Asymmetric Dividend Smoothing of the Aggregate Stock Market*

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This paper explores the asymmetric dividend smoothing behavior of the aggregate stock market. We extend the Lintner (1956) model so as to incorporate asymmetry in the dividend payout policy, which involves the regime-dependent adjustment costs depending on the deviations of the actual dividends from the permanent earnings. We find a strong evidence of the threshold effect in the adjustment process of the aggregate real dividends when real stock prices are used for the permanent earnings. The empirical results indicate that the dividend decision accompanies asymmetric smoothing behavior of the aggregate dividends.

Key words: Asymmetry; Dividend smoothing; Signaling; Stickiness
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1. Introduction

The behavior of dividend smoothing is the one of the most stylized facts found in the corporate payout policy. The smoothing behavior is associated with the managerial reluctance to the deviations of the actual dividends from the long-run sustainable target level or permanent earnings, which generates the stickiness of the dividends. The dividend smoothing behavior has been analyzed in several studies such as Lintner (1956), Fama and Babiak (1968), Marsh and Merton (1987), and Garrett and Priestley (2000). In this paper, we consider the asymmetric dividend smoothing behavior of the aggregate stock market. We extend the Lintner model so as to incorporate asymmetry in the dividend payout policy.

The pioneering work by Lintner (1956) uses the partial adjustment model to explain the sticky dividend behavior. The subsequent studies have extended and evaluated the Lintner model by using the comprehensive micro level data of individual firms in Fama and Babiak (1968) and the different measure of permanent earnings in Marsh and Merton (1987). In particular, Garrett and Priestley (2000) generalized the Lintner model using the objective function of the dividend decision. The objective function is based on the deviations of the actual dividends from the permanent earnings or the target level and the adjustment costs.

The partial adjustment process used in Lintner (1956) and subsequent studies to explain the dividend smoothing behavior posits the linear error correction, where the change in dividends is linearly associated with the deviations of the actual dividends from the target level. While most previous studies analyzed the dividend behavior in the linear functional form, there exist some arguments for asymmetric smoothing behavior of the dividends. Jalilvand and Harris (1984) have examined the process of partial adjustment by allowing the speed of adjustment to vary by firms and over time according to the size of firm and the capital market conditions such as interest rates and stock prices. Marsh and Merton (1987) supported asymmetric adjustment of dividends in explaining the deterministic component of their model, "……the standard textbook proposition that, if the current payout is high relative to permanent earnings and therefore the retention rate is low, then dividends per share will be expected to grow more slowly than if the current payout were lower and the retention rate were corresponding higher."

An important feature of the corporate dividend behavior is that the dividend policy may vary according to the firm's financial condition. The signaling hypothesis implies that the dividend adjustment is associated with the change in permanent earnings, as explained by Bhattacharya (1979) and Miller and Rock (1985). While managers are reluctant to cut dividends, the dividend adjustment is necessary with respect to the change in capital structure and dividend targets. DeAngelo and DeAngelo (1990) have provided the empirical evidence of the dividend policy adjustments to financial distress associated with multiple losses during 1980-1985. Dividends are cut more often than omitted, and some of reductions have been strategically motivated to enhance the bargaining position with organized labor.

In this paper, we hypothesize the asymmetric adjustment in the aggregate dividends, which the dividend adjustment varies according to the dividend deviations from the target dividends. Garrett and Priestley (2000) have extended Lintner's partial adjustment model with a modification of the objective function.[1] Here, we consider the adjustment cost for revising the dividend decision, which varies depending on the current state and the magnitude of the deviations of the dividends from the target level. In other words, the degree of dividend stickiness may depend on the sign and the magnitude of the dividend deviations from the target level.

