machinery and Construction. In addition, in most cases (7 out of the total 8 industries) there is evidence that $|\rho_1| < |\rho_2|$ implying that the speed of adjustment toward fundamental values is faster in the case of a negative shock with respect to μ_t. For example, the rate of the textile industry converges to its fundamental value, τ, at the rate of 9.3% for a positive deviation and 25.7% for a negative deviation.

Table 3 The estimated adjustment equations using the standard cointegration test

Industry	ρ [1]	AIC	Lags
Symmetric adjustment			
TAIEX	-0.0887 (-3.4556)	-115.3418	1
Cement	-0.1588 (-3.8207)	-34.6435	0
Foods	-0.0397 (-1.9906)	-51.5182	1
Plastics & Chemicals	-0.1044 (-2.9666)	-48.9067	0
Textile	-0.1229 (-3.2972)	-11.0939	2
Electric & Machinery	-0.0942 (-3.2409)	-34.4345	2
Construction	-0.1029 (-2.9651)	25.4451	0
Finance	-0.0774 (-2.7234)	-30.4631	0

Notes: [1]The critical vales of *t*-statistics for the null hypothesis $\rho = 0$ with three variables in the cointegrating relationship are -4.73, -4.11, and -3.83 at the 1%, 5% and 10% significance levels respectively.

Table 4 *Estimated adjustment equations using momentum threshold cointegration test with zero threshold*

Industry	ρ_1	ρ_2	Φ_μ [1]	$\rho_1 = \rho_2$ [2]	AIC	Lags	Q(4)
Asymmetric adjustment with $\tau = 0$							
TAIEX	-0.088**	-0.089**	5.969**	0.001	-46.613	1	1.683
Cement	-0.146**	-0.212***	7.226**	0.589	109.722	3	1.642
Foods	-0.031	-0.037	1.457	0.020	78.489	2	0.713
Plastics & Chemicals	-0.169***	-0.054	5.349*	2.647	85.379	3	0.307
Textile	-0.072	-0.173***	6.482**	1.968	156.430	2	1.291

Electric & Machinery	-0.107**	-0.099**	5.484*	0.017	112.756	4	0.327
Construction	-0.079	-00112**	3.249	0.209	232.047	3	1.889
Finance	-0.056	-0.074*	2.219	0.090	119.287	5	0.029

Note: *, **, *** indicate significance levels at 10%, 5% and 1% respectively.

[1]Entries in this column are the *F*-statistics for the null hypothesis $\rho_1 = \rho_2 = 0$. This test follows a non-standard distribution so the test statistics are compared with critical values reported by Enders and Siklos(2001).

[2]the numbers reported in this column are *F*-statistics of symmetric adjustment.

Table 5 *Estimated adjustment equations using momentum threshold cointegration test with consistent threshold*

Industry	ρ_1	ρ_2	Φ_μ [1]	$\rho_1 = \rho_2$ [2]	AIC	Lags	τ	Q(4)
Asymmetric adjustment with τ =threshold								
TAIEX	-0.188***	-0.064**	8.072**	3.914**	-50.552	1	0.05834	2.399
Cement	-0.137**	-0.294***	8.443**	2.826*	107.439	3	-0.06409	1.509
Foods	0.0045	-0.057**	2.536	2.140	76.330	2	0.03433	0.762
Plastics & Chemicals	-0.209***	-0.057	6.057*	3.995**	84.016	3	0.03846	0.739
Textile	-0.093**	-0.257***	7.129**	3.179*	155.208	2	-0.12239	1.533
Electric & Machinery	-0.092**	-0.193*	6.179*	1.315	111.413	4	-0.10810	0.371
Construction	-0.026	-0.278***	8.844***	10.964***	221.328	3	-0.08751	1.221
Finance	-0.134**	-0.049	2.859	1.333	117.993	5	0.07323	0.045

Note: *, **, *** indicate significance levels at 10%, 5% and 1% respectively.

[1]Entries in this column are the *F*-statistics for the null hypothesis $\rho_1 = \rho_2 = 0$. This test follows a non-standard distribution so the test statistics are compared with critical values reported by Enders and Siklos(2001).

[2]the numbers reported in this column are *F*-statistics of symmetric adjustment.

