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Implementing Residual Income Valuation With Linear Information Dynamics

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ABSTRACT: Residual income (RI) valuation is a method of estimating firm value based on expected future accounting numbers. This study documents the necessity of using linear information models (LIMs) of the time series of accounting numbers in valuation. I find that recent studies that make *ad hoc* modifications to the LIMs contain internal inconsistencies and violate the no arbitrage assumption. I outline a method for modifying the LIMs while preserving internal consistency. I also find that when estimated as a time series, the LIMs of Ohlson (1995), and Feltham and Ohlson (1995) provide value estimates no better than book value alone. By comparing the implied price coefficients to coefficients from a price level regression, I find that the models imply inefficient weightings on the accounting numbers. Furthermore, the median conservatism parameter of Feltham and Ohlson (1995) is significantly negative, contrary to the model's prediction, for even the most conservative firms. To explain these failures, I estimate a LIM from a more carefully modeled accounting system that provides two parameters of conservatism (the income parameter and the book value parameter). However, this model also fails to capture the true stochastic relationship among accounting variables. More complex models tend to provide noisier estimates of firm value than more parsimonious models.

Key Words: *Residual income, Valuation, Linear information dynamics, Conservatism.*

Data Availability: *Data are available from sources indicated in the text.*

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I. INTRODUCTION

To relate firm value and accounting earnings, there must be a link between earnings and dividends. Until recently, researchers have assumed either a proportional payout of earnings or a monotonic relationship between earnings and dividends. Assuming only clean surplus accounting, Ohlson (1995) shows that a firm's ''intrinsic'' value is equal to the book value of equity plus the present value of expected future residual income.[1,2] Residual income (RI) is the difference between accounting earnings and a charge for the normal return on equity (the discount rate times book value). ''Intrinsic'' value equals the present value of expected future dividends regardless of the dividend payout policy or the quality of the accounting numbers, providing that clean surplus is observed. RI valuation models firm value as a function of current and expected future accounting numbers. This is appealing because the necessary link between firm value and earnings, book value and dividends is inherent in the accounting system.

However, the clean surplus link between dividends, book value and earnings is not sufficient to implement RI valuation. As Bernard (1994) states, a second link between current accounting numbers and future RI is an essential part of fundamental analysis. This link is the information dynamics (Ohlson 1995).

The information dynamics used by Ohlson (1995) (the Linear Information Model or LIM) is an autoregressive model of RI. Recent empirical research in RI valuation attempts to implement valuation by modifying the LIM (e.g., Frankel and Lee 1998) or by adding other information to the LIM (e.g., Dechow et al. 1998). These modifications can create internal inconsistencies. This is troubling because one common motivation for using the RI valuation model is that it ''provides a theoretical basis for specifying the relation between equity value and accounting information'' (Dechow et al. 1998, 1). The importance of these internal inconsistencies depends on one's perspective. From a purely pragmatic point of view, theory may be irrelevant and the proof of the model is in how well it estimates abnormal stock market returns or how well it approximates stock prices. However, given this perspective, it is unclear why theory is used to motivate these studies. Alternatively, if this line of research seeks to advance the state of knowledge about the theory of firm valuation, then the minimum criterion should be that the underlying theory is internally consistent.

In this study, I first document the pitfalls of straying from linear models of the information dynamics. I then estimate four linear models of the information dynamics proposed by theory and find that the autoregressive model of RI (Ohlson 1995) explains cross-sectional variation in price only as well as book value alone. The two models that incorporate the influence of accounting conservatism on the information dynamics (based on Feltham and Ohlson [1995, 1996]) meet with mixed success. Consistent with theory, I find that accounting conservatism systematically influences the information dynamics. Nonetheless, I find that the models of conservatism's effect on the accounting series are inadequate. While accounting-based empirical estimates of the conservatism parameters in Feltham and Ohlson (1995, 1996) are correlated with a market-based measure of conservatism, the Spearman correlations have the wrong sign. Finally, I compare the value estimates implied by these four models with current stock price. First, I find that although the implied values

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[1] In clean surplus accounting, all changes in equity, not due to transactions with owners, flow through the income statement.

[2] Throughout this paper, I use the term ''residual income'' rather than the standard ''abnormal earnings'' because readers tend to relate abnormal earnings with abnormal stock market returns or unexpected earnings. Residual income (RI) may be completely anticipated. In fact, RI valuation depends on the anticipation of future RI.

are significantly correlated with market prices, this is primarily due to the correlation between book value and stock price. Second, I find that these models consistently understate firm value and misweight current accounting information given current price.[3] The theoretical models of the RI time series seem to significantly underestimate the market's expectations of future RI. This suggests that current theoretical models of RI are incomplete and/or that RI may be a nonstationary time series.

This paper contributes to the growing literature on accounting-based valuation in two ways. First, it points out mistakes inherent in the implementation of RI valuation. Second, it presents evidence on the descriptiveness of existing theoretical models of the information dynamics and offers suggestions for modifying the information dynamics in a manner that does not involve modeling inconsistencies.

The remainder of this paper documents the process of empirically estimating RI valuation. The residual income valuation models are examined in section II. Hypotheses are developed in section III. Section IV describes the data used for empirical estimation. Results are reported in section V, and section VI concludes the paper.