We explore the asymmetric dividend smoothing behavior based on the regime-dependent adjustment cost model, where the adjustment cost of dividends depends on the state of the difference between the actual dividends and the target level. For example, the adjustment cost of dividends faced by managers may be low (or high) when the permanent earnings increase and the previous dividends are below the target than when the permanent earnings decrease and the dividends are above the target. In terms of the adjustment speed, when the actual dividends are above the target, the speed of adjustment may be faster (or slower) than when those are below the target.

From the optimization problem with the regime-dependent adjustment cost, we derive the econometric model in which the dividends follow the nonlinear error correction process. Therefore, the threshold vector error correction model (VECM) proposed by Hansen and Seo (2002) can be applied to estimate the asymmetric adjustment behavior

[1] Garrett and Priestley (2000) point out that the Lintner model has an unattractive feature of uniform penalization to the adjustment of dividends regardless of whether the adjustment brings the actual value closer to the target. In their model, the movement toward the target lowers the adjustment costs although the adjustment costs prevent a complete movement to the target.

of the aggregate dividends. Specifically, this paper analyzes the asymmetric adjustment behavior of the aggregate dividends in U.S. stock market with the threshold VECM, which allows for nonlinear adjustment cost and the long-run relationship. Using the aggregate dividends for the S&P500 stock price index and the real stock prices for a proxy of the target dividends, we find a significant evidence of the threshold effect in the dividend smoothing behavior over the period 1871Q1-2004Q2. This result suggests that the adjustment costs of dividends are regime-dependent. In the lower regime where the deviations of the actual dividends from the target are less than the threshold point, the adjustment costs are heavier than those are in the upper regime. Thus, the dividend smoothing behavior mainly comes from the upward stickiness in the adjustment process. In addition, the dividend adjustment signals the change in permanent earnings more strongly in the upper regimes than in the lower regimes.

The rest of this paper is organized as follows. In the next section, the nonlinear version of the Lintner model is derived from the regime-dependent quadratic objective function. Section 3 deals with the econometric methods to assess the asymmetric dividend smoothing behavior. The empirical results are provided in section 4.

2. The Model

The corporate dividend decision can be based on the loss function, which depends on the deviations of the dividends from the target level and the adjustment costs of revising the dividends from the long-run growth rate. The pervasive presence of the adjustment costs implies dividend smoothing or stickiness of the dividend behavior. Garrett and Priestley (2000) incorporate the adjustment costs in the loss function. Due to the adjustment costs, firms cannot adjust dividends completely to the target dividends, but instead the gradual adjustment implies a pattern of partial adjustment.

The Lintner model can be derived from the following optimization problem:

$$\underset{\{d_t\}}{Min} \quad L = \phi(d_t - d_t^*)^2 + \varphi(\Delta d_t - g)^2, \tag{1}$$

where d_t is the observed dividends, d_t^* is the target dividends, $\Delta d_t = d_t - d_{t-1}$, and g is the long-run growth rate. The parameters ϕ and φ are positive, which stand for the cost of dividend deviations from the target level and the adjustment cost of revising the change in dividends from the long-run growth rate, respectively.

If we solve the problem (1) with respect to d_t, then Lintner's partial adjustment model can be derived as follows:

$$\Delta d_t = \frac{\varphi}{\phi + \varphi} g + \frac{\phi}{\phi + \varphi}(d_t^* - d_{t-1}). \tag{2}$$

As Lintner (1956) shows, the dividend decision involves stickiness in the sense that managers are willing to avoid making changes in dividends that stand a good chance of having to be reversed within the near future if reversals or changes are costly. This indicates that the partial adjustment coefficient ($\phi/(\phi + \varphi)$) in equation (2) is likely to be close to 0, which can be implied by the significant size of the adjustment cost. If dividend decisions can be made without the adjustment cost, the partial adjustment coefficient should be one, and the deviations of deviation do not exist.

