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Modeling Dividends, Earnings, and Book Value Equity: An Empirical Investigation of the Ohlson Valuation Dynamics

SASSON BAR-YOSEF
The Hebrew University of Jerusalem

JEFFREY L.CALLEN
Department of Accounting, Stern School of Business, New York University, New York, NY 10012

JOSHUA LIVNAT
Department of Accounting, Stern School of Business, New York University, New York, NY 10012

Abstract. This study empirically investigates the information dynamics of the Ohlson valuation framework. Single-period lagged linear autoregressive relationships among dividends, earnings, and book values of equity are estimated for a sample of stochastically stationary firms and are found not to support the valuation framework. This study further extends the empirical analysis to a multilagged vector autoregressive linear information system. Consistent with the Ohlson valuation framework, *the past time series* of all three variables are generally found to be relevant for firm valuation. This study brings into question empirical research utilizing the Ohlson framework that presupposes a single-period lagged information dynamic.

The valuation models of Ohlson (1989, 1990, 1995) and Feltham and Ohlson (1994a, 1994b, 1995) represent firm value by reference to (discounted) accounting variables rather than cash flows. This is important for accounting researchers who have a comparative advantage in understanding accounting variables but who are often forced by the extant cash-flow valuation models to unbundle the accounting numbers in order to obtain cash-flow figures. It is ironic. On the one hand, accounting practice and research maintain that accounting earnings and the accrual process generate numbers that are more relevant for firm valuation than cash flows, and yet, on the other hand, when studying the valuation process, accounting researchers often find themselves unbundling those same earnings numbers to apply valuation models represented by (discounted) cash-flow variables. In essence, the Ohlson and Feltham-Ohlson valuation representations permit accounting researchers to investigate accounting concepts that are potentially valuation relevant, such as conservatism, for example, but that are difficult if not impossible to frame within a cash-flow representation of value.

Despite the potential benefits of their framework for empirical accounting research, it appears that accounting empiricists have a penchant for misusing the Ohlson and Feltham-Ohlson (hereinafter Ohlson) valuation framework. This misuse comes about because many empiricists take the Ohlson valuation equations at face value without considering that these equations are conditioned on the assumed information dynamic. Change the information dynamic and the valuation equations change as well. In fact, Ohlson and Feltham-Ohlson choose specific information dynamics because of analytical tractability or because of some analytical point they are trying to convey, not because that particular dynamic necessarily has any empirical content. Being primarily concerned with analytical development, neither Ohlson nor Feltham-Ohlson tell us which dynamic is correct. By their silence on the issue, they implicitly leave that job for the empiricist.

The overall purpose of this article is to empirically investigate the potential relevance of earnings, book value equity, and dividends for firm valuation. Initially, we analyze the valuation relevance of these variables in the context of a one-period lagged linear dynamic model. The one-period lagged linear dynamics are typically the information dynamics that are assumed in the Ohlson and Feltham-Ohlson valuation papers although multilagged information dynamics may be completely consistent with the Ohlson valuation framework. There are in fact theoretical and empirical reasons to believe that lags of more than one period are important for accounting variables. Ryan (1995), for example, shows that it may take up to nine lags for the book-to-market ratio to adjust to market shocks. As a consequence, we investigate the potential relevance of earnings, dividends, and book value equity in the context of a multilagged vector autoregressive information system.

Unlike studies that directly estimate how accounting variables relate to security prices, this study relegates security prices to the background. Instead, the validity of the one-period lag assumption is determined by reference to the implications of the Ohlson valuation framework and, in particular, to the restrictions and signs of certain parameters in the information dynamics. These parameters involve accounting variables only, not prices.[1] This approach is very useful for empirically validating the information dynamics since one need not specify the specific price that is to be associated with a specific set of accounting information. This is especially important where the data are annual and it is unclear what specific market price should be associated with annual accounting data.

Our approach follows the work of Bar-Yosef, Callen, and Livnat (1987) (hereafter BCL). Like BCL, we investigate the relationships among accounting variables by assuming that these variables can be modeled as a system of vector autoregressive linear equations. Whereas BCL investigated the relationship between accounting earnings and investment, this study investigates the relationships among the three accounting variables central to the Ohlson framework—namely, accounting earnings, book values of equity, and dividends. Unlike BCL, however, we report our empirical test results only for the subsample of firms exhibiting weak-form stochastic stationarity, since weak-form stationarity is assumed by the underlying theory.[2] Nevertheless, we obtained qualitatively similar results for a larger sample of firms whose time series were not necessarily stationary.[3]

This article is structured in the following manner. Section 1 introduces a vector autoregressive Garman and Ohlson (1980) model of earnings, book values of equity, and dividends. The theoretical relationship between these variables and security valuation is illustrated. Section 2 briefly describes the Ohlson fundamental application of the basic Garman-Ohlson model, especially as it concerns the clean surplus relation. Section 3 tests the empirical validity of the single-period lagged linear dynamic information system typically assumed by the Ohlson valuation framework. Section 4 empirically analyzes a (multilagged) vector autoregressive linear information system. Section 5 concludes the article.

1. Valuation and Granger Causality in the Garman-Ohlson Model

We assume that the accounting variables earnings, book values of equity, and dividends can be modeled as a weak-form *stationary* stochastic process $Z_t = \{D_t, E_t, S_t\}$, where D_t denotes dividends at time t, E_t earnings at time t, and S_t book value of equity at time t.[4] It is well known that such a process can be modeled under fairly general conditions by the autoregressive representation:[5]

$$\begin{aligned} S_t &= \alpha_1 + \beta_{11} S_{t-1} + \beta_{12} S_{t-2} + \cdots + \mu_{11} E_{t-1} + \mu_{12} E_{t-2} + \cdots \\ &\quad + \delta_{11} D_{t-1} + \delta_{12} D_{t-2} + \cdots + v_{1t} \end{aligned} \tag{1}$$

$$\begin{aligned} E_t &= \alpha_2 + \beta_{21} S_{t-1} + \beta_{22} S_{t-2} + \cdots + \mu_{21} E_{t-1} + \mu_{22} E_{t-2} + \cdots \\ &\quad + \delta_{21} D_{t-1} + \delta_{22} D_{t-2} + \cdots + v_{2t} \end{aligned} \tag{2}$$

$$\begin{aligned} D_t &= \alpha_3 + \beta_{31} S_{t-1} + \beta_{32} S_{t-2} + \cdots + \mu_{31} E_{t-1} + \mu_{32} E_{t-2} + \cdots \\ &\quad + \delta_{31} D_{t-1} + \delta_{32} D_{t-2} + \cdots + v_{3t} \end{aligned} \tag{3}$$

where the α's, β's, μ's, and δ's are parameters and the v_{it} are conventional zero-mean error terms with constant variance-covariance matrix.