II. RESIDUAL INCOME VALUATION MODELS

Clean Surplus and the Dividend Discount Formula

The clean surplus relation (CSR) is a restriction on the relation between accounting earnings (x), accounting book value of equity (bv) and net dividends (d) through time (t):

$$bv_t = bv_{t-1} + x_t - d_t. \qquad \text{CSR}$$

The CSR can be solved for dividends, and holds regardless of accounting method choice, so that:

$$d_t = bv_{t-1} + x_t - bv_t.$$

Using the CSR and the dividend discount formula:

$$V_t = \sum_{\tau=1}^{\infty} E\left[\frac{d_{t+\tau}}{(1 + r)^\tau}\right]$$

where V is the ''intrinsic'' value and r is the discount rate, firm value can be written in terms of expected future accounting earnings and book values:

$$V_t = bv_t + \sum_{\tau=1}^{\infty} E\left[\frac{x_{t+\tau} - r \cdot bv_{t+\tau-1}}{(1 + r)^\tau}\right]. \qquad (1)$$

The only assumption required to move from the dividend discount formula to equation (1) is clean surplus. However, this assumption is not sufficient to perform valuation.

Implementation Issues

Because expectations are unobservable, and equation (1) is a function of expectations, an additional assumption that links observable information with expectations of future RI

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[3] I use price as the benchmark for the firm's intrinsic value. My analysis assumes that prices are correct, on average, during the sample period.

is unavoidable. Two basic techniques have been used to estimate the market's expectations of future RI: averaging across realizations (Bernard 1994; Penman and Sougiannis 1998) and projecting current information into the future (Stober 1996; Dechow et al. 1998; Frankel and Lee 1998; Lee et al. 1998). Studies using the first technique have been used empirically to evaluate equation (1).[4] Studies using the second technique step beyond equation (1) and examine the relation between firm value and current observables. This study concentrates on the second approach.

Ohlson (1995) and Feltham and Ohlson (1995) demonstrate that identifying the joint time series of accounting book values and RI provides a basis for determining the relation between current accounting numbers and ''intrinsic'' value. The time series of book values and RI can take any form that is consistent with the laws of probability. However, the time-series models used in past empirical research often violate the law of iterated expectations. Additionally, most time-series models do not provide a closed-form price equation. Ohlson (1990, 665) suggests that a linear information dynamic seems essential to obtain prices that are linear in the observable variables.

Linear Information Models

I begin by examining a general class of information dynamics that is both consistent with rational expectations and will provide a tractable price function. The linear relationship between current information and future RI can be described by a finite difference equation:

$$RI_{t+1} = \omega_{10} + \omega_{11}\, RI_t + \omega_{12}\, z_{2t} + \cdots + \omega_{1n}\, z_{nt} + \varepsilon_{1t+1} \tag{2}$$

where the z_{it} are information other than past values of RI and ε_{1t} is mean-zero random error. The ω_{1i} characterize the marginal change in period $t + 1$ expected RI for a unit change in z_{it}. Valuation requires estimating the present value of the entire series of future RI. Each z_{it} in equation (2) may be stochastic and may be influenced by other variables in the system. To estimate $RI_{t+\tau}$ for $\tau > 1$, we must also characterize each z_i series:

$$\begin{aligned}
z_{2t+1} &= \omega_{20} + \omega_{21}RI_t + \omega_{22}z_{2t} + \cdots + \omega_{2n}z_{nt} + \varepsilon_{2t+1},\\
z_{3t+1} &= \omega_{30} + \omega_{31}RI_t + \omega_{32}z_{2t} + \cdots + \omega_{3n}z_{nt} + \varepsilon_{3t+1},\\
&\;\;\vdots \qquad\qquad\qquad\qquad \vdots\\
z_{nt+1} &= \omega_{n0} + \omega_{n1}RI_t + \omega_{n2}z_{2t} + \cdots + \omega_{nn}z_{nt} + \varepsilon_{nt+1}.
\end{aligned} \tag{3}$$

Future realizations of each of the other information variables are linear functions of current observables (including RI) plus error.

Let $\mathbf{z}_t$ be the vector of information variables, Θ_t be the information available at time t and Ω be the transition matrix of ω_{ij} coefficients from equation (3). Then $E(\mathbf{z}_{t+\tau}|\Theta_t) = \Omega^\tau\, \mathbf{z}_t$. That is, the expected value of the variables in the information system at date $t + \tau$ is determined by the current value of $\mathbf{z}$ and the matrix of time-series parameters. This ensures a price function:

$$V_t = bv_t + \alpha_0 + \alpha_1 RI_t + \alpha_2 z_{2t} + \cdots + \alpha_n z_{nt} \tag{4}$$

[4] For instance, using equation (1), Bernard (1994) finds that two-thirds of the cross-sectional variation in price is explained by current book values, future return on equity and growth in book value.

where V is the value implied by the linear system. Linearity is necessary to calculate the valuation parameters, $\alpha_0, \alpha_1, \ldots, \alpha_n$. Although internally consistent valuation models of some nonlinear information dynamics may exist, they are generally not tractable. Ohlson (1990, 665) states, ‘‘there is no reason suggesting that other kinds of models can be used to determine [firm] value.’’

To demonstrate, assume that RI is an autoregressive process with an intercept:

$$RI_{t+1} = \omega_{10} + \omega_{11} RI_t + \varepsilon_{t+1}. \tag{5}$$

The linearity of the information dynamics implies that this system will support a valuation function that is linear in current information (Garman and Ohlson 1980):

$$P_t = bv_t + \alpha_0 + \alpha_1 RI_t \tag{6}$$

and

$$P_{t+1} = bv_{t+1} + \alpha_0 + \alpha_1 RI_{t+1}. \tag{7}$$

Equations (6) and (7) describe the relation between RI, book value and price at times t and $t + 1$. Although the valuation coefficients, α_0 and α_1, are unknown, no arbitrage and the information dynamics link equations (6) and (7). No arbitrage imposes a restriction between price at time t and expected price at time $t + 1$:

$$E(P_{t+1} + d_{t+1}) = (1 + r) \cdot P_t. \tag{8}$$

Substituting equations (6) and (7) into equation (8):

$$E(d_{t+1} + bv_{t+1} + \alpha_0 + \alpha_1 RI_{t+1}) = (1 + r)(bv_t + \alpha_0 + \alpha_1 RI_t). \tag{9}$$

