Time-Series Implications of Aggregate Dividend Behavior

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This article investigates the hypothesis that dividend changes are determined by changes in some measure of permanent earnings. The analysis employs two measures of permanent earnings and takes into account the nonstationarity of dividend and earnings series. This study finds that dynamic dividend behavior is accounted for primarily by changes in permanent earnings. Dividends respond strongly to permanent changes in earnings without any significant overreaction, whereas they respond little, if at all, to transitory changes in earnings. The findings also suggest that the partial adjustment hypothesis, which assumes managers partially adjust dividends to a target dividend, performs better when the target dividend level is proportional to permanent earnings than when it is proportional to current earnings.

This article studies the time-series behavior of dividend series in relation to earnings series. The hypothesis investigated is that dividend changes are determined by changes in some measure of permanent earnings. Henceforth, we will call this hypothesis the permanent earnings hypothesis (PEH) of dividends. The PEH dates back to the work of Lintner (1956). His findings were based on a series of interviews with corporate managers about corporate dividend

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policy. Marsh and Merton (1987) summarize these findings as follows [see also Brealey and Meyers (1988, p. 360)].

> (i) Managers believe the firms should have some long-term target payout ratio. (ii) In setting dividends, they focus on the change in existing payout, not on the level. (iii) A major unanticipated and nontransitory change in earnings would be an important reason to change dividends. (iv) Most managers try to avoid making changes in dividends that stand a good chance of having to be reversed within the near future.

Marsh and Merton (1987) further claim:

> Most textbook discussions seem to agree with the interpretation of these stylized facts to the effect that it is changes in some measure of long-term sustainable or "permanent" earnings, rather than current earnings, that drive dividend decisions. That is, a change in current earnings flow that is viewed by management as essentially transitory would not be likely to give rise to a noticeable change in dividends.

This article takes the ideas of Lintner (1956) and Marsh and Merton (1987), regarding the relationship between the dividend decision and permanent earnings, as the essence of the PEH: dividend decisions are driven by changes in some measure of permanent earnings.[1]

In this article we estimate a bivariate time-series model of earnings and dividends. The specification is sufficiently general that the restrictions suggested by various models of dividend determination can be nested within it, and these restrictions can then be formally tested. The model allows for two measures of permanent earnings: a permanent component of earnings and a present discounted value of future expected earnings. While the former does not include any transitory component of earnings, the latter includes the present value of future transitory earnings that are expected, given the currently observed earnings. With these measures, we identify the permanent and transitory components of dividends and earnings so that we can evaluate the central idea of the PEH: the extent to which changes in dividends are due to permanent changes in earnings.

The findings of Lintner have traditionally been cast in terms of the partial adjustment hypothesis (PAH) of dividends, emphasizing that managers use a long-term target payout ratio and that they only

[1] John and Nachman (1987) also acknowledge the idea of the PEH suggested by Lintner (1956). They state, "Although Lintner (1956) suggests that such dividend smoothing by managers may be in response to the permanent component of corporate earnings, it is at best a conjecture that has yet to find an accepted anchorage in the theory of the firm."

partially adjust dividends to the target dividend, which is related to a measure of profit. The target dividend level has been modeled to be proportional either to current earnings [by Brittain (1964, 1966), Choe (1991), Fama and Babiak (1968), and Lintner (1956, 1963)], or to some measure of permanent earnings [by Fama and Babiak (1968), Kao and Wu (1991), and Marsh and Merton (1987)].[2]

This article utilizes a bivariate time-series model with various specifications of target dividends, taking into account the nonstationarity of dividend and earnings series and the cointegration between them. Thus, we can reevaluate the PAH in comparison with the PEH and examine the empirical validity of different versions of the PAH, enhancing our understanding of the relationship between dividends and earnings.

The PEH has been present in various forms in the theoretical literature.[3] Miller and Rock (1985) show that in the context of a two-period signaling equilibrium model, dividend payout is positively related to the persistent effect of an earnings innovation on future earnings. Their idea can be interpreted to imply a relationship between dividend payout and the permanent component of earnings, although they do not pursue the decomposition of earnings into permanent and transitory components [see also Miller (1986b)]. John and Williams (1985) suggest that dividends signal future earnings prospects, which can be interpreted to mean that dividends are related to the present discounted value of future earnings. In a dynamic model with asymmetric information about firm quality (value), Juster (1994) shows that the costly payout of dividends is used by managers to signal firm quality (value), since current earnings are a noisy signal, thereby avoiding excessive dilution of the existing shareholders' claims when the firm issues new risky instruments. His dynamic model is consistent with the PEH in that dividends are closely related to firm value, from which the permanent earnings are derived, rather than to noisy current earnings.[4]

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[2] Although Fama and Babiak (1968) consider a weighted average of current and past earnings as a target dividend based on a single equation model, still they find their model rejected by data. Kao and Wu (1991) use a present discounted value of earnings as a target dividend. But they model earnings series as a stationary process so that they cannot consider an important aspect of nonstationarity of earnings and dividend series, cointegration of the two series, and they cannot use the bivariate model of dividend changes and the spread.

[3] Kormendi and Lipe (1987) investigate and find evidence supporting the hypothesis that the magnitude of the relation between stock returns and earnings depends on the persistence of earnings by using a rational expectations time-series model. They consider a system of stock returns and differenced earnings and find no evidence that stock returns are excessively sensitive to the earnings innovations.

[4] In another dynamic model with asymmetric information about the evolution in the value of the firm's assets in place, Chowdhry and Nanda (1994) present a theory in which the decision about whether to repurchase stock depends on whether managers believe the firm is being undervalued

This article operationalizes and empirically evaluates both the PAH and the PEH as restrictions on the joint time series of earnings and dividends. The spirit of this article is similar to that of Marsh and Merton (1987): both aim at developing a dynamic time-series model of aggregate corporate dividends as a function of changes in permanent earnings based on the idea of the PEH. This article also fully accounts for the nonstationarity of dividend and earnings series, as do Marsh and Merton. However, unlike Marsh and Merton, who use stock price as an indicator of permanent earnings, this article confronts earnings data directly, using a bivariate model of dividend changes and the spread between earnings and dividends. Therefore, the analysis in this article can identify the two components of dividends and earnings from the bivariate model and evaluate the empirical validity of various interpretations of the relationship between dividends and earnings.[5]

The principal findings in this article are that dynamic dividend behavior is accounted for primarily by the changes in permanent earnings. Dividends respond strongly and immediately to permanent changes in earnings, whereas they respond little, if at all, to transitory changes in earnings. The findings also indicate that the PAH performs better when the target dividend level is proportional to permanent earnings than when it is proportional to current earnings.

This article is organized as follows. Section 1 presents a time-series representation of earnings and introduces a bivariate model of dividends and earnings. Section 2 discusses two versions of the PEH, accounting for a decomposition of earnings and dividends into permanent and transitory components. Section 3 discusses three versions of the PAH with each model characterized by its own restrictions on the bivariate model. Section 4 discusses how to impose the restrictions on the data. Section 5 presents the data and empirical results. Concluding remarks are offered in Section 6.

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by the market. In their model, dividends are increasing in the level of accumulated cash and, for a given level of accumulated cash, decreasing in the probability of being undervalued. In their model, managers have no incentive to engage in costly signaling to reveal information about firm value. Therefore, compared with Juster's model, their model is interpreted to be more closely related to the PAH than to the PEH.

[5] Marsh and Merton (1987), assuming market efficiency and rational expectations, posit that stock price is proportional to long-run or permanent earnings as optimally forecasted by the market. Using market price as a proxy for permanent earnings, they interpret their findings as consistent with Lintner's stylized fact that managers smooth dividends responding to an unanticipated change in permanent earnings.

Campbell and Shiller (1988a) claim, based on an alternative interpretation of error correction models, that Marsh and Merton's finding may reflect little more than the persistence of dividends and the noisiness of prices, rather than partial adjustment or smoothing by management.