This model can be described more compactly in the polynomial form:

$$S_t = \alpha_1 + \beta_1(L)S_t + \mu_1(L)E_t + \delta_1(L)D_t + v_{1t} \tag{1$'$}$$

$$E_t = \alpha_2 + \beta_2(L)S_t + \mu_2(L)E_t + \delta_2(L)D_t + v_{2t} \tag{2$'$}$$

$$D_t = \alpha_3 + \beta_3(L)S_t + \mu_3(L)E_t + \delta_3(L)D_t + v_{3t} \tag{3$'$}$$

where $\beta_i(L)$ (and similarly for $\mu_i(L)$ and $\delta_i(L)$) is the lag polynomial $\Sigma_{k=1}\beta_{ik}L^k$, and L^k is the lag operator $L^k S_t = S_{t-k}$. Equations (1)$'$, (2)$'$, and (3)$'$ state that the firm's future book value of equity, earnings, and dividends (in period t) are linear stochastic functions of the firm's past book values of equity, earnings, and dividend series.

The relationships among the accounting variables, in particular, the relationship between dividends and each of earnings and book value of equity, can be described in terms of lag operators and the terminology of Granger (1969) causality. Specifically, we say that earnings do not cause dividends provided $\mu_3(L) \equiv 0$ (that is, $\mu_{3k} = 0$ for all k), whereas book value of equity causes dividends provided $\beta_3(L) \not\equiv 0$ (that is, $\beta_{3k} \neq 0$ for some k). If, in the latter case, dividends also cause book value of equity ($\delta_1(L) \not\equiv 0$), then feedback between dividends and book value of equity is said to occur. The language of causality is especially useful in describing the direct and indirect effects that an accounting variable could have on dividends. If earnings do not cause dividends, this means that earnings have no direct effect on dividends. On the other hand, if earnings do not cause dividends but earnings cause book values of equity and book values cause dividends, then earnings have an indirect effect on dividends.

In the Garman-Ohlson model, causality relationships have valuation consequences. To see this, let us consider a one-period lagged special case of the above model (equations (1)′, (2)′, (3)′)—namely,

$$S_t = \beta_1 S_{t-1} + \mu_1 E_{t-1} + \delta_1 D_{t-1} + v_{1t} \tag{1}''$$

$$E_t = \beta_2 S_{t-1} + \mu_2 E_{t-1} + \delta_2 D_{t-1} + v_{2t} \tag{2}''$$

$$D_t = \beta_3 S_{t-1} + \mu_3 E_{t-1} + \delta_3 D_{t-1} + v_{3t}. \tag{3}''$$

Given the Garman-Ohlson assumptions of perfect capital markets, homogeneous expectations, a constant risk-free rate, and an arbitrage-free economy, their Theorem 2 can be applied to this one-period lagged model to yield the valuation equation

$$P_t = B_o + B_1 S_t + B_2 E_t + B_3 D_t, \tag{4}$$

where P_t is price of the security at time t. The B_i are constants that satisfy the matrix equation

$$\begin{bmatrix} R-1 & \sigma_1 & \sigma_2 & \sigma_3 \\ 0 & R-1-\beta_1 & -\beta_2 & -\beta_3 \\ 0 & -\mu_1 & R-1-\mu_2 & -\mu_3 \\ 0 & -\delta_1 & -\delta_2 & R-1-\delta_3 \end{bmatrix} \cdot \begin{bmatrix} B_o \\ B_1 \\ B_2 \\ B_3 \end{bmatrix} = \begin{bmatrix} -\sigma_3 \\ \beta_3 \\ \mu_3 \\ 1+\delta_3 \end{bmatrix} \tag{5}$$

where R is the risk-free rate and σ_i is covariance $(v_i,\ Q_{t+1})$.[6]

Causality relationships determine whether a particular accounting variable is or is not relevant for valuation purposes. Two cases are particularly illuminating.

Case 1. *Supposing that dividends are not caused by other accounting variables, excluding dividends themselves, then the other accounting variables are not valuation relevant (Ohlson, 1979).*

Proof: Since by assumption $\beta_3 = \mu_3 = 0$, equation (5) can be solved to show that $B_1 = B_2 = 0$. ■

Case 2. *Supposing that earnings (book values of equity) do not cause dividends, and earnings (book values) do not cause book values (earnings), then earnings (book values) are not valuation relevant.*

Proof: Since by assumption $\mu_3 = \mu_1 = 0$, equation (5) can be solved to show that $B_2 = 0$. Similarly, if $\beta_3 = \beta_2 = 0$, then $B_1 = 0$. ■

These two cases imply that a particular accounting variable is not relevant for valuation purposes if (1) no accounting variables (excluding dividends) cause dividends or if (2) the particular accounting variable does not cause dividends both directly and indirectly (via other accounting variables). In general, the fact that a specific accounting variable does not cause dividends directly does not mean that this variable is not valuation relevant. Although $\mu_3 = 0$, earnings may still be valuation relevant if β_3 and μ_1 are not zero, since earnings could affect dividends indirectly via book values of equity. In fact, it is not difficult to show that $\mu_3 = 0$ is *not* sufficient for $B_2 = 0$.