Clean surplus and the definition of RI ensures:

$$bv_{t+1} = (1 + r)bv_t + RI_{t+1} - d_{t+1}. \tag{10}$$

Substituting equations (5) and (10) into equation (9):

$$bv_t + (1 + r)(\alpha_0 + \alpha_1 RI_t) = bv_t + \omega_{10} + \omega_{11} RI_t + \alpha_1(\omega_{10} + \omega_{11} RI_t).$$

Simplifying provides:

$$(1 + r)(\alpha_0 + \alpha_1 RI_t) = \alpha_0 + (1 + \alpha_1)(\omega_{10} + \omega_{11} RI_t). \tag{11}$$

To solve for the valuation coefficients of equations (6) and (7), equate the coefficients on RI and solve for α_0 and α_1:

$$\alpha_0 = \frac{(1 + \alpha_1)\omega_{10}}{r}.$$

$$\alpha_1 = \frac{-r \cdot \alpha_0 + \omega_{10} + \omega_{11}}{1 + r - \omega_{10} - \omega_{11}}.$$

Simplifying provides:

$$\alpha_0 = \frac{1 + r}{r} \cdot \frac{\omega_{10}}{(1 - \omega_{11})} \tag{12}$$

and

$$\alpha_1 = \frac{\omega_{11}}{1 + r - \omega_{11}}. \tag{13}$$

Equations (12) and (13) follow directly from Ohlson (1995) when RI is not equal to zero on average.

Linear information models provide the framework for the development of empirically testable models of accounting-based valuation. With nonlinear information dynamics, equations (6) and (7) do not obtain and equations (12) and (13) cannot be calculated. However, researchers often find the linearity of the information dynamics to be constraining or counter-intuitive.

Nonlinear Information Dynamics and Internal Inconsistencies

Two studies that use historical data to estimate firm value using the RI valuation model are Frankel and Lee (1998) and Dechow et al. (1998). Each of these studies modifies the information dynamics in an intuitively appealing way but both fail to preserve internal consistency. The point of analyzing the theoretical aspect of these empirical studies is to demonstrate that adopting information dynamics that seem reasonable in isolation can generate rather subtle inconsistencies when evaluated within the totality of the model linking information to firm value.

Intertemporal Inconsistency

In one part of their analysis, Frankel and Lee (1998) use a projection of current return on equity (ROE) to estimate future RI. To be consistent with their analyst forecast model, they model expectations of future ROE as a piecewise function. In the short run, ROE is estimated to be constant and in the long run, RI is estimated to be constant (i.e., RI is assumed to be constant in the terminal value computation).

No arbitrage requires a consistency between intrinsic values and terminal values (Penman 1997). However, as implemented, piecewise functions of the information dynamics often imply arbitrage. This occurs because every period that currently lies in the long run will eventually cross into the short run. At that point, the information dynamics change predictably. To be rational, expectations must anticipate this change. However, piecewise models do not allow for this anticipation, so the posited beliefs violate the law of iterated expectations. As shown in the appendix, a valuation model that ignores predictable changes in the information dynamics posits rational pricing of irrational beliefs.

Underspecified Information Dynamics

A similar violation of rationality can occur when researchers try to improve the information dynamics. Dechow et al. (1998) estimate a modified (conditional) version of equation (5) with five conditioning variables, including the absolute value of abnormal earnings and the absolute value of special items. These additional variables are analogs to the z variables in equation (2):

$$RI_{t+1} = \omega_0 + \omega_{11}RI_t + \omega_{12}z_{2t} + \cdots + \omega_{16}z_{6t} + \varepsilon_{t+1}. \tag{14}$$

Rather than estimating the system of equations (3) describing the time series of z_2 through z_6, Dechow et al. (1998) assume that the modified autoregressive parameter (ω_m) is the sum of ω_{11} through ω_{16}. They then use the price function:

$$P_t = bv_t + \alpha_m RI_t \tag{15}$$

where

$$\alpha_m = \frac{\omega_m}{1 + r - \omega_m}. \tag{16}$$

Equation (16) is the equilibrium price coefficient on RI from Ohlson (1995). However, Ohlson (1995) uses different information dynamics. Equation (14) does not support the price function (15) for two reasons. First, the information dynamics contain a nonzero intercept, so the equilibrium price function must contain an intercept. When Dechow et al. (1998) estimate equation (5) using a discount rate of 12 percent, they find an intercept of -2 percent of price and an autoregressive parameter of 0.62. Substituting these parameter estimates into equation (12), the equilibrium intercept on the price function is -49 percent of price. Accordingly, equation (15) overstates the implied value by more than 49 percent. Second, the time-series equation (14) does not support the price equation (15) because the implied time series of z_2 through z_6 are logically inconsistent. Dechow et al. (1998) do not estimate the time series of z_2 through z_6, implying that they are constants. However, the expected value of their $z_{it+\tau}$ cannot be constant in expectation because each is a function of $RI_{t+\tau-1}$ which, in turn, is a function of ω_m and RI_t.[5] If the model predicts that $E(RI_{t+1})\ \omega_m\ RI_t$, then it cannot also assume that $E(|RI_{t+1}|) = RI_{t+1}$ and that ω_m is less than one.

The *equilibrium* price coefficients will be a complex function of ω_{11} through ω_{66}. I later show that the value function for a two-variable information dynamic has price coefficients that are a complex ratio of the six information dynamic parameters and the discount rate. The equilibrium coefficients for a six-variable system would each contain up to 42 parameters. Although the method for obtaining the equilibrium price coefficients for this system is a straightforward extension of equations (6) through (11), the required algebra is daunting. It is clear however, that simply summing the coefficients in equation (14) does not provide the equilibrium price.