1. Time-Series Model of Earnings and Bivariate Model of Earnings and Dividends

Since it is assumed in this article that the dividend process is driven by the earnings process, we begin by modeling the time-series behavior of the earnings process. It is recognized that the real earnings series, X_t, is nonstationary in levels, and the first difference is stationary [see Ali and Zarowin (1992), Campbell and Shiller (1988b), Kleidon (1986), Kormendi and Lipe (1987), and Marsh and Merton (1987);[6] see also Section 5.1 for evidence of nonstationarity of earnings based on unit-root tests]. We regard earnings as affected by two types of disturbances: permanent (e_1) and transitory (e_2) disturbances. As such, we model earnings as composed of the permanent (X_t^p) and transitory (X_t^s) components:

$$X_t = X_t^p + X_t^s, \tag{1}$$

$$\Delta X_t^p \equiv X_t^p - X_{t-1}^p = \sum_k q_k e_{1t-k}, \quad X_t^s = \sum_k r_k e_{2t-k}, \tag{2}$$

where $\sum_k \equiv \sum_{k=0}^{\infty}$ [see also Ali and Zarowin (1992)].[7]

The disturbance vector $e_t = [e_{1t}, e_{2t}]'$ is serially uncorrelated by construction, and e_{1t} and e_{2t} are assumed to be contemporaneously uncorrelated by an appropriate orthonormalization (see Section 4.1).[8] That is, $Var(e_t) = I$, where I is the identity matrix of rank 2. Also note from Equation (2) that, by construction, the permanent component of earnings, X_t^p, is a nonstationary process and the transitory component of earnings, X_t^s, is a stationary process. The decomposition of earnings into the two components — permanent and transitory — is particularly relevant for earnings series because, in the PEH, it is changes in some measure of long-term sustainable or permanent earnings, rather than current earnings, that drive dividend decisions. A positive innovation in X_t^p will lead to an upward movement of X_t^p

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[6] Kleidon (1986) formally tests for the nonstationarity of dividends and earnings as well as of stock price series. He finds evidence of nonstationarity of stock prices, dividends, and earnings, and investigates implications of the nonstationarity for the variance bounds tests based on stock price valuation models. Recognizing nonstationarity of earnings series, Campbell and Shiller (1988b) use log earnings-price ratios based on moving averages of earnings, and Kormendi and Lipe (1987) use differenced earnings in their model.

[7] Ali and Zarowin (1992) use an IMA(1,1) model of annual earnings to capture transitory components as well as permanent components of annual earnings. They show that, in the presence of transitory components of earnings, the change in earnings may be a poor proxy for unexpected earnings, causing earnings response coefficients to be biased toward zero.

[8] This orthogonalization helps to achieve the identification of each shock and component. For a similar treatment, see Fama and French (1988b), Lee (1995), Poterba and Summers (1988), and Watson (1986).

for all horizons thereafter, whereas a positive innovation in X_t^s has only a temporary effect on X_t^s.[9]

When both earnings (X_t) and dividends (D_t) are nonstationary processes, one may wish to employ a bivariate model of first differences in X_t and D_t. However, if a linear combination of (for example, the spread between) X_t and D_t is stationary, then X_t and D_t are cointegrated. As a consequence the bivariate moving average representation (BMAR) of the first differenced series is not invertible, so that the BVAR of the first differenced series would be misspecified [see Engle and Granger (1987)]. Instead, there exists a correctly specified BVAR of first differences in D_t and the spread.

Let S_t be the spread defined as a linear combination of current earnings and dividends that is stationary:

$$S_t = X_t - \gamma D_t, \tag{3}$$

where S_t is stationary and γ is a constant. This definition of the spread implies that X_t and D_t are cointegrated of order one and one: (*i*) D_t and X_t are nonstationary processes, and (*ii*) the spread S_t is a stationary process. In Section 5.1, we will provide empirical evidence of cointegration of X_t and D_t.

Now consider the following BMAR of z_t, which consists of the first difference in dividends and the spread (i.e., $z_t \equiv [\Delta D_t, S_t]'$):

$$\begin{aligned} z_t \equiv \begin{bmatrix} \Delta D_t \\ S_t \end{bmatrix} &\equiv \begin{bmatrix} D_t - D_{t-1} \\ X_t - \gamma D_t \end{bmatrix} \\ &= \begin{bmatrix} \sum_k c_{11}(k) e_{1t-k} + \sum_k c_{12}(k) e_{2t-k} \\ \sum_k c_{21}(k) e_{1t-k} + \sum_k c_{22}(k) e_{2t-k} \end{bmatrix} \end{aligned} \tag{4}$$

Each interpretation of the relationship between dividends and earnings will be characterized by the restrictions it imposes on this BMAR.

2. Two Models of the Permanent Earnings Hypothesis

To make the PEH of dividends amenable to empirical estimation and testing, we have to employ an empirical measure for permanent earnings. As mentioned in the introduction, this article considers two measures of permanent earnings: a permanent component of earnings, and a present discounted value of future expected earnings. Miller

[9] Fama and French (1988b) and Poterba and Summers (1988) model the permanent component of log of stock price series as a random walk process in explaining mean reversion behavior of stock returns. In general, however, the permanent component can be any nonstationary process [see Quah (1992)].

and Rock (1985) seem to relate dividend payout to the permanent component of earnings. Marsh and Merton (1987) interpret permanent earnings as a perpetual annuity from the intrinsic value of a firm, which is the discounted value of the expected future cash flows available for distribution. Kao and Wu (1991) also define permanent earnings as the present discounted value of all future earnings expected by managers.

2.1 Model 1: Dividends are proportional to the permanent component of earnings

The first interpretation of the PEH is that managers change dividends only when there is a change in the permanent component of earnings. That is, a change in current earnings that is viewed by management as transitory would not affect dividend decisions. The simplest specification that captures this intuition is to assume that dividends are proportional to the permanent component of earnings:

$$D_t = \alpha_1 X_t^p, \tag{5}$$

so that

$$\Delta D_t \equiv D_t - D_{t-1} = \alpha_1 \Delta X_t^p = \alpha_1 \sum_k q_k e_{1t-k}, \tag{6}$$

where α_1 is a positive constant. Since X_t^p is a nonstationary process, it follows that D_t is a nonstationary process and ΔD_t is a stationary process. Proofs of various propositions are contained in the Appendix.

Proposition 1 (Model 1). *If dividends are a constant fraction of the permanent component of earnings (i.e., ΔD_t is proportional to ΔX_t^p), the bivariate model $z_t (= [\Delta D_t, S_t]')$ is characterized by the restriction that*

$$c_{12}(k) = 0 \quad \textit{and} \quad c_{21}(k) = 0 \textit{ for all } k. \tag{7}$$

The moving average coefficient $c_{12}(k)$ measures the effect of e_2 on ΔD after k periods, and thus the restriction $c_{12}(k) = 0$, for all k, implies that the transitory disturbances in earnings do not affect the dividend changes. The changes in dividends are determined only by the permanent disturbances in earnings. Since $c_{21}(k)$ measures the effect of e_1 on S_t after k periods, the restriction $c_{21}(k) = 0$, for all k, implies that the permanent disturbance in earnings does not affect the spread at all. The spread is determined only by the transitory disturbances in earnings. These restrictions are valid whether X_t^p is a random walk or a more general nonstationary process.

2.2 Model 2: Dividends are proportional to a present discounted value of future expected earnings (PVX)

The second interpretation of the PEH is that managers change dividends when they perceive a change in the present discounted value of future expected earnings (PVX_t). We capture this idea by

$$D_t = \alpha_2 PVX_t \equiv \alpha_2 E_t \sum_k \beta^k X_{t+k}, \tag{8}$$

where PVX_t denotes a present discounted value of future expected earnings with a time-constant discount factor β, α_2 is a constant, and E_t is the conditional expectations operator based on information available to management at time t. For econometric purposes, however, we treat conditional expectations as equivalent to linear projections on information.

Proposition 2 (Model 2). *If dividends are a constant fraction of the present discounted value of future expected earnings* (PVX_t)*, the bivariate model* $z_t (= [\Delta D_t, S_t]')$ *is characterized by the restriction that*

$$\sum_k c_{12}(k) = 0. \tag{9}$$

Since $c_{12}(k)$ measures the effect of e_2 on ΔD in k periods, $\sum_k c_{12}(k)$ measures the net (cumulative) effect of e_2 on ΔD. Thus, the restriction $\sum_k c_{12}(k) = 0$ means that the long-term net (cumulative) effect of e_2 on ΔD is zero. The transitory change in earnings does not have a long-term effect on dividends, whereas it may have a temporary effect on dividends. In contrast, the permanent disturbance in earnings, e_1, may have a long-term (or permanent) effect on dividends because $\sum_k c_{11}(k) \ddagger 0$.[10] As such, the restriction $\sum_k c_{12}(k) = 0$ identifies e_1 and e_2 as the permanent and transitory innovations in earnings, respectively.