The Garman–Ohlson model generalizes to a multilagged environment providing it is assumed that the lag structures of the information variables are finite. A linear information structure yields a linear valuation operator except that, in the multilagged case, the price of the security will be a linear function of past as well as current information. Thus, a sufficient condition for past and current earnings and for past and current book values of equity to be valuation irrelevant is that $\mu_3(L) \equiv \beta_3(L) \equiv 0$. Similarly, past and current earnings are not valuation relevant provided $\mu_3(L) \equiv \mu_1(L) \equiv 0$.

2. The Ohlson Valuation Framework

The strength of the Garman-Ohlson model is that it is completely general and can include in theory any finite number of accounting variables. This is also the model's weakness. The model does not specify a priori which, if any, *accounting* variables are informationally relevant, nor is the model sufficiently structured to provide testable restrictions on the signs of the parameters. More recently, Ohlson (1989, 1990, 1995) and Feltham and Ohlson (1994a, 1994b, 1995) extended the model by imposing theoretical constraints on the valuation equation and the linear information system.[7] These constraints are sufficient to sign a number of the parameters of the information system. More specifically, they assume a single-period lagged linear information system (equations (1)″, (2)″, (3)″) comprised of earnings, dividends, and book values of equity that are assumed to be related in equilibrium via the clean surplus equation:[8]

$$S_t = S_{t-1} + E_t - D_t. \tag{6}$$

In addition, they assume that the equilibrium is characterized by two Miller-Modigliani (1961) dividend irrelevance conditions. One condition requires dividends to be irrelevant in that an incremental dollar of dividends reduces the ex-dividend value of the firm by exactly one dollar. The second dividend irrelevance condition requires that the foregone expected earnings in period t due to an incremental dollar of dividends in period $t-1$ should equal the negative of the interest rate. The clean surplus equation and the two Miller-Modigliani conditions imply value and sign restrictions on some of the parameters of the information system. It is precisely these parameter value and sign restrictions, as well as the causality relationships, which are utilized in this study to test the empirical validity of the one-period lagged information dynamic.

The following sections of this article are empirical in nature. In Section 3, we initially estimate an unrestricted linear one-period lagged system (equations (1)″, (2)″, (3)″ inclusive of a constant term in each equation).[9] The major objectives here are to see if (1) the data naturally satisfy the parameter value and sign restrictions implied by the clean surplus relation and the two Miller-Modigliani dividend irrelevance conditions and if (2) earnings, book values of equity, and dividends are valuation relevant. To the extent that the parameter values and sign restrictions are satisfied by the data and to the extent that these variables are valuation relevant, this suggests that the one-period lagged linear dynamics have empirical validity. Specifically, given the clean surplus equation and the two Miller-Modigliani conditions, the Ohlson model predicts that the parameters in equation (2)″ take on the signs $\beta_2 \geq 0$, $\mu_2 \geq 0$, $\delta_2 \leq 0$, where $\beta_2 > 0$ if and only if $\delta_2 < 0$ (see Ohlson, 1989, p. 24, for proof). Moreover, valuation relevance of earnings *and* book values dictates that the conditions of Case 1 do not hold. On the other hand, if these parameter value and sign restrictions are not satisfied and if both earnings and book value are not valuation relevant, this would signify rejection of these dynamics.

Since one could argue that the model is misspecified unless the underlying dynamics incorporate the parameter restrictions inherent in the clean surplus relation, we also estimate a restricted linear one-period lagged model in which the clean surplus relation is imposed on the data. The objective here is to see if the *sign* restrictions of the model are satisfied and if earnings, book values of equity and dividends are valuation relevant.

Section 4 considers a multilagged vector autoregressive linear information system (equations (1)′, (2)′, (3)′) where the data determine the lag structure. It is assumed that earnings, dividends, and book values of equity comprise the potential universe of valuation-relevant *accounting* data. Since the Garman-Ohlson model places no restrictions on accounting variables, it is difficult if not impossible to reject the model on the basis of our data. Rather, the objective here is to determine which if any of the accounting variables are potentially valuation relevant, the causality relationships among them, and their lag structure. To the extent that all three of these variables are valuation relevant and the lag structure is multilagged suggests that, within the Ohlson valuation framework, the assumption of a single-period lag dynamic is overly restrictive. On the other hand, a finding of the accounting variables to be valuation irrelevant suggests that the empirical results seriously question the usefulness of the framework.

3. Empirical Analysis: The Single-Period Lagged Information Dynamic

3.1. The Data

Annual data were obtained from the COMPUSTAT Annual Industrial File for a sample of manufacturing firms. The sample was initially limited to firms with available data on dividends, book value of equity, net income before extraordinary items and total assets for the entire 1960 to 1987 (inclusive) period.[10] These requirements were satisfied by 348 firms. In addition to the underlying theory, the estimation of vector autoregressive models requires that each firm in the sample exhibit stochastic stationarity with respect to all relevant time series (see Davidson and MacKinnon, 1993, chs. 19–20). Therefore, each of the 348 firms was tested for stationarity using the (augmented) Dickey-Fuller (1979) unit root tests. A firm was deemed to be stationary if stationarity could not be rejected for all of its time series at the 10% significance level. This requirement further limited the final sample size to 118 firms.

Table 1. Estimates of the unrestricted single-period lag model.

$S_t =$	.185 (1.22)	+	.6813 S_{t-1} (2.43)**	−	.0709 E_{t-1} (−.08)	−	.3628 D_{t-1} (−.12)	(1)″
$E_t =$	.027 (.36)	+	.0138 S_{t-1} (.09)	+	.3428 E_{t-1} (1.09)	+	.0128 D_{t-1} (.00)	(2)″
$D_t =$	−.000 (−.00)	+	.0109 S_{t-1} (0.24)	+	.0197 E_{t-1} (.19)	+	.6773 D_{t-1} (2.80)*	(3)″

Note: The model (equations (1)″ to (3)″) is estimated separately for each firm. Table entries represent mean coefficients over all sample firms. t-statistics (in parentheses) represent the mean coefficient divided by its standard error using all sample firms.
S_t = Equity in period t deflated by total assets at the beginning of period t.
E_t = Earnings in period t by total assets at the beginning of period t.
D_t = Dividends in period t deflated by total assets at the beginning of period t.
** Significant at the 5 percent level or less.
* Significant at the 1 percent level or less.