In this paper, we extend the Lintner model with regime-dependent adjustment costs. We assume that the adjustment costs vary depending on the dividend deviations from the target level in the previous period. With the regime-dependent adjustment costs, the dividend decision can be based on the optimization problem as follows:

$$\begin{aligned} \underset{\{d_t\}}{Min} \quad L = \phi(d_t - d_t^*)^2 & \\ + \varphi_1(\Delta d_t - g)^2 \cdot 1(d_{t-1} - d_{t-1}^* \le \gamma) & \qquad (3) \\ + \varphi_2(\Delta d_t - g)^2 \cdot 1(d_{t-1} - d_{t-1}^* > \gamma), & \end{aligned}$$

where $1(\cdot)$ is the indicator function, and γ is the threshold parameter.

Compared to Lintner's problem, the adjustment costs are regime-dependent. In the lower regime, where the deviations of the actual dividend from the target level are no more than the threshold value γ, the adjustment cost accompanies the parameter φ_1. In the upper regime, where the deviations are greater than the threshold value, the adjustment cost involves the parameter φ_2. Thus, the adjustment costs can be different depending on the state of dividend deviations from the target level.

The minimization of the loss function (3) yields the dividend decision as follows:

$$\begin{aligned} \Delta d_t = & [(\frac{\varphi_1}{\phi + \varphi_1})g - (\frac{\phi}{\phi + \varphi_1})(d_{t-1} - d_t^*)] \cdot 1(d_{t-1} - d_{t-1}^* \le \gamma) \\ & + [(\frac{\varphi_2}{\phi + \varphi_2})g - (\frac{\phi}{\phi + \varphi_2})(d_{t-1} - d_t^*)] \cdot 1(d_{t-1} - d_{t-1}^* > \gamma). \qquad (4) \end{aligned}$$

The dividend decision (4) follows a nonlinear partial adjustment model, where the coefficient of $d_{t-1} - d_t^*$ is $-\phi/(\phi + \varphi_1)$ in the lower regime ($d_{t-1} - d_{t-1}^* \le \gamma$) and

$-\phi/(\phi+\varphi_2)$ in the upper regime ($d_{t-1}-d^*_{t-1}>\gamma$). If the adjustment cost does not depend on the state of dividend deviations from the target $(\varphi=\varphi_1=\varphi_2)$, the dividend decision (4) reduces to the linear partial adjustment model (2). Thus, our model generalizes the Lintner model.

We assume that the permanent earnings or the desired dividends follow a Martingale process.

$$d^*_t = d^*_{t-1}+\varepsilon_t, \tag{5}$$

where $E_{t-1}(\varepsilon_t)=0$.

The dividend decision now can be written as follows:

$$\begin{aligned}\Delta d_t &= [\mu_1+\alpha_1(d_{t-1}-d^*_{t-1})]\cdot 1(d_{t-1}-d^*_{t-1}\le\gamma)\\ &\quad +[\mu_2+\alpha_2(d_{t-1}-d^*_{t-1})]\cdot 1(d_{t-1}-d^*_{t-1}>\gamma)+u_t,\end{aligned} \tag{6}$$

where $\mu_1=(\frac{\varphi_1}{\phi+\varphi_1})g$, $\alpha_1=-\frac{\phi}{\phi+\varphi_1}$, $\mu_2=(\frac{\varphi_2}{\phi+\varphi_2})g$, $\alpha_2=-\frac{\phi}{\phi+\varphi_2}$, and

$$u_t=[(\frac{\phi}{\phi+\varphi_1})\cdot 1(d_{t-1}-d^*_{t-1}\le\gamma)+(\frac{\phi}{\phi+\varphi_2})\cdot 1(d_{t-1}-d^*_{t-1}>\gamma)]\cdot\varepsilon_t.$$

From the Martingale assumption (5), the error term satisfies $E_{t-1}(u_t)=0$, where $E_{t-1}(\cdot)$ is the conditional expectation operation using the information given at period $t-1$. The error term can be heteroskedastic, and we deal with these issues in section 3.