Note that Model 1 and Model 2 are characterized by different restrictions on the BMAR in Equation (4). The difference is due to the different measure of permanent earnings. In Model 2, dividends are proportional to a present discounted value of future expected earnings that includes future expected *transitory* earnings, whereas dividends in Model 1 are proportional only to the permanent component of earnings. Hence, unlike Model 1, dividends in Model 2 are affected

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[10] This method of deriving restrictions on the BMAR and of identifying two types of innovations is due to Blanchard and Quah (1989).
Since $z_t = [\Delta D_t, S_t]'$ is assumed to be stationary, neither disturbance has a long-term effect on either the dividend change, ΔD_t, or the spread, S_t.

by the transitory disturbances in earnings, although their effect on dividends is temporary by definition.

3. Models of the Partial Adjustment Hypothesis

Here we derive restrictions implied by various versions of the PAH on the BMAR, and discuss the relationship between the PEH and the PAH. The PAH is modeled as

$$\Delta D_t \equiv D_t - D_{t-1} = b[D_t^* - D_{t-1}], \quad 0 < b < 1, \tag{10}$$

where D_t^* is a target dividend and b is the speed of adjustment coefficient. Equation (10) states that managers partially adjust dividends to the target dividend.[11] The target dividend level D_t^* is assumed to be proportional to a firm's measure of permanent earnings, which may be the permanent component of earnings (X_t^p), the present discounted value of future expected earnings (PVX_t), or current earnings (X_t):

Model 3:

$$D_t^* = \alpha_3 X_t^p, \tag{11.1}$$

Model 4:

$$D_t^* = \alpha_4 PVX_t = \alpha_4 E_t \sum_k \beta^k X_{t+k}, \tag{11.2}$$

Model 5:

$$D_t^* = \alpha_5 X_t, \tag{11.3}$$

where X_t^p, PVX_t, and X_t are defined in Equations (2), (8), and (1), respectively, α_j for $j = 3$, 4, and 5 is the target payout ratio, and $0 < \beta < 1$.

By rearranging Equation (10), D_t and ΔD_t in the PAH can be rewritten as

$$D_t = b \sum_k (1-b)^k D_{t-k}^*, \quad \text{or} \quad \Delta D_t = b \sum_k (1-b)^k \Delta D_{t-k}^*. \tag{12}$$

This representation of dividends implies that, under the PAH, dividends are a weighted average of current and past target dividends because the coefficients of target dividends add up to 1 (i.e., $b\sum_k (1-b)^k = 1$).

Substituting D_t in Equation (12) into the definition of S_t yields S_t

[11] Usually, the PAH takes the following regression form: $\Delta D_t = a + b[D_t^* - D_{t-1}] + u_t$, where a is a constant and u_t is the disturbance term in the regression. For simplicity, we do not allow for a constant term.

in the PAH:

$$S_t \equiv X_t - \gamma D_t = X_t - \gamma\, b \sum_k (1-b)^k D^*_{t-k}, \tag{13}$$

where the constant γ will be determined to make S_t a stationary process.

Proposition 3 (Model 3). *When the target dividend in the PAH is proportional to the permanent component of earnings (i.e., $D^*_t = \alpha_3 X^p_t$), the bivariate model $z_t (= [\Delta D_t, S_t]')$ is characterized by the restriction that*

$$c_{12}(k) = 0 \textit{ for all } k. \tag{14}$$

This means that dividends in Model 3, as in Model 1, are not affected by transitory changes in earnings. This follows because, as shown in Equations (11.1) and (12), dividends are a weighted average of current and past target dividends that are affected only by permanent changes in earnings. Unlike Model 1, the spread in Model 3 is affected by permanent disturbances in earnings $c_{21}(k) \neq 0$, for some k, because dividends and earnings are not affected proportionately by permanent changes in earnings.

Proposition 4 (Model 4). *When the target dividend in the PAH is proportional to the present discounted value of future expected earnings (i.e., $D^*_t = \alpha_4 PVX_t = \alpha_4 E_t \sum_k \beta^k X_{t+k}$), the bivariate model $z_t (= [\Delta D_t, S_t]')$ is characterized by the restriction that*

$$\sum_k c_{12}(k) = 0. \tag{15}$$

Comparison of the PAH Model 4 with the PEH Model 2 shows that the two models are characterized by the same restrictions on the BMAR of ΔD_t and S_t.[12] In Model 2, dividends are proportional to the present discounted value of future expected earnings. In Model 4, dividends are a weighted average of current and past target dividends that are proportional to the present discounted value of future expected earnings. In both models, dividends are proportional to future expected earnings leading to the same restriction on the BMAR.

[12] Although Models 2 and 4 are characterized by the same restriction on the BMAR of z_t, $\sum_k c_{12}(k) = 0$, the time-series process of ΔD_t and S_t are not identical as shown by Equations (A.4), (A.5), (A.8), and (A.9) in the Appendix.

Proposition 5 (Model 5). *When the target dividend in the PAH is proportional to current earnings (i.e., $D_t^* = \alpha_5 X_t$), the bivariate model $z_t (= [\Delta D_t, S_t]')$ is characterized by the restriction that*

$$\sum_k c_{12}(k) = 0 \quad \textit{and} \quad \sum_k c_{22}(k) = 0. \tag{16}$$

These restrictions imply that the transitory changes in earnings may have a temporary effect on dividends, but do not have a long-term effect on dividends, and their net effect on the spread should be zero. In this model, dividends are a weighted average of current and past target dividends that are proportional to current earnings. Dividend changes in Model 5 become a weighted average of current and past changes in earnings, and e_2 does not have a long-term effect on dividends. The spread becomes, by setting $\gamma = \alpha_5^{-1}$, a linear combination of current and past changes in earnings:

$$S_t = X_t - \gamma \alpha_5 b \sum_k (1-b)^k X_{t-k} = (1-b) \sum_k (1-b)^k \Delta X_{t-k}.$$

As such, e_2 may have a temporary effect on S_t, but its net effect will be zero.

The restriction $\sum_k c_{22}(k) = 0$ of Model 5 implies that earnings and dividends respond proportionately to transitory changes in earnings so their net effect on the spread is zero. This requires dividends to respond to some extent to the transitory changes in earnings. As such, this restriction is not compatible with the idea that dividend changes are only due to changes in some measure of permanent earnings (i.e., the PEH), and the rejection of this restriction would suggest the empirical validity of the PEH.

In studying the PAH, Fama and Babiak (1968) consider Model 5 and find the model to be incompatible with the data. When the target dividend is proportional to current earnings as in Model 5, they find that the PAH cannot explain the observed significance of lagged earnings in the regression of the first differenced dividends on lagged dividends and current and lagged earnings. In an attempt to explain this result, they consider a model in which dividends are proportional to a weighted average of current and past earnings (a variation of our Model 5), but still find the model to be incompatible with their data. Thus, although they consider our Model 5, their single regression approach does not provide as much insight into the relation between dividends and earnings as do our results.