3.2. *The Empirical Results*

The single-lag information dynamic (equations (1)″, (2)″, (3)″) was estimated for each firm separately by Zellner's (1963) seemingly unrelated regression equations estimators. The variables earnings, book value of equity, and dividends were deflated by total assets.[11] Table 1 reports summary results for the unrestricted information dynamic.[12] The coefficients in the table represent mean coefficients over all 118 firms in the sample. The t-values of these coefficients are reported in parentheses. These t-values are calculated as the mean coefficient divided by the standard error for all sample firms.

The estimated parameters of the unrestricted single-period lagged information dynamic are obviously inconsistent with the Ohlson framework. In fact, all three estimated equations are characterized by the lack of causality relationships. Only the univariate coefficients in the book value equity equation (1)″ and the dividend equation (3)″ are significant. None of the accounting variables except for dividends are valuation relevant. The parameter restrictions implied by the clean surplus relation (see equations (7) below) are not satisfied either.

These results are not too surprising, perhaps, since the unrestricted system abstracts from the clean surplus relation, which is at the heart of the Ohlson framework. Therefore, we impose the linear restrictions on the parameters implied by the clean surplus relation—namely, the cross-equation restrictions:

$$\begin{aligned} \beta_1 &= 1 + \beta_2 - \beta_3 \\ \mu_1 &= \mu_2 - \mu_3 \\ \delta_1 &= \delta_2 - \delta_3. \end{aligned} \tag{7}$$

Table 2 summarizes the SUR regressions for the restricted system. The results are almost identical to those of Table 1. An F-statistic to test the significance of the restrictions was

Table 2. Estimates of the restricted single-period lag model.

$S_t =$	.030	$+$	.9386 S_{t-1}	$+$	.2656 E_{t-1}	$-$	.5808 D_{t-1}	(1)″
	(.32)		(5.01)*		(.80)		(−.42)	
$E_t =$	.057	$-$	.0345 S_{t-1}	$+$	.2930 E_{t-1}	$+$	.0827 D_{t-1}	(2)″
	(.61)		(−.19)		(.90)		(.06)	
$D_t =$	−.005	$+$	.0269 S_{t-1}	$+$	.0275 E_{t-1}	$+$	.6636 D_{t-1}	(3)″
	(−.28)		(0.35)		(.23)		(2.81)*	

Note: The model (equations (1)″ to (3)″) is estimated separately for each firm. Table entries represent mean coefficients over all sample firms. t statistics (in parentheses) represent the mean coefficient divided by its standard error using all sample firms.
S_t = Equity in period t deflated by total assets at the beginning of period t.
E_t = Earnings in period t deflated by total assets at the beginning of period t.
D_t = Dividends in period t deflated by total assets at the beginning of period t.
* Significant at the 1 percent level or less.
The cross-equation restrictions are

$$\beta_1 = 1 + \beta_2 - \beta_3$$
$$\mu_1 = \mu_2 - \mu_3$$
$$\delta_1 = \delta_2 - \delta_3.$$

calculated for each firm in the sample. These firm level F-statistics were then aggregated into a chi-square statistic of the form

$$\chi^2(2N) = -2 \sum ln\,(p_n) \qquad (n = 1, 2, \ldots, N), \tag{8}$$

where p_n is the p-value associated with the F-statistic for firm n, $n = 1, 2, \ldots, 118$. The resulting calculation allowed us to reject the linear restrictions at the 1 percent significance level.[13] Again, the only significant relationships obtained are univariate in nature. This implies that none of the accounting variables are valuation relevant except of course for dividends.

In addition, given the clean surplus equation and the two Miller-Modigliani conditions, the Ohlson model predicts that the parameters in equation (2)″ take on the signs $\beta_2 \geq 0$, $\mu_2 \geq 0$, $\delta_2 \leq 0$, where $\beta_2 > 0$ if and only if $\delta_2 < 0$. Table 2, however, indicates that these sign restrictions are at best satisfied trivially since none of these coefficients are significant. As point estimates, these sign restrictions are violated completely since the estimated β_2 and δ_2 have the wrong sign.

In the next section, we investigate whether these results carry over to a multilagged linear information system.

4. Empirical Analysis: The Multilagged Information Dynamic

4.1. Methodology

The causality relationships among dividends, earnings, and book values of equity could, at least in theory, be estimated in a fairly straightforward fashion. One could simply fit finite lagged formulations of equations (1)′, (2)′, and (3)′ by ordinary least squares, thus obtaining estimates of the $\beta_i(L)$, $\mu_i(L)$, and $\delta_i(L)$ $(i = 1, 2, 3)$ that are consistent and asymptotically normally distributed. Subsequently, one could proceed to test whether or not the estimated $\beta_i(L)$, $\mu_i(L)$, and $\delta_i(L)$ are significantly different from zero, thereby establishing the causality relationships.

This approach is problematic, as Hsiao (1979a, 1979b) has emphasized, because the test of $\beta_i(L) \equiv \mu_i(L) \equiv \delta_i(L) \equiv 0$ is quite sensitive to the order of lags. If, as is normally the case, the lag structure is prespecified, the test results may simply be due to the imposed lag specification rather than true causality in the data. One solution suggested by Hsiao is to let the data determine the lag structure instead of imposing some arbitrary lag structure on the model. His suggested procedure for obtaining the optimal order of the lags for each of $\beta_i(L)$, $\mu_i(L)$, and $\delta_i(L)$ in each of equations (1)′, (2)′, and (3)′ is to employ the final prediction error (FPE) criterion developed originally by Akaike (1969a, 1969b). Consider first the book value variable S_t. The FPE of S_t is defined to be the mean squared prediction error:

$$E(S_t - \hat{S}_t)^2, \tag{9}$$

where $\hat{S}_t$ is the predicted book value in period t and $E(\cdot)$ is the expectations operator. The predicted book value $\hat{S}_t$ is determined by fitting equation (1)′ using ordinary least squares for a given lag structure of orders m, n, and p on $\beta_1(L)$, $\mu_1(L)$, and $\delta_1(L)$, respectively. In other words, $\hat{S}_t$ is the least-squares estimate

$$\hat{S}_t = \hat{\alpha}_1 + \hat{\beta}_1^m(L)S_t + \hat{\mu}_1^n(L)E_t + \hat{\delta}_1^p(L)D_t, \tag{10}$$

where $\hat{\alpha}_1$ is the estimated intercept, $\hat{\beta}_1^m(L)$ are the estimated parameters of $\beta_1(L)$ assuming a lag structure of order m, $\hat{\mu}_1^n(L)$ are the estimated parameters of $\mu_1(L)$ assuming a lag structure of order n, and $\hat{\delta}_1^p(L)$ are the estimated parameters of $\delta_1(L)$ assuming a lag structure of order p. Since the population mean of the FPE's is unknown, Akaike estimates the final prediction error (for book value equity) by

$$FPE_s(m, n, p) = \frac{T + m + n + p + 1}{T - m - n - p - 1}\left(\sum_{t=1}^{T}(S_t - \hat{S}_t)^2/T\right), \tag{11}$$

where T is the total number of data points. The first term of the product on the right side of equation (11) is a measure of estimation error, while the second (bracketed) term represents a measure of the average modelling error. The greater the number of lags the smaller will be the average modeling error, but the greater will be the estimation error. Akaike's FPE criterion is to choose the lag structure (m, n, p) that minimizes this tradeoff—namely, the final prediction error given by equation (11).[14] In a similar fashion, one can estimate equation (2)′ and (3)′ by ordinary least squares to obtain an estimated value $\hat{E}_t$ for earnings and $\hat{D}_t$ for dividends. The estimated final prediction error for earnings and dividends, respectively, would then be

$$FPE_E(m, n, p) = \frac{T + m + n + p + 1}{T - m - n - p - 1}\left(\sum_{t=1}^{T}(E_t - \hat{E}_t)^2/T\right) \tag{12}$$

$$FPE_D(m,n,p) = \frac{T+m+n+p+1}{T-m-n-p-1}\left(\sum_{t=1}^{T}(D_t - \hat{D}_t)^2/T\right). \tag{13}$$

Except for computational costs, the FPE approach for determining causality yields a number of distinct benefits in terms of identifying the model. First, as we have already pointed out, the data are used to determine the lag structure of the model instead of imposing some arbitrary lag-order specification. Second, the FPE criterion does not constrain the lag structure of each variable to be identical—that is, m is not constrained to be necessarily equal to n or p. Nor need the lag structure be the same for all equations. Third, it can be shown that the FPE criterion is equivalent to choosing the model specification on the basis of an F-test with varying significance levels (see Hsiao, 1981).

The procedure for finding the optimal lag structure for each of equations (1)′, (2)′, and (3)′ using the FPE criterion is to estimate each equation for *every* potential lag structure (for each firm) and to choose the lag structure that yields minimum FPE. If N denotes the number of firms in the sample and Q the maximum possible lag for each variable, then we estimate $3 \times (Q+1)^3 \times N$ regressions in total to find the optimal lag structure for every firm in the sample.

4.2. *The Empirical Results*

Univariate and multivariate models were estimated for each firm separately with five lags as the maximum potential lag for each variable.[15] The best model for each firm was based on the minimum FPE criterion. The statistical significance of the causality relationships were then tested using the FPE data.[16]

Table 3 summarizes the median lags for each variable and each model. In the earnings and book value equity models, the median lags of all variables are between 1 and 2 for the univariate and bivariate models and between 1.5 and 3 for the multivariate models. In the dividend equation, the median lag is 2 almost uniformly for all variables and models.

Table 4 lists summary data of a standard nonparametric sign-test of the FPE data. The first column lists the models being compared in mnemonic form. For example, the first E in the mnemonic E-ES denotes that the earnings equation (equation (2)′) is being studied. The remainder of the mnemonic should be interpreted to mean that the FPEs of two models (for the same firm) are being subtracted from each other: the FPE of the best-fit bivariate earnings model—with earnings and book value of equity as independent variables denote by ES—is being subtracted from the FPE of the best-fit univariate earnings model. The next three columns show the number of firms for which these differences are positive, negative and zero, respectively. For the E-ES models, sixty-seven firms have positive FPE differences, fifty-one had negative FPE differences, and no firms had identical univariate and bivariate minimum FPEs. On the basis of a two-tailed sign test (columns 5 and 6), one cannot reject the hypothesis that the median FPE of the bivariate earnings-book value model is identical to the median FPE of the univariate earnings model, implying that book values of equity do *not* cause earnings. Similarly, consider the mnemonic E-ESD in the third row of Table 4. Here the comparison is between the FPEs of the best univariate earnings model and the FPEs of the best multivariate earnings model with earnings, book value, and dividends

Table 3. Median lags for the various models.

Model	Equity	Earnings	Dividends
Earnings Models:			
1. E	—	1	—
2. ES	1	1	—
3. ED	—	1	1
4. ESD	2	2	1.5
Equity Models:			
1. S	1	—	—
2. SE	1	1.5	—
3. SD	1	—	2
4. SED	2	2	3
Dividend models			
1. D	—	—	2
2. DE	—	2	2
3. DS	1	—	2
4. DES	2	2	2

E = Univariate earnings model
D = Univariate dividend model
S = Univariate book value model
ES = Bivariate (earnings – book value) earnings model
ED = Bivariate (earnings – dividend) earnings model
SE = Bivariate (book value – earnings) book value model
SD = Bivariate (book value – dividends) book value model
DE = Bivariate (dividends – earnings) dividend model
DS = Bivariate (dividends – book value) dividend model
ESD = Multivariate earnings model
SED = Multivariate book value model
DES = Multivariate dividend model

as the independent variables. For eighty-seven firms the minimum FPE of the multivariate earnings model is less than the minimum FPE of the univariate earnings model. In thirty-one cases, the multivariate model has greater FPE and in no case is the minimum FPE the same for both models. The two-tailed probability test and z-value criterion indicate that one can reject the hypothesis that the multivariate and univariate models have identical median FPEs so that both book value of equity and dividends cause earnings. For completeness sake, comparisons between the bivariate and multivariate models are also presented.