Equation (6) represents the threshold error correction process, in which the adjustment coefficient and the intercept vary depending on the state. The state can be decided based on the dividend deviations ($d_{t-1}-d^*_{t-1}$) and the threshold parameter

$d_{t-1} - d^*_{t-1} \le \gamma$. In the lower regime ($d_{t-1} - d^*_{t-1} \le \gamma$), the adjustment process of the dividends is governed by the coefficients μ_1 and α_1 . In the upper regime ($d_{t-1} - d^*_{t-1} > \gamma$), the adjustment process accompanies the coefficients μ_2 and α_2 .

The error correction representation (6) renders the dividends to adjust to the dividend deviations from the target level at time period $t-1$. This representation can be rationalized in that the response of the dividend policy may be delayed when there is unanticipated change in the target dividends, which is induced by the change in the permanent earnings. The aggregate dividends, as explained by Marsh and Merton (1987), may show slow reaction because of the difference in the dates of dividend announcement and the wide spectrum of the reaction speed across heterogeneous firms.

3. Econometric Methods

In this section, we develop econometric methods that can be used to estimate the asymmetric dividend smoothing behavior. One problem in estimating equation (6) is that we cannot observe the target dividends. The target dividends are measured by accounting earnings in Lintner (1956) and Fama and Babiak (1968). Marsh and Merton (1987) distinguished economic earnings from accounting earnings and defined the target dividends or permanent earnings as a linear function of the stock prices. Garrett and Priestley (2000) specified the target dividends as a linear function of stock prices and earnings.

Our empirical analysis is based on the specification of Marsh and Merton (1987). Lintner's observation is that the dividend adjustment tends to be made in response to an unanticipated and non-transitory change in earnings. Thus, dividend decisions are based on the long-run sustainable earnings or permanent earnings. According to Marsh and Merton (1987), the permanent earnings is related to the intrinsic value of the firm.

We denote $x_t = (d_t, p_t)'$, where d_t is real dividends and p_t is real stock prices in the logarithms. We use the threshold vector error correction model (VECM).

$$\Delta x_t = [\mu_1 + \alpha_1 \omega_{t-1} + \sum_{i=1}^{k} \Gamma_{1,t-i} \Delta x_{t-i}] \cdot 1(\omega_{t-1} \le \gamma)$$

$$+ [\mu_2 + \alpha_2 \omega_{t-1} + \sum_{i=1}^{k} \Gamma_{2,t-i} \Delta x_{t-i}] \cdot 1(\omega_{t-1} > \gamma) + u_t, \tag{7}$$

where $E_{t-1}(u_t) = 0$ and $1(\cdot)$ is the indicator function. The long-run relationship is defined as $\omega_{t-1} = d_{t-1} - \beta p_{t-1}$, which is stationary as discussed by Engel and Granger (1987). The dividend-price relation accompanies the cointegrating vector β.

The threshold vector error correction model has been proposed by Hansen and Seo (2002). They provide the grid-search algorithm for estimating the threshold VECM. Here, we briefly explain the estimation algorithm and the testing for the threshold effect. We define the parameter vector $\theta = (\mu, \alpha, \Gamma_{t-1}, \cdots, \Gamma_{t-k})'$. For the fixed parameter values of β and γ, the threshold VECM can be estimated by linear regression such that

$$\theta_1(\beta, \gamma) = [\sum_{t=1}^{n} z_t z_t' 1(\omega_{t-1} \le \gamma)]^{-1} \sum_{t=1}^{n} z_t x_t' 1(\omega_{t-1} \le \gamma),$$

$$\theta_2(\beta,\gamma)=[\sum_{t=1}^{n} z_t z_t' 1(\omega_{t-1}>\gamma)]^{-1}\sum_{t=1}^{n} z_t x_t' 1(\omega_{t-1}>\gamma),$$

$$\sum(\beta,\gamma)=\frac{1}{n}\sum_{t=1}^{n} u_t(\beta,\gamma)u_t'(\beta,\gamma),$$

where $z_t' = (1,\omega_{t-1},\Delta x_{t-1},\cdots,\Delta x_{t-k})'$ and $u_t(\beta,\gamma)$ is the linear estimates for fixed β and γ in equation (7).