4. Restrictions on a Bivariate Vector Autoregression

4.1 The relationship between BMAR and BVAR

In Sections 2 and 3 we characterized each theoretical relationship between dividends and earnings as a set of restrictions on a BMAR of z_t with orthonormalized innovations, e_{1t} and e_{2t}. In practice, the BMAR in Equation (4) is obtained by inverting a BVAR model with nonorthonormalized innovations and the restrictions are imposed on this BVAR model. For expositional convenience, we restate the BMAR in Equation (4) using the lag operator L (i.e., $L^n x_t = x_{t-n}$):

$$z_t \equiv \begin{bmatrix} \Delta D_t \\ S_t \end{bmatrix} = C(L)e_t \equiv \begin{bmatrix} c_{11}(L), & c_{12}(L) \\ c_{21}(L), & c_{22}(L) \end{bmatrix} \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix}, \tag{4}$$

where $C(L)$ is a polynomial in the lag operator, i.e., $C(L) = [C_{ij}(L)] = [\sum_{k=0}^{\infty} c_{ij}(k)L^k]$ for $i, j = 1, 2$. Consider the following BVAR model of z_t:

$$\begin{aligned} z_t \;\equiv\; & \begin{bmatrix} \Delta D_t \\ S_t \end{bmatrix} = A(L)z_{t-1} + u_t \\ \equiv\; & \begin{bmatrix} A_{11}(L), & A_{12}(L) \\ A_{21}(L), & A_{22}(L) \end{bmatrix} \begin{bmatrix} \Delta D_{t-1} \\ S_{t-1} \end{bmatrix} + \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix} \end{aligned} \tag{17}$$

where $A(L) = [A_{ij}(L)] = [\sum_{k=1}^{m} a_{ij}(k)L^{k-1}]$ for $i, j = 1, 2$, $u_t = [u_{1t}, u_{2t}]' = z_t - E(z_t \mid z_{t-s}, s \geq 1)$, with $Var(u_t) = \Omega = [\sigma_{ij}]$. Estimating this BVAR gives estimates of $A(L)$ and Ω. While e_t is an orthonormalized innovation in z_t with $Var(e_t) = I$, u_t is a nonorthonormalized innovation in z_t. By inverting this BVAR of z_t, we obtain a BMAR of z_t:

$$z_t = (I - A(L)L)^{-1}u_t, \tag{18}$$

where I is the identity matrix of rank 2.

By comparing the BMAR in Equation (4) with that in Equation (18) [or equivalently with the BVAR in Equation (17)], estimates of the MAR coefficients, $C(L)$, can be obtained as follows. First, a typical innovation in the BMAR of Equation (4) and that in the BVAR of Equation (17) should be identical:

$$C_0 e_t = u_t, \tag{19}$$

where C_0 is $[c_{ij}(0)]$. Second, z_t in Equations (4) and (18) should be identical:

$$z_t = C(L)e_t = (I - A(L)L)^{-1}u_t. \tag{20.1}$$

Using Equation (19), Equation (20.1) implies that

$$\begin{aligned} C(L) &= (I - A(L)L)^{-1} C_0, \\ &= \delta^{-1} \begin{bmatrix} (1 - A_{22}(L)L)c_0^{11} + A_{12}(L)Lc_0^{21}, & (1 - A_{22}(L)L)c_0^{12} + A_{12}(L)Lc_0^{22} \\ A_{21}(L)Lc_0^{11} + (1 - A_{11}(L)L)c_0^{21}, & A_{21}(L)Lc_0^{12} + (1 - A_{11}(L)L)c_0^{22} \end{bmatrix}, \end{aligned} \tag{20.2}$$

where δ is the determinant of $[I - A(L)L]$. Equation (20.2) implies that, to calculate $C(L)$, we only need an estimate of C_0. This can be obtained by taking the variance of each side of Equation (19):

$$C_0 C_0' = \Omega. \tag{21.1}$$

In the bivariate model of z_t, Equation (21.1) is given as

$$\begin{bmatrix} c_0^{11} & c_0^{12} \\ c_0^{21} & c_0^{22} \end{bmatrix} \begin{bmatrix} c_0^{11} & c_0^{21} \\ c_0^{12} & c_0^{22} \end{bmatrix} = \begin{bmatrix} \sigma_{11} & \cdot \\ \sigma_{21} & \sigma_{22} \end{bmatrix} \tag{21.2}$$

Here, we obtain three restrictions (equations) for the four elements of C_0. Hence, we need an additional restriction to identify the four elements of C_0. Our bivariate models of z_t in Sections 2 and 3 provide various restrictions. Models 2 and 4 provide only one restriction. Hence, these models are just-identified. Models 1, 3, and 5, however, provide more than one restriction. Tests of these (overidentifying) restrictions provide a measure of goodness of fit of these models.

4.2 Restrictions on BVAR

The relation between the coefficients of the BMAR, $C(L)$, and those of the BVAR, $A(L)$, in Equation (20.2) enables us to translate various restrictions on the BMAR in Sections 2 and 3 into restrictions on the BVAR in Equation (17). Table 1 illustrates this relationship.

The coefficients of $c(k)$ in the BMAR [Equation (4)] represent responses to shocks in particular variables. Since e_t is serially and contemporaneously uncorrelated, we can allocate the variance of each element in z to elements of e. By imposing restrictions on the BVAR, we can conduct a restricted VAR analysis, as developed by Sims (1980a,b). The empirical results are reported in Section 5.5. Estimating a restricted BVAR model of $[\Delta D_t, S_t]'$ also yields a restricted BVAR model of $[D_t, S_t]'$, which will characterize the effects of each shock on the *level* of dividends rather than on the first difference.

Table 1
Restrictions of models on the BMAR and BVAR

Model	Restrictions on BMAR $zt = C(L)e_t$	Restrictions on BVAR $z_t = A(L)z_{t-1} + u_t$	Comments
1	$C_{12}(L) = 0$ and $C_{21}(L) = 0$	$A_{12}(L) = 0$ and $A_{21}(L) = 0$ with $\sigma_{12} = 0$*	PEH with X_t^p
2	$C_{12}(1) = 0$	$[1 - A_{22}(1)]c_0^{12} + A_{12}(1)c_0^{22} = 0$	PEH with PVX_t
3	$C_{12}(L) = 0$	$A_{12}(L) = 0$	PAH with X_t^p
4	$C_{12}(1) = 0$	$[1 - A_{22}(1)]c_0^{12} + A_{12}(1)c_0^{22} = 0$	PAH with PVX_t
5	$C_{12}(1) = 0$ and $C_{22}(1) = 0$	$[1 - A_{22}(1)]c_0^{12} + A_{12}(1)c_0^{22} = 0$ and $A_{21}(1)c_0^{12} + [1 - A_{11}(1)]c_0^{22} = 0$	PAH with X_t

$z_t = [\Delta D_t, S_t]'$, $Var(e_t) = I$, and $Var(u_t) = \Omega$.
PEH = the permanent earnings hypothesis; X_t^p = the permanent component of earnings; PVX_t = the present discounted value of future expected earnings; PAH = the partial adjustment hypothesis; and X_t = current earnings.
$C_{ij}(L) = 0$ is equivalent to $c_{ij}(k) = 0$ for all k.
$C_{ij}(1) = 0$ is equivalent to $\sum_k c_{ij}(k) = 0$.
$A_{ij}(L) = 0$ is equivalent to $a_{ij}(k) = 0$ for all k.
$A_{ij}(1) = 0$ is equivalent to $\sum_k a_{ij}(k) = 0$.
*The restriction $\sigma_{12} = 0$ follows from the restrictions $C_{12}(L) = 0$ and $C_{21}(L) = 0$ and the assumption that $Var(e_t) = I$.

5. Data and Empirical Results

5.1 Data and preliminary empirical results

For our empirical estimation, we used annual observations on dividends and earnings for the Standard and Poor's Composite Stock Price Index. The data set is extended back to 1871 by using the data in Cowles (1939).[13] We deflate nominal series using a January producer price index (annual average before 1900), 1967 = 100. The same dividend series is used in Campbell and Shiller (1987, 1988b), and the same earnings series is used in Campbell and Shiller (1988b).

One of the issues in dividend modeling is choosing between economic and accounting earnings for use in a theoretical and empirical study of dividends in relation to earnings. In studying the PAH of dividends, Fama and Babiak (1968) consider three earnings variables: net income (i.e., accounting earnings), cash flow (net income plus depreciation), and net income and depreciation included as separate

[13] The nominal earnings series for 1871 to 1925 is the earnings-price ratio series R-1 [Cowles (1939)] times the annual average Standard and Poor's Composite Index for the year. The nominal dividends before 1926 were also taken from Cowles (1939).

A problem with using individual firm data is that the data is not available for the prewar period. For example, the usual COMPUSTAT tape contains individual firm's quarterly earnings and dividends per share only from 1965 and the COMPUSTAT II annual industrial files merged at the University of Chicago contains individual firm's annual data from 1951. Furthermore, it is observed that dividend payments remain the same for close to a year.

variables. They find that, in explaining dividend changes, net income performs better than others in terms of adjusted R^2 and the t-value for the coefficient. Marsh and Merton (1987) find that aggregate dividend models that use accounting earnings variables perform as well as dividend models using stock prices as a measure of permanent earnings.