The Implementation of Equilibrium Models of Residual Income Valuation

In the remainder of this section, I outline four different information dynamics and the equilibrium price equations that they imply. The empirical performance of these models is evaluated in the following section.

The Ohlson Model—LIM1

Intuition suggests that the persistence of monopoly rents must affect RI. Although monopoly rents may persist for some time, competition should force returns toward the cost of capital. Modeling the RI series as an autoregressive process captures this notion. Ohlson (1995) proposes a bivariate autoregressive model of RI. Because past realizations of RI may not be the only predictor of future RI, the influence of nonaccounting information on future RI is modeled as a second related autoregressive process, that is:

[5] Each of the z_{it} is a function of the absolute value of RI, so if RI is nonconstant, then each z_{it} must be nonconstant.

$$\begin{aligned} RI_{t+1} &= \omega_{11}RI_t + \nu_t + \varepsilon_{1t+1}, \\ \nu_{t+1} &= \gamma\nu_t + \varepsilon_{2t+1}, \end{aligned} \qquad \text{LIM1*}$$

where ν_t is information about future RI that has yet to reach the accounting system. Possible examples are order backlog or a newly signed contract. LIM1* does not specify what the ν_t is and it is not possible to explicitly control for all possible ν_t.

It is common in the empirical literature to ignore ν_t because it is unobservable (Stober 1996; Dechow et al. 1998). However, when γ is nonzero, omitting ν_t from LIM1* has consequences for empirical estimation. When ν_t is ignored, it becomes part of the error. The mean of ν_t (and consequently the errors) may be nonzero and may be correlated through time. The intercept in LIM1* will also be nonzero if the discount rate differs from ROE, on average. An empirical estimate of LIM1* should allow for a nonzero intercept and test for autocorrelation in the errors. When ν_t is unobservable, LIM1* is equivalent to equation (5):

$$RI_{t+1} = \omega_{10} + \omega_{11}RI_t + \varepsilon_{1t+1}. \qquad \text{LIM1}$$

This implies the valuation formula:

$$V_1 = bv_t + \alpha_0 + \alpha_1 RI_t \qquad V_1$$

where α_0 and α_1 are as described in equations (12) and (13):

$$\alpha_0 = \frac{1 + r}{r} \cdot \frac{\omega_{10}}{(1 - \omega_{11})}, \qquad V_{1.0}$$

$$\alpha_1 = \frac{\omega_{11}}{1 + r - \omega_{11}}. \qquad V_{1.1}$$

The Feltham and Ohlson Model—LIM2

Historical cost accounting differs systematically from fair value accounting. Even if competition drives economic rents to zero over time, other factors such as accounting conservatism may influence the long-run RI series. Feltham and Ohlson (1995) separate operating and financial assets. Conservative accounting systematically understates the value of operating assets. Therefore, one effect of accounting conservatism is that it reduces the benchmark for normal earnings. To allow for understated assets, Feltham and Ohlson (1995) propose a second linear information model (LIM2*):[6]

$$\begin{aligned} RI_{t+1} &= \omega_{11}RI_t + \omega_{12}bv_t + \nu_{1t} + \varepsilon_{1t+1}, \\ bv_{t+1} &= \omega_{22}bv_t + \nu_{2t} + \varepsilon_{2t+1}, \\ \nu_{1t+1} &= \gamma_1\nu_{1t} + \varepsilon_{3t+1}, \\ \nu_{2t+1} &= \gamma_2\nu_{2t} + \varepsilon_{4t+1}. \end{aligned} \qquad \text{LIM2*}$$

[6] Although Feltham and Ohlson (1995) use financial assets and operating income, I include all net assets and all earnings for two reasons. First, RI and operating RI are equal since financial assets only earn the normal return. Second, it is difficult to separate out all assets that are held at market value and the interest associated with these assets. In analysis not reported, I attempt to remove financial assets and interest. The empirical results are very similar.

As with LIM1, ω_{11} is the persistence of monopoly rents. The book value effect of RI is captured by ω_{12}, the conservatism parameter. When the accounting is conservative, the conservatism parameter, ω_{12}, should be greater than zero because a portion of RI stems from the conservative valuation of book value rather than from monopoly power. Growth in book value is captured by ω_{22}, which must be equal to or greater than one for a going concern, but less than one plus the discount rate. Because the ν variables are unobservable and residual income may not be zero on average, I estimate the first equation in LIM2* with an intercept:[7]

$$\begin{aligned} RI_{t+1} &= \omega_{10} + \omega_{11}RI_t + \omega_{12}bv_t + \varepsilon_{1t+1}, \\ bv_{t+1} &= \omega_{22}bv_t + \varepsilon_{2t+1}. \end{aligned} \qquad \text{LIM2}$$

This model implies the valuation equation:

$$V_2 = \alpha_0 + \alpha_1 RI_t + (1 + \alpha_2)bv_t \qquad V_2$$

where

$$\alpha_0 = \frac{\omega_{10}}{[(1 + r) - \omega_{11}]r}, \qquad V_{2.0}$$

$$\alpha_1 = \frac{\omega_{11}}{[(1 + r) - \omega_{11}]}, \qquad V_{2.1}$$

$$\alpha_2 = \frac{\omega_{12}(1 + r)}{[(1 + r) - \omega_{11}][(1 + r) - \omega_{22}]}. \qquad V_{2.2}$$

The Clean Surplus Effects of Conservatism—LIM3

The actual effects of conservatism may be more complex than can be captured by a single parameter on book value. In a clean surplus system, the understatement of assets results from the understatement of revenue or the overstatement of expenses. Conservatism affects both the income and the book value components of RI. For example, accelerated depreciation affects both book value and expenses. The book value effect overstates RI because the charge for the use of capital is too small. The income effect understates RI in the early years because the depreciation expense is too large. The magnitude of the income effect is a function of growth (Beaver and Ryan 1998). Under no growth, the firm will achieve equilibrium where the level of conservatism does not affect the reported income. However, while the firm is growing, more conservative accounting systems will lead to lower reported earnings.