1. Make a grid on [γ_L , γ_U] and [β_L , β_U] based on the linear cointegrating vector estimate $\tilde{\beta}$.

2. For each value of (β,γ) on this grid, calculate $\theta_1(\beta,\gamma)$, $\theta_2(\beta,\gamma)$ and $\sum(\beta,\gamma)$.

3. Get $(\hat{\beta},\hat{\gamma})$ as the values of (β,γ) on this grid which yields the lowest value of $\log|\sum(\beta,\gamma)|$.

4. Find $\sum(\hat{\beta},\hat{\gamma})$, $\theta_1(\hat{\beta},\hat{\gamma})$, $\theta_2(\hat{\beta},\hat{\gamma})$ and $u_t(\hat{\beta},\hat{\gamma})$.

The testing for the threshold effect can be carried out based on the difference between $\theta_1(\hat{\beta},\hat{\gamma})$ and $\theta_2(\hat{\beta},\hat{\gamma})$. However, the threshold parameter cannot be identified under the null hypothesis, and as a result the standard methods cannot be applied. Therefore, we use the SupLM statistic defined in Hansen and Seo (2002), which does not depend on the nuisance parameter.

$$SupLM_n = \underset{\gamma\in[\gamma_L,\gamma_U]}{Sup} LM_n,$$

where γ_L and γ_U satisfy $P(\omega_{t-1}\le\gamma_L)=q$ and $P(\omega_{t-1}>\gamma_U)=1-q,$ respectively. The threshold parameter γ_L is the q-th percentile of the dividend deviations from the target, and γ_U is the $(1-q)$-th percentile. Depending on the degrees of freedom, the value of p can be set at 0.05, 0.10, or 0.15. The SupLM statistic has the nonstandard asymptotic distribution. Therefore, the testing for the threshold effect can be based on the bootstrapping p-values. If the bootstrapping p-values are smaller than the size chosen, we reject the null hypothesis of no threshold effect.

4. Main Results

The data set used in the estimation consists of the Standard and Poor's 500 composite stock price index and the aggregate dividends. The quarterly data set is obtained from the monthly data. The detailed descriptions are referred to Shiller (2000). The data set is extracted from Robert Shiller's web site at http://www.econ.yale.edu/shiller. The sample spans from the period 1871Q1 to 2004Q2. The choice of frequency reflects the fact that the public companies usually pay dividends four times a year. All variables are real values in the logarithms. Figure 1 depicts the time plots of real dividends and real stock prices. The real dividends show smooth movement while the real stock prices reveal volatile movement for the sample period.

The error correction representation (6) assumes the long-run relationship between real dividends and real stock prices. First, we analyze I(1) against I(0) properties using the Augmented Dickey and Fuller (ADF) unit root test. As shown in Table 1, the unit root hypothesis of real stock prices cannot be rejected for the specifications with drift and with drift and trend at the 5% significance level. The unit root hypothesis of real dividends cannot be rejected for the specification with drift only. However, if the linear trend is added, the unit root hypothesis of real dividends can be rejected at the 5% size. This result may come from the fact that the power of the unit root tests depends heavily on the specification of the deterministic trends. In this paper, real dividends are assumed to be I(1) with drift.[2]

As Table 2 shows, one long-run relationship between real dividends and real stock prices can be found from the Johansen (1988) cointegration rank test. The likelihood ratio statistics reject the null hypothesis of no cointegration at the 1% significance level. The long-run relationship supports the assumption that stock prices can be a good proxy variable for the target dividends.