In general, the theoretical construct X_t is economic earnings. Accounting earnings are likely to be smoother than economic earnings because of opportunities to reduce year-to-year variability around a growth rate. In this article, we do not test cross-equation restrictions that are sensitive to a particular parameterization of models. Instead, we test the minimum implications of dividend behavior in relation to earnings in the context of some measure of permanent earnings. Therefore, the same set of restrictions applies to accounting earnings if only the transitory components of earnings are affected by accounting adjustments. That is, the restrictions in Sections 2 and 3 may not hold if accounting adjustments involve changes in the permanent components of earnings or the present discounted value of future expected earnings.

In previous sections it was assumed that D_t and X_t series are nonstationary processes, but S_t is a stationary process. To check this, panel A of Table 2 reports the results of the Dickey and Fuller (1979) unit root test of these series for the sample period of 1874 to 1992. The augmented Dickey and Fuller regression is used, allowing for more dynamics in the Dickey and Fuller regression by including second-order autocorrelations. The null hypothesis is that a series is nonstationary. The test results evidently support the null hypothesis that D_t and X_t are nonstationary series as Kleidon (1986) shows.

In panel B, we estimate a cointegrating regression of X_t on D_t to obtain the spread, S_t, for the sample period of 1874 to 1992. Engle and Granger (1987) propose to regress X_t on D_t (or D_t on X_t) and this regression is called the cointegrating regression. The regression exhibits an R^2 of 0.8604, a very strong association between the D_t and X_t series, and the coefficient of D_t is about 2.11, indicating that on average 47 percent of current earnings have been paid out as dividends for the sample period. The cointegration test in panel A of Table 2 shows that the nonstationarity of S_t is rejected based on an augmented Dickey and Fuller regression at the conventional significance level.[14] These results confirm the assumptions in previous sections that D_t

[14] Engle and Granger (1987) and Engle and Yoo (1987) provide a set of test statistics and tabulations of critical values to test for the presence of a unit root of the series obtained from the cointegrating regression. This is because the distribution of the Dickey and Fuller test will reject the null of noncointegration too often when a parameter must be estimated to compute the spread.

Table 2
Unit root and cointegration tests

A. Unit root test based on augmented Dickey and Fuller regression:
sample period, 1874–1992

$$\Delta y_t = a_0 + \alpha y_{t-1} + \sum_{i=1}^{2} \gamma_i \Delta y_{t-i} + \nu_t$$

Variables (y_t)	α	τ	H_0: $\alpha = 0$
D_t	−0.0030	−0.1345	Not rejected
X_t	−0.0341	−1.1008	Not rejected
S_t	−0.3102	−3.7015	Rejected

B. Cointegration regression: $S_t = X_t + b_0 + b_1 D_t$

Sample period	b_0	b_1	R^2
1874–1992	.5835	−2.1149	.8604
	(.1388)	(.0778)	
1874–1945	−.1281	−1.3711	.5530
	(.1717)	(.1443)	
1946–1992	−.3269	−1.8205	.6812
	(.4553)	(.1857)	
1946–1992*	−2.0456	−1.0188	.5191
	(.3988)	(.1462)	

D_t = real dividend series for the Standard & Poor's Composite Index
X_t = real earnings series for the Standard & Poor's Composite Index
S_t = the spread between earnings and dividend series computed by $X_t + 0.5835 - 2.1149 D_t$
Δ = the difference operator (e.g., $\Delta X_t = X_t - X_{t-1}$), τ = t-statistic of coefficient α
Numbers in parentheses below estimates are the corresponding standard errors.
* indicates that a broader measure of dividends including share repurchases is used for D_t.
For the unit root test of D_t and X_t in panel A, critical values for τ with 100 observations are 10%, −2.58; and 5%, −2.89 [Fuller (1976, pp. 371–373, Tables 8.5.1 and 8.5.2)].
For the cointegration test of S_t in panel A, critical values for τ with 200 observations are 10%, −3.02; 5%, −3.37; and 1%, −4.00 [Engle and Yoo (1987, Table 2) p. 157].

and X_t are nonstationary processes and they are cointegrated so that the spread S_t is a stationary process.

5.2 Tests of restrictions on the BVAR

This section reports the test results of the restrictions of each model on the BVAR. First of all, to estimate the BVAR of z_t, we have to choose the number of lags in each equation. The Akaike (1974) information criterion (AIC) chooses the number of parameters to minimize "number of parameters − log of likelihood." Using AIC, we pick two lags for the BVAR of z_t.[15]

The estimates for the BVAR and test results for the sample period of 1874 to 1992 are presented in Tables 3 and 4. Recall that Models 2

[15] The test results are invariant with respect to the number of lags in the bivariate VAR.

and 4, in which dividends are proportional to a present discounted value of future expected earnings, are characterized by the same restriction on the BMAR, and the two models are just-identified without providing testable over-identifying restrictions. As such, implications of these two models will be discussed in Section 5.5 through various simulations.

In Models 1 and 3, dividends are proportional to the permanent component of earnings. The significance levels associated with these restrictions are 0.1766 and 0.2419, respectively, so that they are not rejected at a 10 percent significance level. This provides evidence in favor of the idea that dividend decisions are driven only by changes in the permanent component of earnings, which is quite a strong restriction on the data.

In contrast, Model 5, in which dividends are proportional to current earnings in the PAH, is rejected at any significance level. This shows that managers consider more than current earnings in their dividend decisions. Since the restriction $\sum_k c_{12}(k) = 0$ [i.e., $C_{12}(1) = 0$] is imposed to just-identify the model and to distinguish e_{1t} and e_{2t} as permanent and transitory disturbances in earnings, this test result implies a strong rejection of the restriction $\sum_k c_{22}(k) = 0$ [i.e., $C_{22}(1) = 0$]. As discussed in Section 3, the rejection of $\sum_k c_{22}(k) = 0$ implies that earnings and dividends do not respond proportionately to transitory changes in earnings. This suggests that dividends do not respond significantly to transitory changes in earnings, although there may be significant transitory components in earnings. As such, the rejection of Model 5 is again consistent with the PEH. This also suggests that the relationship between dividends and earnings that does not distinguish between the two components of earnings may not be compatible with the data. Instead, the relation between dividends and earnings should consider the two components of earnings and relate only the permanent component of earnings to dividend decisions.

In sum, the test results indicate that dividend changes are not significantly affected by transitory changes in earnings. As a consequence, the spread between earnings and dividends is significantly affected by transitory changes in earnings. Permanent changes in earnings have long-term effects on dividends as well as on earnings, and a proportional relation is not rejected so that they have no significant effects on the spread.

5.3 The subperiod analysis

Previous research has uncovered structural shifts in dividend policy. Brittain (1966) presents evidence that dividend policy in the post–World War II period is quite different from that in the prewar period. Recently, by estimating Lintner's partial adjustment model, Choe

Table 3
BVAR estimates

$$z_t \equiv \begin{pmatrix} \Delta D_t \\ S_t \end{pmatrix} = \begin{pmatrix} A_{11}(L), & A_{12}(L) \\ A_{21}(L), & A_{22}(L) \end{pmatrix} \begin{pmatrix} \Delta D_{t-1} \\ S_{t-1} \end{pmatrix} + \begin{pmatrix} u_{1t} \\ u_{2t} \end{pmatrix},$$

where $A_{ij}(L) = \sum_{k=1}^{2} a_{ij}(k)L^{k-1}$ for $i, j = 1, 2$.