The overall results of Table 4 are fairly unambiguous. For all equations and all models, the multivariate model yields the lowest FPE. Moreover, the highest z-score is obtained in the comparison between the univariate and multivariate models for all equations. Therefore, on the basis of the sign test, there is significant feedback among all three accounting variables; dividends cause and are caused by earnings and book values of equity. Also, earnings cause and are caused by book values of equity.

Further evidence of feedback among the three variables is found in Table 5. Table 5 is similar to Table 4, except that the equality of median FPEs is tested by a Wilcoxon signed-rank test.[17] Columns 2 and 3 list the mean positive and negative rank differences,

Table 4. Sign tests: FPE differences for the various models.

	Model	Positive Signs[a]	Negative Signs[a]	Ties	Significance Level[b] Less than	Z Value
1.	*E-ES*	67	51	0	.1673	1.3809
2.	*E-ED*	57	61	0	.7824	0.2762
3.	*E-ESD*	87	31	0	.0000	5.0632
4.	*ES-ESD*	73	45	0	.0129	2.4856
5.	*ED-ESD*	78	40	0	.0007	3.4061
6.	*S-SE*	73	45	0	.0129	2.4856
7.	*S-SD*	71	47	0	.0342	6.5361
8.	*S-SED*	95	23	0	.0000	4.1426
9.	*SE-SED*	82	36	0	.0000	4.1426
10.	*SD-SED*	86	32	0	.0000	4.8790
11.	*D-DE*	72	45	1	.0162	2.4037
12.	*D-DS*	72	44	2	.0122	2.5069
13.	*D-DES*	93	23	2	.0000	6.4065
14.	*DE-DES*	69	49	0	.0803	1.7491
15.	*DS-DES*	81	35	2	.0000	4.1781

E = Univariate earnings model
D = Univariate dividend model
S = Univariate book value model
ES = Bivariate (earnings – book value) earnings model
ED = Bivariate (earnings – dividend) earnings model
SE = Bivariate (book value – earnings) book value model
SD = Bivariate (book value – dividends) book value model
DE = Bivariate (dividends – earnings) dividend model
DS = Bivariate (dividends – book value) dividend model
ESD = Multivariate earnings model
SED = Multivariate book value model
DES = Multivariate dividend model

a. Positive (negative) signs represent the number of firms with a higher (lower) FPE for the first model than the second model.

b. Significance levels indicate the probability of observing the number of positive (negative) signs in the table due to chance, when the FPEs of the two models have identical medians.

respectively, for each of the models in column 1. Again, on the basis of the Wilcoxon signed-ranked test, it would appear that all of the accounting variables exhibit feedback, since the mean rank of the positive differences is significantly greater than that of the negative differences for all comparisons involving univariate and multivariate models.

Further evidence of causality relationships amongst earnings, book values, and dividends can be obtained by plotting the cumulative distributions of the FPEs for the univariate, bivariate, and multivariate models.[18] Figure 1 shows the FPE distributions for the earnings equation. The distributions of the bivariate models cross over a number of times and no dominance is evident, but both seem to dominate the distribution of the univariate model. The distribution of the multivariate model, on the other hand, lies almost everywhere beneath the distributions of the other models and, in particular, that of the univariate earnings model.

Table 5. Wilcoxon signed-rank tests: FPE differences for the various models.

	Models	Mean Rank of Positive Differences[a]	Mean Rank of Negative Differences[a]	Significance Level[b] Less Than	Z Value
1.	E-ES	60.43	58.27	.1481	1.4461
2.	E-ED	63.15	56.09	.8111	0.2390
3.	E-ESD	61.03	55.19	.0000	4.8325
4.	ES-ESD	66.14	48.73	.0004	3.5381
5.	ED-ESD	63.51	51.69	.0001	3.8750
6.	S-SE	70.92	40.98	.0000	4.4753
7.	S-SD	69.96	43.70	.0001	3.9114
8.	S-ESD	66.43	30.87	.0000	7.5206
9.	SE-SED	69.48	36.78	.0000	5.8717
10.	SD-SED	69.50	32.63	.0000	6.6237
11.	D-DE	63.93	51.11	.0017	3.1319
12.	D-DS	67.83	43.23	.0000	4.1076
13.	D-DES	64.05	36.07	.0000	7.0622
14.	DE-DES	72.51	41.18	.0001	4.0080
15.	DS-DES	65.12	43.17	.0000	5.1847

E = Univariate earnings model
D = Univariate dividend model
S = Univariate book value model
ES = Bivariate (earnings – book value) earnings model
ED = Bivariate (earnings – dividend) earnings model
SE = Bivariate (book value – earnings) book value model
SD = Bivariate (book value – dividends) book value model
DE = Bivariate (dividends – earnings) dividend model
DS = Bivariate (dividends – book value) dividend model
ESD = Multivariate earnings model
SED = Multivariate book value model
DES = Multivariate dividend model
a. Mean rank of positive (negative) differences represent the average rank of the positive (negative) differences in FPEs between the first and second model.
b. Significance levels indicate the probability of observing the mean rank of positive (negative) differences in the table due to chance, when the FPEs of the two models have identical medians.

Thus, the multivariate model dominates the others in the sense of having smaller FPEs by second-degree stochastic dominance (see, for example, Hanoch and Levy, 1969). This result provides again very clear evidence that earnings are caused by both dividends and book values of equity. Similar plots are shown for book values of equity (Figure 2) and dividends (Figure 3) when the latter are the dependent variables. In these cases, too, the multivariate distribution lies underneath the univariate and bivariate distributions. Thus, the multivariate distribution dominates the others, which again implies that dividends are caused by earnings and book values of equity, and book values are caused by earnings and dividends.