Feltham and Ohlson (1996) develop a model of conservative clean surplus accounting for a firm that generates cash flows by investing in a depreciable asset. To assess the determinants of the income and book value effects of conservatism, one can extend the model to the linear information framework. The productive technology is described with the following cash flow dynamic equations:[8]

[7] The parameter ν_{2t} may also be nonzero on average implying a nonzero intercept in the second equation of LIM2*. However, estimation of an intercept in this equation is difficult due to the nonstationarity of bv. Therefore, in the empirical estimation, I constrain the intercept in the second equation of LIM2* to be zero.

[8] Although profitability may affect capital expenditures, due to the complexity of the price coefficients, I develop the price equation constraining this influence to be zero.

$$\begin{aligned} cr_{t+1} &= \gamma\, cr_t + \kappa\, capx_t + \varepsilon_{1t+1}, \\ capx_{t+1} &= \qquad\qquad \omega\, capx_t + \varepsilon_{2t+1}, \end{aligned}$$

where cr is cash receipts, capx is the capital investment in assets, γ is the economic depreciation, κ describes the expected profitability of investments and ω describes the rate of investment growth.

The firm uses historical cost accounting and depreciates assets using declining balance depreciation:

$$bv_{t+1} = \delta\, bv_t + capx_{t+1}$$

where bv is the cost of net assets less accumulated depreciation. Earnings, x_t, are equal to cash receipts, cr_t, less depreciation expense, $(1 - \delta)bv_{t-1}$:

$$x_t \equiv cr_t - (1 - \delta)bv_{t-1}.$$

As before, RI is the difference between earnings and a charge for the use of book value:

$$\begin{aligned} RI_t &\equiv x_t - (r)bv_{t-1}, \\ &= cr_t + (\delta - 1 - r)bv_{t-1}. \end{aligned}$$

Algebraic manipulation yields the time series of the system of accounting information under this model:

$$\begin{aligned} RI_{t+1} &= \omega_{11}RI_t + \omega_{12}bv_t + \omega_{13}capx_t + \varepsilon_{1t+1}, \\ bv_{t+1} &= \qquad\qquad \omega_{22}bv_t + \omega_{23}capx_t + \varepsilon_{2t+1}, \\ capx_{t+1} &= \qquad\qquad\qquad\qquad \omega_{33}capx_t + \varepsilon_{3t+1}, \end{aligned} \qquad \text{LIM3}$$

where, if we assume a zero expected net present value investment on average, $(\kappa = 1 + r - \gamma)$:

$0 \leq \omega_{11}$ (the rate of economic decay) ≤ 1,

ω_{12} (the book value effect of conservatism) $= \left[\dfrac{(\delta - \gamma)[\delta - (1 + r)]}{\delta}\right] \geq 0$,

and ω_{13} (the income effect of conservatism) $= (\delta - \gamma)\left[1 - \dfrac{[\delta - (1 + r)]}{\delta}\right] \leq 0$.

LIM3 captures all three of the factors identified as affecting the RI series. First, ω_{11} captures the influence of monopoly rents. When the accounting system is unbiased $(\delta = \gamma)$, ω_{12} and ω_{13} are zero; RI is purely the result of economic forces and decays at the same rate as monopoly rents, γ. Second, ω_{12} captures the book value effect of conservatism. When there is no new investment at date t, accelerated depreciation will overstate the rate of decay of existing assets by $(\delta - \gamma)$. Because the assets are more understated at date t than they were at date $t - 1$, the normal earnings, $(r \cdot bv_t)$, will be reduced, thereby increasing date $t + 1$ RI. Third, ω_{13} captures the income effect of conservatism. Assets are held at their market value when they are purchased. Therefore, the book value effect in the first period is zero. However, depreciation expense is overstated by the income effect, ($\delta - \gamma$) $capx_t$, thereby reducing date t RI. If the average capital expenditure is a positive net present value investment ($\kappa > 1 + r - \gamma$), then ω_{13} may be greater than zero.

Allowing for a nonzero intercept, LIM3 implies the value equation:

$$V_3 = \alpha_0 + \alpha_1 RI_t + (1 + \alpha_2)bv_t + \alpha_3\, capx_t \qquad V_3$$

where

$$\alpha_0 = \frac{\omega_{10}}{[(1 + r) - \omega_{11}]},$$

$$\alpha_1 = \frac{\omega_{11}}{[(1 + r) - \omega_{11}]},$$

$$\alpha_2 = \frac{(1 + r)\omega_{12}}{[(1 + r) - \omega_{11}][(1 + r) - \omega_{22}]},$$

$$\alpha_3 = \frac{(1 + r)[\omega_{12}\omega_{23} + (1 + r)\omega_{13} - \omega_{13}\omega_{22}]}{[(1 + r) - \omega_{11}][(1 + r) - \omega_{22}][(1 + r) - \omega_{33}]}.$$

The three linear information models discussed so far have not incorporated nonaccounting information. In the next section, nonaccounting numbers are incorporated into the analysis.