Next, we estimate the linear vector error correction model. Table 3 reports the estimation results. The model without lagged differenced variables ($k = 0$) is consistent with the theoretical model derived in Section 2. The adjustment coefficient of the dividend equation is significant at the 5% significance level. On the other hand, the adjustment coefficient of the stock price equation is not significant. The dividend deviations, if exist, are corrected by the adjustment of dividends. The stock prices do not respond to the dividend deviations. Thus, the stock prices are weakly exogenous with respect to the dividend policy, which supports the irrelevance theorem of Miller and Modigliani (1961) that the dividend policy does not affect the value of firm or stock prices.

[2] Our model assumes that the dividend payments occupy a constant proportion of permanent earnings. Since real stock prices follow the unit root process, real dividends also have the same I(1) property.

The fact that the estimate of the adjustment coefficient in the dividend equation is close to zero supports the dividend smoothing behavior, which comes from managers' reluctance to reverse the dividend policy because reversals or changes are costly. Thus, several studies such as Tsai (2005) point the adjustment cost as the main source of the sluggish movement of dividends. From the linear VECM, the estimate of the adjustment coefficient is about -0.05. Using the relation $\alpha = -\phi/(\phi + \varphi)$, we can infer the relative importance of the adjustment cost (φ) compared to the deviation cost (ϕ).[3]

Next, we consider the asymmetric dividend smoothing behavior of the aggregate stock market. Table 4 shows the results of the testing for asymmetric adjustment in the aggregate dividends. The SupLM statistic for the null hypothesis of symmetric adjustment is calculated at 17.236 with a bootstrapping p-value of 0.019. Thus, the null hypothesis can be rejected for the alternative of asymmetric adjustment at the 5% significance level. This result supports the hypothesis of asymmetric smoothing behavior in the dividend process when real stock prices are used for the target dividends. The tests are based on the threshold VECM without lag and the trimming parameter q=0.10. The bootstrapping p-values are calculated with 1000 bootstrapping replications.

As Table 5 shows, the threshold VECM is estimated using the algorithm of Hansen and Seo (2002). The trimming parameter q is set at 0.10. The standard errors in the parentheses are calculated from the heteroskedasticity-robust covariance estimator. In the threshold VECM without lag, the threshold parameter is estimated at -1.125, and

[3] The parameter of the adjustment cost is 19 times larger than the cost of deviations from the target. Tsai (2005) finds the evidence that the adjustment cost is four times larger than the deviation cost in a different model specification using the monthly data.

consequently $P(\omega_{t-1} \le \gamma)$ and $P(\omega_{t-1} > \gamma)$ correspond to the values of 0.818 and 0.182, respectively. Figure 2 shows the time plot of the dividend deviations from the target. The upper and lower regimes are separated by the estimate of the threshold parameter. The adjustment coefficient of the dividend equation is estimated at -0.017 in the lower regime and it is estimated at -0.183 in upper regime, respectively.

As expected, the estimates of the adjustment coefficient are negative in both regimes. However, the adjustment coefficient in the lower regime is very close to zero and statistically insignificant. If permanent earnings increase, the dividend deviations from the permanent earnings fall into the lower regime. The increase in dividends would correct the dividend deviations, but the deviations prevail as the adjustment coefficient is not strong in the lower regime. Thus, our empirical results indicate an upward stickiness in the dividend behavior when the permanent earnings rise.

In the upper regime, the estimate of the adjustment coefficient is statistically significant. If permanent earnings decrease, the dividend deviations press the dividend payout policy in the direction of reversal. As discussed in DeAngelo and DeAngelo (1990), the managerial reluctance to cut the dividends hinders a complete adjustment, but the financial distress faced by firms lead to a gradual decline in the dividends. Managers are reluctant to reverse dividends because the reversal in the dividend policy may signal the performance of the firm in the near future. However, the discounted sum of dividends cannot exceed to the value of the firm, which is based on the stock prices following the rational expectations model. Although the reversal in the dividend policy is costly, the financial constraints lead to the adjustment of dividends when the permanent earnings decrease. The parameter estimates indicate that the downward stickiness, which appears when the permanent earnings fall, is less pervasive than the upward stickiness.