In Section 1 of this article we showed that two conditions suffice for an accounting

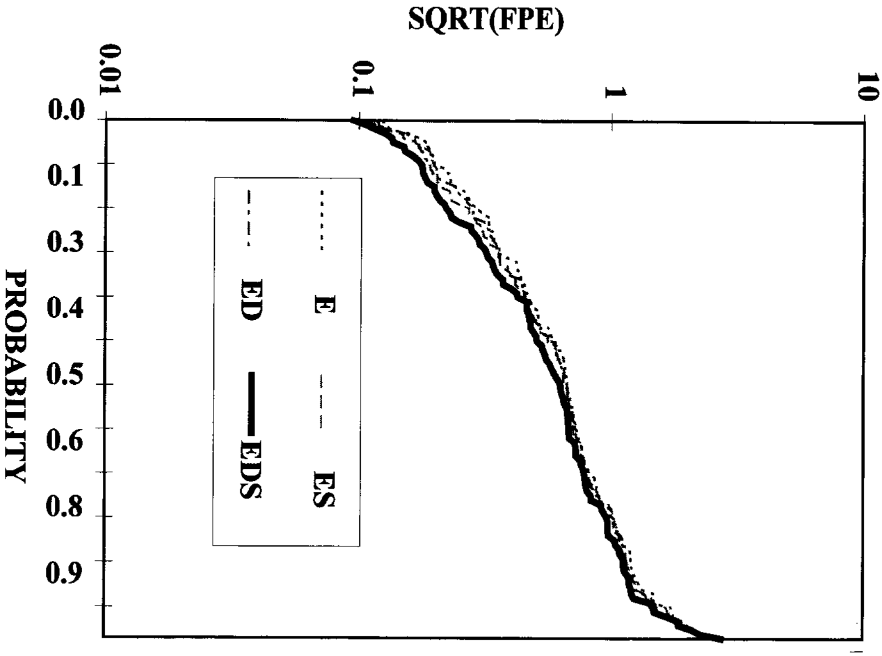

Figure 1. Earnings.

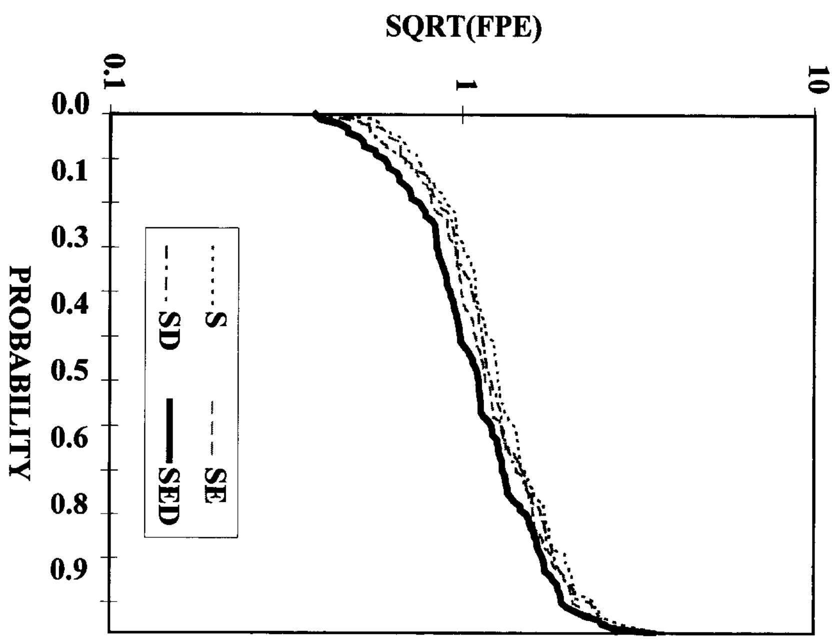

Figure 2. Equity.

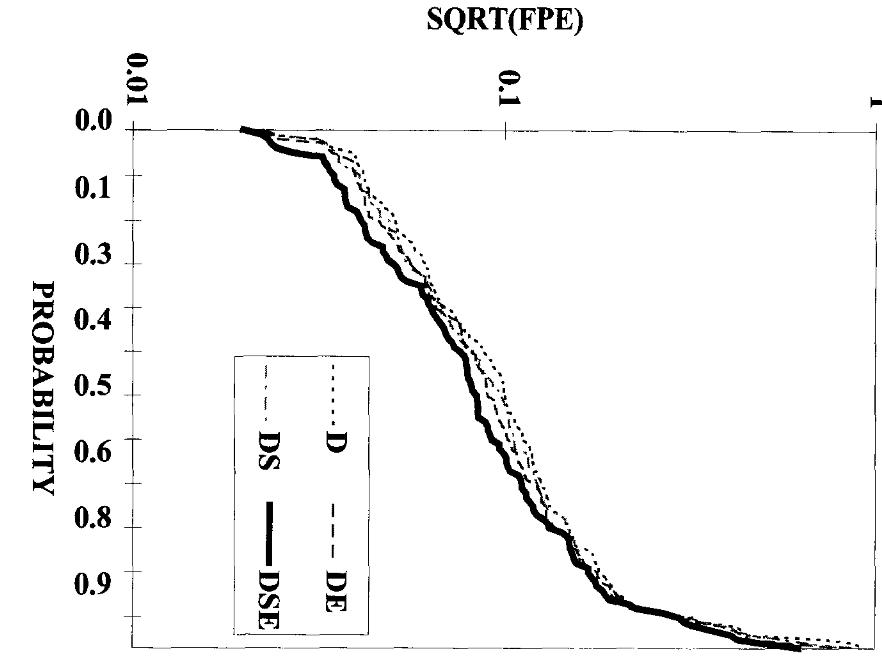

Figure 3. Dividends.

variable to be irrelevant for valuation purposes. One condition, that emphasized by Ohlson, is satisfied when none of the accounting variables (excluding dividends) cause dividends. Row 13 of Table 4 shows that at most there are only twenty-five firms for which neither earnings nor book values of equity cause dividends. This is a maximum number because if earnings alone or book values alone cause dividends for these twenty-five firms, then the Ohlson condition is violated. A comparison of the minimum FPEs of the optimal univariate, bivariate, and multivariate dividend models for these firms (not reported in the table) shows that, out of 118 firms, only twelve firms, about 10 percent of the sample, satisfied the Ohlson condition for valuation irrelevance. These results indicate that the essential accounting variables in the Ohlson framework are valuation relevant.