Incorporating Nonaccounting Information—LIM4

Two possible approaches to improving on the LIMs are, first, to model the accounting system more thoroughly (such as in LIM2 and LIM3) and, second, to utilize information that is available to market participants but that has not yet been incorporated into the accounting system. Equation (1) makes clear that nonaccounting information is relevant for valuation only if it affects expectations about future RI. The linear models provide a structure for adding nonaccounting information into the analysis. Information that will affect future RI, either directly or indirectly, can be incorporated into the analysis as an additional variable in the transition matrix. Obvious candidates for this are new patents, regulatory approval of a new drug for pharmaceutical companies, new long-lived contracts and order backlog. Because order backlog is readily available, I augment LIM2 with order backlog as the additional variable, ν.

$$\begin{aligned} RI_{t+1} &= \omega_{10} + \omega_{11}RI_t + \omega_{12}bv_t + \omega_{13}bklog_t + \varepsilon_{1t+1}, \\ bv_{t+1} &= \omega_{22}bv_t + \varepsilon_{2t+1}, \\ bklog_{t+1} &= \omega_{33}bklog_t + \varepsilon_{3t+1}. \end{aligned} \qquad \text{LIM4}$$

On average, order backlog should indicate increased RI in the following period. First, temporary shortages of inventory, capacity, or labor may cause backlogs. This should depress current RI and as the shortages ease, RI should grow. Alternatively, order backlog may be due to increased demand. In this case, current RI would be normal, but future RI should grow as orders are filled. This implies that ω_{13} will be greater than zero.

III. HYPOTHESIS TESTING

Model Estimation

Two possible methods to estimate the LIMs are (1) year-by-year, in the cross-section, and (2) firm-by-firm, in a time series. I estimate the parameters of the LIMs as a time series rather than in the cross-section because the parameters of the LIMs must be a function of the firms' economic pressures, production technology and accounting policies, and adding conditioning variables to control for these forces is difficult. Estimating the information dynamics firm-by-firm allows for cross-sectional variation in the persistence of RI while preserving internal consistency.

Each firm's coefficients from the RI equations are estimated using an ordinary least squares (OLS) time-series regression. The other equations in the system cannot be estimated using OLS because of nonstationarity. When a variable grows over time, OLS time-series estimates are inconsistent (Hamilton 1994). The usual remedy for this is to use OLS to estimate the time series of the first differences of the variable. However, when the time series of the first differences is linear, the time series of the levels is nonlinear. Thus, OLS cannot be used for estimating the linear information dynamics of nonstationary variables. Because book value of equity and capital expenditures tend to grow on average for most firms, I estimate the expected future growth rate of these variables as the median of the year-to-year past growth rates.[9]

Price Level Regressions

As section II demonstrates, the information dynamics imply a linear relation between current accounting numbers and current price (the price function). After estimating the information dynamics, I calculate the price function coefficients implied by the estimated information dynamics. As a test of how closely the information dynamics conform to market expectations, I compare the price coefficients implied by the median information dynamics parameter estimates to the coefficients from cross-sectional regressions of price on the information variables. The cross-sectional regressions are estimated for 1996, which is the last year of the sample period.[10]

Tests of the Linear Information Models

The first set of tests is designed to determine how well LIM1, LIM2, LIM3 and LIM4 describe the joint time series of accounting information for the average firm. Each of the models makes predictions about the coefficients. I test whether the estimated coefficients from the four models fall within the hypothesized range.

The Ohlson Model—LIM1

LIM1 models the evolution of RI for an unbiased accounting system. The model predicts positive serial correlation of the RI, so the coefficient from LIM1 is between zero and one:

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[9] For example, I estimate the growth rate of equity for each firm as the median ratio of year $t + 1$ book value of equity to year t book value of equity. The second equation in LIM3 presents another estimation problem because both bv_t and $capx_t$ are needed to estimate bv_{t+1}. To estimate this equation, I first calculate the median growth rate of capx. I then regress the difference between bv_t and estimated (based on average growth) $capx_t$ on bv_{t-1}. The resulting coefficient is the estimated ω_{22}. Note that in LIM3, ω_{22} is not the growth rate of book value, but one minus the depreciation rate.

[10] Limiting this investigation to a single year raises the possibility that the average firm was mispriced in that year. However, performing this analysis in other years requires either reducing the sample period for estimating the information dynamics or including accounting information in the LIM model that was not available when firm values were determined. Analysis, not reported in the tables, confirms that regression coefficients estimated in other years (1990, 1995) do not differ materially from those reported.

$\mathbf{H_{1a}}$: $0 < \omega_{11} < 1$.

The Feltham and Ohlson Model—LIM2

Feltham and Ohlson (1995) model the effects of conservatism on the information dynamics. This model predicts that RI is positively correlated with lagged RI and the lagged book value of equity, so both ω_{11} and ω_{12} are between zero and one:

$\mathbf{H_{1b}}$: $0 < \omega_{11} < 1$ and $0 < \omega_{12} < 1$.

The Clean Surplus Effects of Conservatism—LIM3

The clean surplus model predicts that RI will be positively correlated with lagged RI and lagged book value. The model also predicts that RI will be negatively correlated with lagged capital expenditures, so both ω_{11} and ω_{12} are between zero and one and ω_{13} is less than zero:

$\mathbf{H_{1c}}$: $0 < \omega_{11} < 1$, $0 < \omega_{12} < 1$ and $\omega_{13} < 0$.

Incorporating Nonaccounting Information—LIM4

Ohlson (1995) and Feltham and Ohlson (1995) suggest a method for incorporating additional information into the expectations model of future RI. I implement this methodology by adding order backlog to LIM2. LIM4 predicts that order backlog should translate into positive future RI and should decay over time. For LIM4, this implies the coefficients:

$\mathbf{H_{1d}}$: $0 < \omega_{13} < 1$ and $0 < \omega_{33} < 1$.