Sample period	Equation	constant	$a_{11}(1)$ $a_{21}(1)$	$a_{11}(2)$ $a_{21}(2)$	$a_{12}(1)$ $a_{22}(1)$	$a_{12}(2)$ for ΔD_t $a_{22}(2)$ for S_t	R^2	DW
1874–1992	ΔD_t	.0242	.1433	−.1336	.0518	−.0211	.0598	1.9721
		(.0158)	(.0918)	(.8907)	(.0332)	(.0354)		
	S_t	.0081	−.2625	−.3508	.8035	−.1570	.5111	1.9851
		(.0430)	(.2489)	(.2461)	(.0901)	(.0961)		
1874–1945	ΔD_t	.0078	.0251	−.1630	.1297	−.0547	.1019	2.0185
		(.0207)	(.1152)	(.1139)	(.0556)	(.0571)		
	S_t	.0041	−.0677	−.2223	.6825	−.1997	.3584	1.9356
		(.0427)	(.2374)	(.2348)	(.1146)	(.1177)		
1946–1992	ΔD_t	.0541	.3032	−.2184	−.0382	−.0180	.1544	2.0030
		(.0233)	(.1442)	(.1443)	(.0388)	(.0423)		
	St	.0605	−.5254	−.6108	.8486	−.2855	.5190	2.0663
		(.0859)	(.5309)	(.5315)	(.1430)	(.1559)		
1946–1992*	ΔD_t	.1483	−.4759	−.3745	.1109	−.2290	.2992	1.8429
		(.0817)	(.1636)	(.1687)	(.1264)	(.1298)		
	S_t	−.0260	.3913	.1614	.7013	.0015	.4328	1.9314
		(.1129)	(.2260)	(.2330)	(.1746)	(.1792)		

For notation, see notes to Table 2.
DW = Durbin-Watson statistic.
* indicates that a broader measure of dividends including share repurchases is used for D_t.

Table 4
Tests of restrictions on the BVAR

Model	Test statistic (significance level)	1874–1992	1874–1945	1946–1992	1946–1992*
1	$\chi^2(5)$	7.6499 (.1766)	5.9527 (.3108)	6.3256 (.2758)	14.6451 (.0120)
2	Just-identified				
3	$\chi^2(2)$	2.8381 (.2419)	5.5728 (.0616)	2.9525 (.2285)	3.7317 (.1548)
4	Just-identified				
5	$\chi^2(1)$	73.4244 (.0000)	48.3406 (.0000)	18.5574 (.0000)	38.0311 (.0000)

* denotes that a broader measure of dividends including share repurchases is used.

(1991) reports evidence of a downward shift both in the target payout ratio in the mid-1940s and in the speed of adjustment coefficient in the mid-1940s and the early 1970s [see also Fama and French (1988a), Miller (1986a)].

To investigate a potential structural shift in the relation between earnings and dividends around the mid-1940s, Tables 3 and 4 present the estimation and test results of each model for the two subperiods: the prewar period (1874 to 1945) and the postwar period (1946 to 1992). To compute the spread for each subperiod, the cointegration regression is estimated for each sample period (panel B of Table 2). As in Choe (1991), it shows a significant decrease in the dividend payout ratio for a given change in earnings: about 73 percent and 55 percent of earnings changes are paid out as dividends in the prewar period and in the postwar period, respectively.[16]

[16] One may wonder, in cointegrating regressions (panel B of Table 2), why we obtain a large constant term in the full sample and small and insignificant constants in both subperiods, and smaller coefficients on dividends in both subperiods than that in the full sample. One way to interpret these differences is to consider the magnitude (or size) of earnings and dividends for the two subperiods, which are reported below.

	Earnings (X_t)		Dividends (D_t)		Cointegration	
	Mean	Range	Mean	Range	Constant	Slope
1874–1992	2.84	[0.50, 7.61]	1.62	[0.52, 3.59]	−0.5835 (0.1389)	2.1149 (0.0778)
1874–1945	1.69	[0.50, 4.00]	1.14	[0.52, 2.06]	0.1281 (0.1708)	1.3711 (0.1443)
1946–1992	4.65	[1.91, 7.61]	2.38	[1.12, 3.59]	0.3269 (0.4540)	1.8205 (0.1856)

Note: Cointegration regression is $X_t = a + bD_t$, and numbers in parentheses are standard errors.

As we observe from the above table, the magnitude of earnings and dividends for the first subperiod (1874 to 1945) are smaller and the slope coefficient is smaller than those of the second subperiod (1946 to 1992), with the constant terms insignificantly different from zero. To reconcile

Table 5
Subsample period analysis: stability test

A. Cointegration regression: 1871–1945 versus 1946–1992

$F(2, 116) = 14.3025$; significance level = .0000

B. VAR equation: 1871–1945 versus 1946–1992

ΔD equation: $F(5, 102) = 1.8921$; significance level = .1022
S equation: $F(5, 102) = 3.0059$; significance level = .0143

F-statistic is computed by

$$F(k, n_1 + n_2 - 2k) \sim [(\text{RRSS} - \text{URSS})/k]/[\text{URSS}/(n_1 + n_2 - 2k)],$$

where URSS = unrestricted residual sum of squares, which is obtained by adding the residual sum of squares for each equation corresponding to each sample period that has the degrees of freedom $n_1 + n_2 - 2k$,

RRSS = restricted residual sum of squares, which is obtained by estimating a single equation over the whole sample period that has the degrees of freedom $n_1 + n_2 - k$.

The VAR estimates in Table 3 show quite different coefficient estimates. To provide a formal test of stability for both the cointegrating regressions and the VAR estimates, we conduct Chow's structural stability test (i.e., F-test). The null hypothesis is that coefficients are the same over the two subsample periods. The results in Table 5 show that (i) the cointegrating regression has changed (panel A), and (ii) the spread equation shifted, but the shift in the dividend equation appears to be weak (panel B).

In terms of the performance of models (Table 4), Models 1 and 3 perform well not only in the prewar period but also in the postwar period, as shown by the significance levels, although Model 5 is strongly rejected in each subsample period. An improved significance level of Model 3 in the postwar period implies that the PAH, with the target dividend being proportional to the permanent component of earnings, seems more relevant in the postwar period, and that dividend decisions are not driven simply by changes in current earnings. The rejection of Model 5 is consistent with findings by Fama and Babiak (1968), who used data from 1946 to 1964. In sum, although there is some evidence of structural shifts in the cointegrating relation and the VAR estimates, our model's implications are not sensitive to the two subperiods.

5.4 On a broad measure of dividends

Recently, Bagwell and Shoven (1989) have argued that it is necessary to recognize that alternative forms of compensating shareholders have become more important. Ackert and Smith (1993) claim for example

these two subperiod estimates, the whole period estimates should have a smaller constant and a steeper slope.

that, using Canadian data, they are unable to reject the hypothesis of market efficiency based on variance bound tests when cash flow measures include share repurchases and takeover distributions in addition to ordinary cash dividends, in contrast to Shiller and others.

We have considered only ordinary cash dividends so far. In view of the recent trend emphasizing the importance of using a broad measure of dividends, we investigate in this section whether our findings are sensitive to the measure of dividends. We collected stock repurchase data from the COMPUSTAT file and included these in the measure of dividends, which we call the broad measure of dividends. The repurchase data were available from 1970 to 1992. Then, we implemented estimation and testing of restrictions using the broad measure of dividends. Since the repurchase data are available from 1970, we analyzed only the postwar period (1946 to 1992).[17]

The result shows that the average dividend payout ratio has increased in the postwar period (panel B of Table 2), and there is some evidence of structural change as reflected in the coefficients of the bivariate model of earnings and dividends (Table 3). The test results of the various restrictions of the models under the broad measure of dividends are reported in Table 4. The restrictions of the non-PEH of Model 5 are again strongly rejected, whereas the restrictions of Model 3 perform relatively well, although the restrictions of Model 1 appear to be quite stringent.[18] In sum, the qualitative implications of the models do not appear to change under the alternative measure of dividends.

5.5 Implications of models through simulations

The restriction of Models 2 and 4, $\sum_k c_{12}(k) = 0$ is common to all the models because $c_{12}(k) = 0$ for all k implies $\sum_k c_{12}(k) = 0$. Furthermore, this restriction provides a minimum requirement for just-identifying the two innovations in earnings. Therefore, we impose this restriction on the bivariate model and discuss the models' implications through various simulations. [See also Lee (1992).]

In fact, Model 3's restriction, $c_{12}(k) = 0$ for all k, does not need an extensive analysis because it implies that dividend changes are driven totally by the permanent innovation without being affected by the transitory innovation. Similarly, the restriction that $c_{21}(k) = 0$ for all k of Model 1 implies that the spread is affected only by the transitory innovation. The restriction that $\sum_k c_{22}(k) = 0$ of Model 5 suggests

[17] In fact, repurchases are small enough to ignore prior to 1970.

[18] A further examination of the restrictions of Model 1 reveals that the poor performance of Model 1 with a broad measure of dividends is in part due to a relatively large value of σ_{12}.