A more interesting question is how often are earnings alone or book values of equity alone irrelevant for valuation purposes. The sufficient condition for earnings alone (book values) not to be valuation relevant is for earnings (book values) not to cause dividends *and* for earnings (book values) not to cause book values (earnings). An analysis of individual FPE results (not reported in Table 5) shows that earnings alone are not valuation relevant for twenty firms, whereas book values of equity alone are not valuation relevant for nineteen firms. It is worth noting that firms for which earnings or book values (or both) are valuation irrelevant are not concentrated in any particular industry.

4.3. Comparison with the Literature

It is rather difficult to compare the results in this study with the existing literature since to date there are no other empirical studies that look at all three variables of interest simultaneously, especially on a time series basis at the firm level. Of the few studies that do investigate the dividend-earnings relationship, most are cross-sectional in nature and allow for at most a one-period lag structure in dividends and earnings (see, for example, Healy and Modigliani, 1990). The one exception is the original study by Fama and Babiak (1968). For each of the 392 firms in their sample, they regress the change in dividends (per share) on prior period dividends of up to two lags, on current earnings and on earnings lagged one period. They find that lagged earnings increases the median adjusted R^2 (a reasonable proxy for the reciprocal of an FPE) but that the second lag on dividends does not. These results are broadly consistent with ours in that lagged earnings and dividends appear to be important in the dividend equation. Unlike Fama-Babiak, however, we find for our sample that the optimal lag structure is two periods rather than one for both variables. But this could be easily due to the differences in the deflator or because Fama-Babiak have the change in dividends rather than dividends as the regressand or because they allow contemporaneous earnings to be a regressor whereas of course we do not.[19] Also, Fama-Babiak do not allow for a second-period lag in earnings.

5. Conclusion

Many accounting empiricists have chosen the Ohlson valuation framework as the basis for their empirical analysis. These empiricists have adopted the one-period lagged information dynamic utilized by the Ohlson framework at face value, without apparently realizing that the specific dynamic was probably chosen for analytical tractability or to demonstrate a specific analytical point and not because of its empirical content. In point of fact, the Ohlson framework is also theoretically consistent with any number of multilagged linear information systems, but each such system yields its own particular valuation results.

At the empirical level, we were able to reject the one-period lagged linear dynamic for a large sample of firms. In contrast, we found that earnings, book values of equity and dividends were valuation relevant for a multilagged information dynamic. In particular, each of earnings and book value turned out to be valuation relevant for over 83 percent of the sample. Only for about 10 percent of the sample were *neither* earnings nor book values of equity valuation relevant. The median lag structure of the estimated multilagged system varied between 1.5 and 3 depending on the specific variable and the optimal multivariate model. In most cases, the median lag structure was 2 irrespective of the variable and model further indicating the inappropriateness of the single-period lag assumption.

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Notes

1. Dividends are both cash flows and an accounting variable for purposes of this study.

2. If neither the mean nor the autocovariance of a stochastic process depend on the date, then the process is said to be weak-form stationary.
3. The results are available from the authors.
4. It is also assumed that the three-ple stochastic process Z_t is full of rank in the sense that the lag one prediction error matrix has a rank of 3. On this issue, see Masani (1966, p. 355).
5. These conditions are also rather abstract. See, for example, Masani (1966).
6. See Garman-Ohlson (1980, pp. 426–427) for a definition of the random variable Q_{t+1}.
7. There are important differences between Ohlson (1989) and Ohlson (1995). Although our discussion below uses the 1989 framework, we later impose the clean surplus relation in a manner that makes the 1989 model consistent with Ohlson (1995).
8. The clean surplus relation can be assumed to be stochastic if the firm has accounting transactions (other than stock issuances) that affect equity but do not go through income or dividends. Examples include gains or losses on foreign-exchange translations and investment in certain marketable securities. The analysis that follows goes through if the usual stochastic error term is added to equation (6).
9. The constant terms are assumed to capture the effect of a nonaccounting information on security valuation. On this point, see Ohlson (1995) and Feltham and Ohlson (1994b).
10. Like many other studies, this study may suffer from survivorship bias, and its results may not be generalizable to the entire population.
11. The Ohlson framework is normally specified in levels, but the analytics go through if the variables are deflated by total assets. Empirically, deflation helps to mitigate heteroskedasticity issues. The (augmented) Dickey-Fuller tests used in the sample selection process were performed on these deflated series.
12. The constant terms reported in Tables 1 and 2 were not deflated by total assets. We also estimated the model by adding a term for the reciprocal of total assets and forcing the regression through the origin. The results were very similar to those reported and are available from the authors.
13. This test assumes firm independence, which is somewhat unlikely because the data are from the same time period for all firms. The test should therefore be interpreted with caution.
14. In other words, Akaike's criterion balances the bias from choosing too small a lag-order against the increased variance of a higher lag-order specification.
15. Since $Q = 5$ and $N = 118$, a total of 76,464 regressions were estimated in our sample.
16. Although earnings, book values, and dividends are likely to be correlated, multicollinearity is not an issue because the FPE is an overall fit statistic like an R^2 and is insensitive to multicollinearity among the independent variables.
17. The nonparametric Wilcoxon signed-rank test is appropriate because it attenuates the problem of outliers in the data and because the distribution of the FPE's is unknown.
18. To enhance the clarity of the plots, the vertical axis shows the square root of the FPEs on a logarithmic scale.
19. To do so would be inconsistent with the notion of an information dynamic.

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