We also estimate the threshold VECM with one lagged differenced variables $(k = 1)$. The VAR lag order picked by BIC is one. In general, the estimation results are not so much different from those of the model without lagged variables. The linear VECM estimate of the adjustment coefficient is significant at the 5% significance level. For the lagged variables, the coefficient on the lagged differenced variables in the dividend equation is significant statistically. On the other hand, the coefficient in the stock price equation is not significant. This result indicates that the dividends respond to the dividend deviations and the short-run movements of dividends and stock prices. The stock prices are not associated with the dividend deviations and the short-run movements.

Table 5 shows the estimation results of the threshold VECM at the VAR lag order 1. Compared to the model without lagged variables, the adjustment coefficient of the dividend equation is statistically significant in the lower regime. Thus, the dividend deviations from the target in previous period can be corrected by the change in dividends.

5. Concluding Remarks

This study provides a statistical assessment of the asymmetric dividend smoothing behavior of the aggregate stock market. Our analysis is based on a model of the dynamic behavior of aggregate corporate dividends, which involves the regime dependent adjustment costs depending on the sign and magnitude of the difference between the actual and target level of dividends. We find a significant evidence of the threshold effect in the adjustment process of the aggregate dividends when the real stock prices are used for the permanent earnings. The empirical results indicate that the dividend payout involves the regime-dependent adjustment cost. The adjustment cost is heavier in the lower-regime, where the actual dividends are lower than the target level. Thus, there exists an upward stickiness in the dividend smoothing behavior, which is stronger than the downward stickiness. Thus, the upward stickiness in the adjustment process explains most of the dividend smoothing behavior. In addition, our empirical results indicate that the dividend adjustment signals the change in permanent earnings more strongly in the upper regimes.

In the paper, we consider the asymmetric adjustment process of the aggregate dividends, which is determined by the dividend deviations from the target dividends. Our analysis can be extended to the other forms of asymmetric adjustment. As suggested by Jalilvand and Harris (1984), the adjustment process of the dividends may depend on the capital market condition such as interest rates and stock prices. Furthermore, a natural extension can be made using the multiple regimes and the micro level data of individual firms. We leave these issues to future research.

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Table 1
ADF Tests for Unit Root

Variable name	With drift	With drift and trend
d_t	-1.628(1)	-4.214(2)**
p_t	-0.907(0)	-2.386(0)
Δd_t	-14.955(0)**	14.940(0)**
Δp_t	-14.278(1)**	-14.276(1)**

Dividends (d_t) and stock prices (p_t) are real variables in the logarithms. The lag order for the tests was determined by BIC, which is in the parentheses. The critical values are -3.442(1%), -2.867(5%) with drift and -3.975(1%), -3.418(5%) with drift and trend. ** indicates a rejection of the null hypothesis at the 1% significance level.

Table 2
Cointegration Tests

Model	(d_t, p_t)
LR (H_0 :rank=0)	33.296**
LR (H_0 :rank=1)	0.661
VAR Lag Length	2

The VAR lag order determined by the BIC is 2. The critical values are 15.495 for the null hypothesis H_0: rank=0 and 3.841 for H_0: rank=1. ** indicates a rejection of the null hypothesis at the 1% significance level.

Table 3
Estimation of Linear VECM

Model	VECM without lag		VECM with 1 lag	
Equation	Δd_t	Δp_t	Δd_t	Δp_t
α	**-0.050**	0.007	**-0.047**	0.007
(s.e.)	(0.010)	(0.032)	(0.009)	(0.028)
μ	**-0.043**	0.011	**-0.038**	0.011
(s.e.)	(0.009)	(0.031)	(0.008)	(0.031)
Δd_{t-1}			**0.399**	0.112
(s.e.)			(0.072)	(0.108)
Δp_{t-1}			-0.016	-0.017
(s.e.)			(0.022)	(0.078)
β	0.585		0.572	
Likelihood	2,517.733		2,563.406	

The bold numbers indicate that they are statistically significant at the 5% significant level.