Table 6
Relative importance of permanent (e_{1t}) and transitory (e_{2t}) innovations in earnings (forecast error variance decomposition)

Model	$[\Delta D_t, S_t]'$			
Variables Explained	ΔD_t		S_t	
	Innovations in			
Horizons (years)	e_{1t}	e_{2t}	e_{1t}	e_{2t}
1	94.5%	5.5	1.3	98.7
2	93.7	6.3	0.8	99.2
3	92.8	7.2	2.0	98.0
4	92.7	7.3	2.8	97.2
6	92.7	7.3	3.0	97.0
8	92.7	7.3	3.0	97.0
10	92.7	7.3	3.0	97.0
12	92.7	7.3	3.0	97.0

ΔD_t = the first difference in real dividend series forthe Standard & Poor's Composite Index
S_t = the spread between earnings and dividend series computed by $X_t + .5835 - 2.1149D_t$ for the 1871 to 1992 period
e_{1t} = the permanent innovation in earnings
e_{2t} = the transitory innovation in earnings

that the net effect of the transitory innovation on the spread is zero, which is rejected by the data. Therefore, these implications are not investigated further in this section.

Since the restrictions of these models identify the two innovations in the BMAR as permanent and transitory innovations in earnings, we can examine the implications of the restriction $\sum_k c_{12}(k) = 0$ by VAR analysis after imposing this restriction. The relative importance of each innovation in predicting future variation in dividends and the spread can be discussed by forecast error decompositions. Specifically,

$$\frac{\sum_{k=0}^{t-1} c_{ij}(k)^2}{\sum_{j=1}^{2} \sum_{k=0}^{t-1} c_{ij}(k)^2}$$

provides the components of error variance in the t-step ahead forecast of z_i, which is accounted for by innovations in z_j.

The results are reported in Table 6. Overall, the results of the forecast error variance decompositions confirm the notion that managers change dividends only when earnings changes are due to permanent shocks and they do not change dividends when earnings changes are due to transitory shocks. As a result, transitory shocks to earnings, not having affected dividends, are reflected in the spread between earnings and dividends. For example, 94.5 percent of 1-year forecast error variance in ΔD_t is accounted for by the permanent shock, e_{1t}. However, 98.7 percent of 1-year forecast error variance in S_t is accounted for by the transitory shock, e_{2t}.

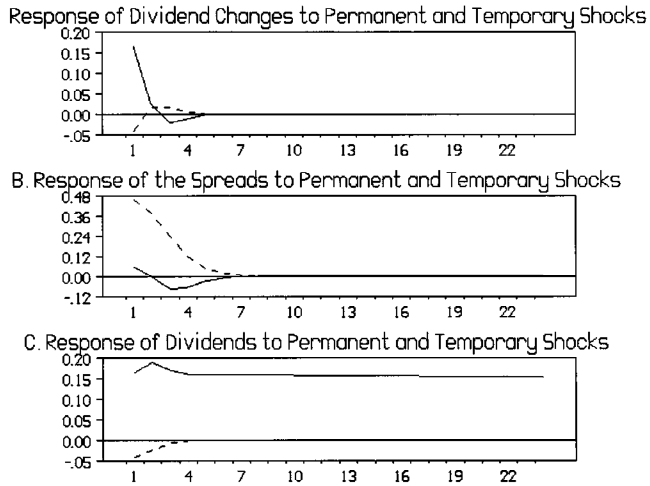

Figure 1
Response to permanent and transitory shocks to earnings
The figure shows the dynamic responses of the first differenced dividends (ΔD), the spread (S) between earnings and dividends, and the level of dividends (D) to a 1 SD permanent (——) and transitory (- - - - -) shock to earnings. Panels A and C show that the effect of a transitory shock on dividend is temporary, whereas that of a permanent shock is of a permanent nature. Panel B shows that a positive permanent shock to earnings initially has a mild positive effect and then weak, negative effects on the spread. In contrast, a transitory shock to earnings, not affecting dividends, is left to affect the spread, showing strong, positive effects on the spread for the first 7 years.

Figure 1 illustrates the dynamic responses of the first differenced dividends (ΔD), the spread (S), and the level of dividends (D) to a 1 SD permanent and transitory shock to earnings. Panels A and C show that the effect of a transitory shock on dividend is temporary, whereas that of a permanent shock is of a permanent nature. Panel B shows that a positive permanent shock to earnings initially has a mild positive effect and then weak, negative effects on the spread. In contrast, a transitory shock to earnings, not affecting dividends, is left to affect the spread, showing strong, positive effects on the spread for the first 7 years. This finding is consistent with the rejection of the restriction of Model 5 that $\sum_k c_{22}(k) = 0$, which requires that the net effect of the transitory disturbances on the spread should be zero.

The historical values of dividends and the spread series can be decomposed into two parts: the permanent and transitory components. Figure 2 illustrates actual series and the transitory component of dividends and the permanent component of the spread. As expected from the forecast error decompositions and the dynamic responses, panel A shows that almost all variations in dividend series are accounted for by the permanent shocks and little, if any, variation is accounted for

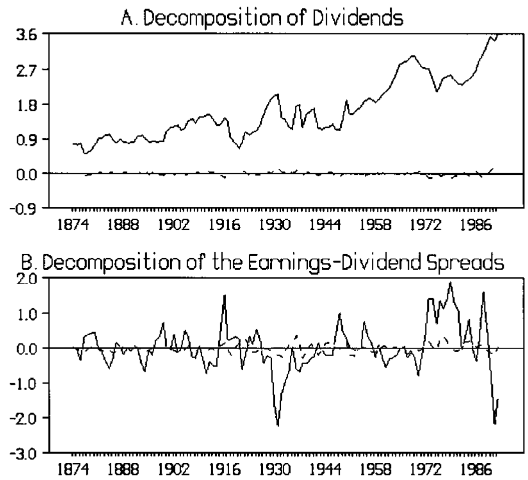

Figure 2
Decomposition of dividends and the spread between earnings and dividends
Panel A shows the actual series (——) and the transitory component (-----) of dividends, and Panel B shows the actual series (——) and the permanent component (-----) of the spread between earnings and dividends. The figure shows that almost all variations in dividend series are accounted for by the permanent shocks and little, if any, variation is accounted for by the transitory shocks. In contrast, the spread is primarily accounted for by the transitory shocks.

by the transitory shocks. In contrast, the spread is primarily accounted for by the transitory shocks (panel B).

6. Summary and Concluding Remarks

This article has investigated the time-series behavior of dividend series in relation to earnings series. We examine various interpretations of dividend behavior based on the permanent earnings hypothesis (PEH), which contends that dividend decisions are made based on some measure of permanent earnings. The partial adjustment hypothesis (PAH), with various specifications of the target dividend level, is also discussed. Two measures of permanent earnings — the permanent component of earnings and the present discounted value of future expected earnings — are employed. The nonstationarity of dividend and earnings series and the cointegration of the two series are fully taken into account throughout the analysis.

This approach allows us to investigate (*i*) the empirical validity of various interpretations of the theoretical relationship between dividends and earnings, (*ii*) the extent to which dividends change due to permanent changes in earnings, and (*iii*) historical decomposition of dividend and spread series into permanent and transitory components.

The findings in this article confirm the notion that dynamic dividend behavior is primarily accounted for by permanent changes in earnings. Dividends respond strongly to them without any significant overreaction, while they respond minimally to transitory innovations in earnings. The findings also show that the conventional PAH, which hypothesizes that dividends are a weighted average of current and past target dividends, is not compatible with the data when the target dividend level is proportional to current earnings. These findings are shown to be qualitatively invariant with respect to the two different subsample periods (prewar and postwar periods) and the two measures of dividends (ordinary dividends and a broad measure of dividends).

Dividend decisions appear to be driven primarily by changes in some measure of permanent earnings or long-term sustainable earnings. This in turn implies that the changes in dividends anticipate changes in permanent earnings, which are supported by changes in future earnings. Therefore, dividend decisions convey information about future earnings prospects of firms, and there is a causal link from dividends to future earnings in a statistical (Granger) sense. This information content of dividends is consistent with Healey and Palepu (1988), Kao and Wu (1991), and Marsh and Merton (1987).[19]

Appendix

In this Appendix, for expositional convenience, we introduce and use the lag operator L (i.e., $L^n x_t = x_{t-n}$) and a polynomial in the lag operator [i.e., $C(L) = \sum_{k=0}^{\infty} c_{ij}(k)L^k$] for $i, j = 1, 2$, $q(L) = \sum_{k=0}^{\infty} q_k L^k$, and $r(L) = \sum_{k=0}^{\infty} r_k L^k$.