Having found evidence supporting asymmetric adjustment, an asymmetric error-correction model can be used to investigate the movement of variables to the long-run equilibrium relationship. We estimate the following system of asymmetric error-correction models for each industry:

$$\begin{aligned} \Delta P_t &= \alpha_{10} + \sum_{i=1}^{K} \alpha_{1i} \Delta P_{t-i} + \sum_{i=1}^{K} \beta_{1i} \Delta D_{t-i} + \gamma_{1P} Z_{t-1}^{+} + \gamma_{2P} Z_{t-1}^{-} + \varepsilon_{1t} \\ \Delta D_t &= \alpha_{20} + \sum_{i=1}^{K} \alpha_{2i} \Delta P_{t-i} + \sum_{i=1}^{K} \beta_{2i} \Delta D_{t-i} + \gamma_{1D} Z_{t-1}^{+} + \gamma_{2D} Z_{t-1}^{-} + \varepsilon_{2t} \end{aligned} \tag{9}$$

where $Z_{t-1}^{+} = I_t \mu_{t-1}$ and $Z_{t-1}^{-} = (1 - I_t)\mu_{t-1}$, μ_{t-1} is the residual from equation (7), $I_t = 1$ if $\Delta u_{t-1} \geq \tau$ and $I_t = 0$, otherwise. The choice of the appropriate lag length is based on the multivariate AIC. The choice of non-zero threshold follows the same procedure outlined earlier. The estimated asymmetric error-correction models with consistent estimate of thresholds are shown in Table 6. The estimated coefficients of Z_{t-1}^{+} and Z_{t-1}^{-}

determine the speed of adjustment for positive and negative deviations from fundamental values, respectively. We found that positive deviations from values are eliminated quicker than negative deviations and the price (not the dividends) is responsible for most of the adjustments. The results reported in Table 6 highlight more generally the roles played by price adjustment. Furthermore, we found that the speed of adjustment coefficients on dividend levels tend to be small in magnitude and statistically insignificant. For comparison purposes, we also estimate symmetric error-correction models for each industry. But, results reported in Table 6 indicate that the dividend (not the price) is responsible for most of these adjustments.

Table 6 *The estimated asymmetric error-correction models*

	Linear ECM	Threshold ECM			
Industry	ρ	Lags	ρ_1	ρ_2	τ
TAIEX					
Δp_t	0. 026 (1.435)	1	-0.139*** (-2.746)	-0.037 (-1.421)	0.05834
Δd_t	-0.084*** (-3.733)	1	-0.076** (-2.140)	-0.094** (-2.175)	-0.07046
Cement					
Δp_t	0. 042* (1.783)	1	-0.075* (-1.771)	-0.103 (-1.638)	-0.06409
Δd_t	-0.129*** (-4.208)	1	0. 165 1. (1.631)	0. 168*** (3.264)	0.09058
Plastics & Chemicals					
Δp_t	0. 055* (1.700)	3	-0.189*** (-3.299)	-0.039 (-0.931)	0.03846
Δd_t	-0.088*** (-2.859)	3	-0.134* (-1.897)	-0.019 (-0.491)	0.04265
Textile					
Δp_t	0. 066*** (2.389)	2	-0.093** (-2.563)	-0.077 (-0.865)	-0.12239
Δd_t	-0.117*** (3.126)	2	-0.051 (-1.407)	-0.086 (-0.774)	0.07723
Electric & Machinery					
Δp_t	0. 054*** (2.996)	4	-0.0759** (-2.524)	-0.224*** (-2.934)	-0.10810
Δd_t	-0.015 (-0.872)	4	-0.038* (-1.797)	-0.014 (-0.302)	0.11841
Construction					
Δp_t	0. 028 (1.337)	1	-0.056* (-1.911)	-0.025 (-0.551)	-0.08751
Δd_t	-0.081*** (-2.861)	1	-0.008 (-0.112)	0. 112*** (2.954)	0.09345

Note: *t*-Statistics are in parentheses,. *, **, *** indicate significance levels at 10%, 5% and 1% respectively

6. Conclusions

The purpose of this paper is to investigate whether rational bubbles exist in Taiwan's stock market. A large part of the current debate on Taiwan stock price behavior concentrated on the question of whether stock prices are driven by fundamentals. We found that the present value model with time-varying expected returns (Campbell & Shiller, 1988a, 1988b) provides an empirically valid description of Taiwan stock price behavior. We apply the momentum threshold autoregressive (MTAR) method by Enders & Granger (1998) and Enders & Siklos (2001) for Taiwan's stock market. Compared to conventional cointegration approach, this technique produces more convincing evidence of the time series properties of the dividend and price, because it is flexible enough to capture non-linear adjustment patterns. These findings support the existence of stock price increases relative to its fundamentals. Hence, these results reveal that stock prices adhere to dividends and rational bubbles were nonexistent in Taiwan's stock market during June 1991 to February 2005.

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