The Implied Price Coefficients

The second set of tests is designed to determine how well the linear information models conform to the market's expectations.[11] Using coefficient estimates from time-series models, current accounting numbers and the associated valuation models, I estimate firm value. Three tests are conducted to test how well the estimated value (V) measures value. First, I test whether V is equal to price (P) on average:

$\mathbf{H_{2a}}$: $V/P = 1$.

Second, I test whether V is correlated with price in the cross-section:

$\mathbf{H_{2b}}$: $\text{Corr}(V, P) > 0$.

Third, I examine whether the median firm-specific valuation coefficients implied by the time-series models are equivalent to the estimated coefficients in the cross-sectional regressions of price on the information variables:

$\mathbf{H_{2c}}$: The coefficients on the information variables in the price level regressions are equivalent to the median valuation coefficients implied by the estimated coefficients in the linear information models.

[11] Implicit in these tests is the belief that market prices are correct on average.

The LIMs' Measurement of Accounting Conservatism

The models of conservatism presented in Feltham and Ohlson (1995, 1996) make predictions about the effect of conservatism on the parameters in LIM2 and LIM3. The final set of tests determines whether the conservatism parameters are associated with an independent, market-based measure of conservatism. The level of conservatism of a firm's accounting policies is a function of its accounting method choices (e.g., straight-line or accelerated depreciation) and the assumptions underlying those choices (e.g., five vs. ten years of depreciable life). This makes identifying the level of conservatism problematic. For example, Bernard (1994) has difficulty identifying measurable differences in the level of conservatism among firms based on accounting methods reported on Compustat. Nonetheless, because all parameters of the LIMs are likely to be affected by the level of conservatism, I attempt to characterize the level of conservatism separately for each firm in the sample. Conservatism can also be estimated as in Beaver and Ryan (1998). They calculate the persistent portion of each firm's book-to-market ratio (BTM) and measure conservatism as the coefficient C_i for firm i, in the following regression:

$$BTM_{it} = \alpha_t + C_i + \sum_{1}^{6}\beta_j R_{i,t+1-j} + e_{it} \tag{17}$$

where BTM is the ratio of the book value of equity to the market value of equity at the fiscal year-end, bv_t/P_t. The year effect is captured by α_t, while C_i captures the firm effect (the persistent component of the firm's BTM). The β_js are coefficients on the firm's stock return, R_t. The parameter C_i captures the persistent portion of the difference between the accounting system's and the market's measures of common equity. Beaver and Ryan (1998) document that this parameter is associated with other measures of conservatism such as research and development expense and the use of accelerated depreciation. Using C as an independent measure of conservatism, I estimate its correlation with the conservatism parameters from LIM2 and LIM3, and I estimate the conservatism parameters for the quartile of firms with the most conservative measures of C.

I test for a relationship between the market-based conservatism parameter, C, and the LIM-based conservatism parameters, ω_{12} and ω_{13}. First, I test how well the models of conservatism describe the LIMs of the most conservative firms (based on C).

H_{3a}: Hypotheses 1b and 1c hold for the most conservative firms.

Second, I test the association between the market-based conservatism parameter, C, and the LIM-based conservatism parameters ω_{12} (ω_{13}):

H_{3b}: Corr (ω_{12}, C) $<$ 0 and Corr (ω_{13}, C) $>$ 0.[12]

IV. DATA AND SAMPLE SELECTION

The initial sample consists of all nonfinancial firms with the necessary data on the 1997 Compustat annual data file. To be included, common equity, income before extraordinary items available for common, market price and the number of common shares outstanding must be available for at least 15 of the 22 years between 1975 and 1996, inclusive. The

[12] The book-to-market ratio will be smaller for more conservative firms. Therefore, smaller (more negative) C_i indicate more conservative accounting policies.

elimination of firm-years before 1975 should reduce problems with nonstationarity while providing sufficient data to estimate the system. Firm-years with negative equity values are omitted. For tests involving order backlog, the additional requirement of at least five years of nonzero order backlog is imposed. Finally, for the conservative subsample, returns must be available from CRSP for at least 15 years during the sample period.

Estimating the Cost of Capital

Lee et al. (1998) find that value estimates track stock prices more closely when a time-varying component of the cost of capital is used. Accordingly, I calculate the following discount rate for each firm-year:

$$r_e(j,m) = r_f(m) + r_{prem}(j)$$

where

$r_e(j,m)$ = the estimated cost of equity for firm j in month m;
$r_f(m)$ = the annualized one month t-bill rate at fiscal year-end;
$r_{prem}(j)$ = the risk premium for firm j.

The risk premium, $r_{prem}(j)$, is the firm's industry risk premium as estimated by Fama and French (1997).[13] RI is calculated as earnings before extraordinary items minus $r_e(j,m) \cdot bv_{t-1}$. Earnings before extraordinary items does not correspond perfectly with the theory because it does not provide a clean surplus accounting system. However, Abarbanell and Bernard (1997, 5) suggest that it is a good approximation in expectation. Other violations of clean surplus that could affect the information dynamics are prior period adjustments, changes in accounting policies and the consolidation of partially owned subsidiaries.[14] Firm value is calculated at the fiscal year 1996, the last year in the sample period. The mean (median) discount rate over the sample period is 12.13 (11.78) percent.[15]

V. RESULTS

Table 1 presents descriptive statistics calculated for all firm-years. Panel A presents results for all 44,980 firm-years in the full sample. The median return-on-equity (ROE) is 10.7 percent and median residual income (RI) is −\$0.72 million, approximately negative one percent of median book value. The negative median RI is consistent with prior research and is due to the fact that the discount rate is higher than ROE, on average. The 10,420 firm-years in the conservative subsample differ significantly from the full sample. The conservative firms (panel B) are larger[16] and they have higher ROEs and RIs than the nonconservative firms, suggesting that the book value effect of conservatism dominates the income effect for the average firm.[17]

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13 I use the risk premia calculated as of 12/31/94.