Proof of Proposition 1. The proposition is immediate from

$$\begin{aligned} \Delta D_t &= \alpha_1 \Delta X_t^p = \alpha_1 q(L) e_{1t}, \text{ and} \\ S_t &= X_t - \gamma D_t = (X_t^p + X_t^s) - \gamma \alpha_1 X_t^p \\ &= (1 - \gamma\alpha_1) X_t^p + X_t^s = X_t^s = r(L) e_{2t} \end{aligned}$$

by setting $\gamma = 1/\alpha_1$ to make the spread stationary.

Proof of Proposition 2. Under Model 2, by setting $\gamma = (1 - \beta)/\alpha_2$ to

[19] Empirical work on the information content of dividends with respect to investment includes Smirlock and Marshall (1983), who find no Granger causal relationship from dividends to investment.

make S_t a stationary process, D_t and S_t are given as

$$\begin{aligned} D_t &= \alpha_2 PVX_t \equiv \alpha_2 E_t \sum_k \beta^k X_{t+k} \\ &= \alpha_2(1-\beta)^{-1} E_t \sum_{k=1}^{\infty} \beta^k \Delta X_{t+k} + \alpha_2(1-\beta)^{-1} X_t \qquad \text{(A.1)} \\ S_t &= X_t - \gamma D_t \\ &= X_t[1-\gamma\alpha_2(1-\beta)^{-1}] - \gamma\alpha_2(1-\beta)^{-1} E_t \sum_{k=1}^{\infty} \beta^k \Delta X_{t+k} \\ &= -E_t \sum_{k=1}^{\infty} \beta^k \Delta X_{t+k} \\ &= -E_t \sum_{k=1}^{\infty} \beta^k (\Delta X_{t+k}^p + X_{t+k}^s - X_{t+k-1}^s). \qquad \text{(A.2)} \end{aligned}$$

To compute this present value relationship, we use the formula, given a stochastic process $y_t = a(L)\eta_t$,

$$E_t \sum_{k=1}^{\infty} \beta^k y_{t+k} = \beta[a(L) - a(\beta)](L-\beta)^{-1}\eta_t, \qquad \text{(A.3)}$$

whose proof can be shown analogous to Hansen and Sargent (1980). Using this formula, S_t is given by

$$\begin{aligned} S_t = & -\beta[q(L) - q(\beta)](L-\beta)^{-1} e_{1t} \\ & - \beta[r(L)(1-L) - (1-\beta)r(\beta)](L-\beta)^{-1} e_{2t}. \qquad \text{(A.4)} \end{aligned}$$

Using this S_t, $\gamma = (1-\beta)/\alpha_2$, and X_t, ΔD_t can be derived as

$$\begin{aligned} \Delta D_t &= \gamma^{-1}[\Delta X_t - \Delta S_t] \\ &= \alpha_2(1-\beta)^{-1}[(1-\beta)q(L)L - \beta(1-L)q(\beta)](L-\beta)^{-1} e_{1t} \\ &\quad + (1-L)\alpha_2(1-\beta)^{-1} \\ &\quad \times [(1-\beta)r(L)L - \beta(1-\beta)r(\beta)](L-\beta)^{-1} e_{2t}. \qquad \text{(A.5)} \end{aligned}$$

Comparison of Equations (A.4) and (A.5) with the BMAR in Equation (4) shows that Equations (A.4) and (A.5) identify the two disturbances as the permanent and transitory disturbances in earnings process and are characterized by the restriction $\sum_k c_{12}(k) = 0$ on the BMAR in Equation (4). It is noted that the spread in Model 2, as shown in Equation (A.2), is the present discounted value of future declines in earnings and is a stationary process because ΔX_{t+k} is a stationary process.

Proof of Proposition 3. By substituting $\alpha_3 X_t^p$ for D_t^*, and X_t^p and X_t^s in Equation (2) into Equations (12) and (13), ΔD_t in Equation (12) and S_t in Equation (13) are given by

$$\Delta D_t = b\alpha_3 q(L)[1-(1-b)L]^{-1}e_{1t}, \tag{A.6}$$

and

$$S_t = [1-(1-b)L]^{-1}(1-b)q(L)e_{1t} + r(L)e_{2t}, \tag{A.7}$$

where S_t is obtained by setting $\gamma = 1/\alpha_3$ to make S_t a stationary process. Rearranging Equations (A.6) and (A.7) in the BMAR in Equation (4) yields the restriction in Equation (14).

Proof of Proposition 4. With $D_t^* = \alpha_4 PVX_t$,

$$\begin{aligned}
D_t &= \alpha_4 b[1-(1-b)L]^{-1}PVX_t \equiv \alpha_4 b[1-(1-b)L]^{-1}E_t\sum_k \beta^k X_{t+k}\\
&= \alpha_4 b(1-\beta)^{-1}[1-(1-b)L]^{-1}E_t\sum_{k=1}^{\infty}\beta^k\Delta X_{t+k}\\
&\quad + \alpha_4 b(1-\beta)^{-1}[1-(1-b)L]^{-1}X_t,\\
S_t &= X_t - \gamma D_t = X_t[1-\gamma\alpha_4 b(1-\beta)^{-1}(1-(1-b)L)^{-1}]\\
&\quad - \gamma\alpha_4 b(1-\beta)^{-1}(1-(1-b)L)^{-1}E_t\sum_{k=1}^{\infty}\beta^k\Delta X_{t+k}.
\end{aligned}$$

By setting $\gamma = (1-\beta)/\alpha_4$ and using the formula in Equation (A.3), S_t can be rearranged as

$$\begin{aligned}
S_t &= [1-(1-b)L]^{-1}[(1-b)q(L) - b\beta(q(L)-q(\beta))(L-\beta)^{-1}]e_{1t}\\
&\quad + [1-(1-b)L]^{-1}[(1-b)(1-L)r(L) - b\beta(1-L)r(L)(L-\beta)^{-1}\\
&\quad + b(1-\beta)\beta r(\beta)(L-\beta)^{-1}]e_{2t}\\
&= C_{21}(L)^* e_{1t} + C_{22}(L)^* e_{2t}.
\end{aligned}\tag{A.8}$$

ΔD_t can be derived by using this S_t as

$$\begin{aligned}
\Delta D_t &= \gamma^{-1}[\Delta X_t - \Delta S_t]\\
&= \alpha_4(1-\beta)^{-1}[q(L)-(1-L)C_{21}(L)^*]e_{1t}\\
&\quad + \alpha_4(1-\beta)^{-1}(1-L)[r(L)-C_{22}(L)^*]e_{2t}.
\end{aligned}\tag{A.9}$$

Rearranging Equations (A.8) and (A.9) yields the restrictions in Equation (15).

Proof of Proposition 5. With $D_t^* = \alpha_5 X_t = \alpha_5[X_t^p + X_t^s]$, ΔD_t in Equation (12) and S_t in Equation (13) will be

$$\begin{aligned}\Delta D_t &= \alpha_5 b[1-(1-b)L]^{-1}\Delta X_t \\ &= \alpha_5 b\sum_k (1-b)^k \Delta X_{t-k}, \text{ or} \\ &= \alpha_5 b[1-(1-b)L]^{-1} q(L)e_{1t} \\ &\quad + (1-L)\alpha_5 b[1-(1-b)L]^{-1} r(L)e_{2t},\end{aligned} \tag{A.10}$$

and

$$\begin{aligned}S_t &= X_t - \gamma\alpha_5 b[1-(1-b)L]^{-1}X_t \\ &= (1-b)[1-(1-b)L]^{-1}\Delta X_t \\ &= (1-b)[1-(1-b)L]^{-1}q(L)e_{1t} \\ &\quad + (1-L)(1-b)[1-(1-b)L]^{-1}r(L)e_{2t},\end{aligned} \tag{A.11}$$

where S_t is obtained by setting $\gamma = 1/\alpha_5$ to satisfy the stationarity of S_t. Thus, this model is characterized by the restriction Equation (16) on the BMAR in Equation (4).

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