Table 4
Testing for Asymmetric Adjustment

Model	*SupLM*	*p-value*	*5% critical value*
VECM(0)	17.236	0.019	14.388
VECM(1)	21.729	0.042	21.236

Table 5
Estimation of Threshold VECM

Model	VECM without lag		VECM with 1 lag	
Dependent variable	Δd_t	Δp_t	Δd_t	Δp_t
α_1	-0.017	0.025	**-0.031**	0.009
(s.e.)	(0.011)	(0.023)	(0.011)	(0.023)
μ_1	-0.015	0.041	**-0.027**	0.013
(s.e.)	(0.015)	(0.032)	(0.011)	(0.024)
$\Delta d_{1,t-1}$			**0.338**	0.048
(s.e.)			(0.078)	(0.089)
$\Delta p_{1,t-1}$			-0.022	0.098
(s.e.)			(0.025)	(0.055)
α_2	**-0.183**	0.221	**-0.203**	0.031
(s.e.)	(0.031)	(0.288)	(0.043)	(0.439)
μ_2	**-0.199**	0.220	**-0.153**	0.014
(s.e.)	(0.032)	(0.297)	(0.030)	(0.300)
$\Delta d_{2,t-1}$			**0.701**	0.283
(s.e.)			(0.094)	(0.367)
$\Delta p_{2,t-1}$			-0.036	-0.283
(s.e.)			(0.028)	(0.172)
β	0.655		0.598	
γ	-1.125		-0.748	
p_1, p_2	0.818	0.182	0.898	0.102
Likelihood	2,532.125		2,585.071	

The bold numbers indicate that they are significant at the 5% significant level.

Figure 1. Real Dividends and Real Stock Prices

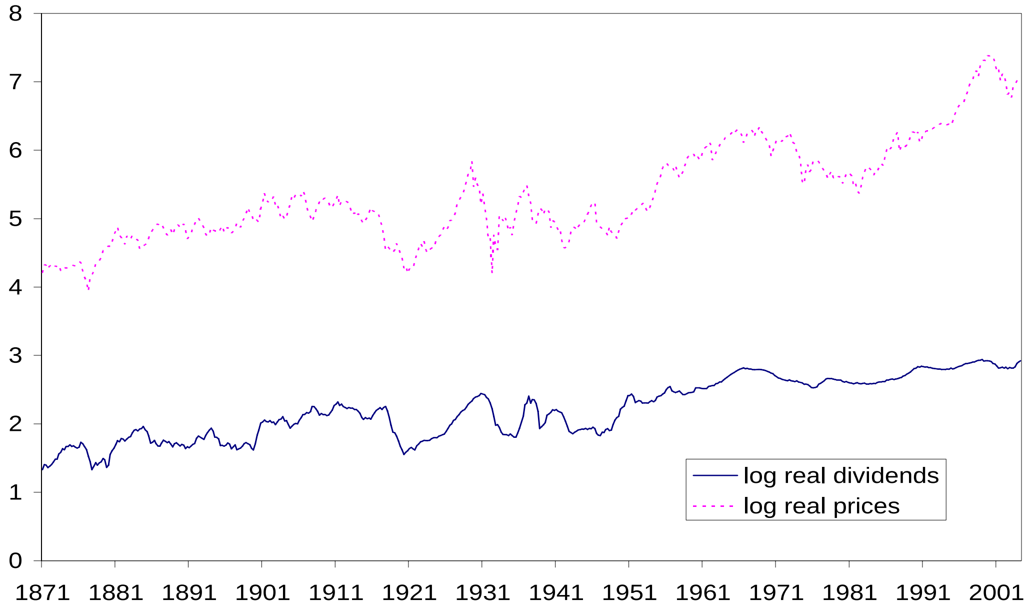

Figure 2. Dividend Deviations and Upper/Lower Regimes