14 Because it is not clear how each of these violations would affect the information dynamics or how to incorporate them into the model, I leave this to future research.

15 Analysis, not reported, is also conducted with constant discount rates of 9, 10 and 11 percent. The results do not differ materially from those reported in tables 2 through 7.

16 This may seem counter-intuitive because small start-up firms are frequently cited as being the most conservative. However, the smallest firms are not included in my sample because of data requirements; to allow for sufficient degrees of freedom, a firm must be publicly traded for 15 years to be included in the analysis.

17 The average BTM is smaller for the conservative firms by construction.

TABLE 1
Descriptive Statistics[a]

	Percentile				
Variable	*20%*	*40%*	*Median*	*60%*	*80%*
Panel A: All Firms					
ROE[b]	0.022	0.083	0.107	0.129	0.182
BTM[c]	0.403	0.624	0.738	0.867	1.251
bv[d]	11.820	40.735	72.788	130.107	554.263
RI[e]	−18.569	−2.445	−0.719	0.139	12.665
Panel B: Conservative Firms[f]					
ROE[b]	0.036	0.107	0.139	0.167	0.230
BTM[c]	0.243	0.354	0.412	0.475	0.642
bv[d]	12.321	68.771	130.769	236.670	814.100
RI[e]	−14.056	−0.499	0.667	6.483	65.696

[a] This table contains one observation for each of the 44,980 firm-years in the sample.
[b] ROE is earnings before extraordinary items divided by beginning of the year book value of equity.
[c] BTM is book value of equity divided by price at the end of the fiscal year.
[d] bv is book value of equity at the end of the fiscal year, in millions.
[e] RI is earnings before extraordinary items minus the risk-adjusted discount rate times book value of equity at the beginning of the year, in millions.
[f] Conservative firms are the 25 percent of firms with the smallest book-to-market ratio, on average, over the sample period, after controlling for recent stock price changes. There are 10,420 firm-years in the conservative subsample.

Results From Tests of the Linear Information Models

LIM1

Panel A of table 2 presents the distribution of parameter estimates for the simple time series of RI. Firm-specific autoregressive parameters for RI are estimated with linear regression. The five columns of panel A are the 20th through the 80th percentiles of the parameter estimates. More than 60 percent of the intercepts are negative. This is because the average discount rate is higher than the average ROE. The median autoregressive parameter, ω_{11}, is 0.234. While this supports H_{1a}, the parameter is smaller than might be expected given the relatively high serial correlation in ROE reported in other studies (Bernard 1994; Beaver and Ryan 1998).[18] From equation $V_{1.1}$, the median estimated ω_{11} implies that, on average, with a 11.78 percent discount rate (the sample median), the market should value \$1 of current RI at \$0.265. By comparison, if RI were perfectly persistent, \$1 of RI would be worth \$8.5, while if RI were purely transitory, then current RI would have a value of \$0, after controlling for current book value.

[18] Although not reported in the tables, I test for residual serial correlation in the time series model, that may be induced by omitting ν_t from empirical estimates of LIM1. The mean (median) residual serial correlation is −0.003 (−0.008) and is statistically insignificant. Also, the mean (median) Durbin-Watson (DW) statistic is 1.895 (1.942). There are few firms with DW statistics far from 2. Finally, I estimate the regressions after adding lagged values of RI. The mean coefficient on lagged RI is close to zero and is statistically insignificant.

TABLE 2
The Distribution of Parameter and Value Estimates Under LIM1

Panel A: RI Regression: $RI_{t+1} = \omega_{10} + \omega_{11}RI_t + \varepsilon_{t+1}$[a]

	Percentile				
Parameters	*20th*	*40th*	*50th*	*60th*	*80th*
ω_{10}	−1.497	−0.581	−0.354	−0.189	0.140
ω_{11}	−0.032	0.155	0.234	0.309	0.492

Panel B: Value/Price and Book/Price Comparisons[b]

Variables					
V_1/P	−0.380	0.238	0.411	0.554	0.950
bv/P	0.333	0.543	0.631	0.733	1.113

Panel C: Implied Price Coefficients and Price Level Regressions[c]

Dependent Variable	Independent Variables *Intercept*	V_1[d]	RI_t	bv_t	*Adjusted* R^2
$Price_t$	17.709 (0.001)	0.392 (0.001)	—	—	0.384
$Price_t$	16.495 (0.001)	—	—	0.500 (0.001)	0.380
$Price_t$	29.690 (0.001)	—	1.205 (0.001)	—	0.034
$Price_t$	18.172 (0.001)	—	1.358 (0.001)	0.464 (0.001)	0.390
Implied Price Coefficients[e]	−4.385	—	0.265	1.000	—

[a] Panel A presents the cross-sectional distribution of coefficient estimates from the time-series residual income (RI) regression of LIM1, estimated by firm. The five columns are the 20th to the 80th percentile estimates of the parameters. There are 2,601 firms in this panel.

[b] Panel B presents the distribution of value estimates (V_1) divided by market price (P) and book value (bv) divided by market price, as of the end of fiscal year 1996. There are 1,992 firms with value and price data available for this year.

[c] Panel C presents the price coefficients obtained by regressing price on V_1, RI and/or bv and the equilibrium price coefficients implied by the median parameter estimates of the information dynamics (panel A). P-values are presented in parentheses. They are determined by comparing the price coefficients with their implied values. The reported regression coefficients are obtained after removing up to two influential observations with Cook's distance greater than 2.

[d] $V_1 = bv_t + \alpha_0 + \alpha_1 RI_t$, where α_0 and α_1 are calculated using firm-specific ω estimates and equations $V_{1.0}$ and $V_{1.1}$. The significance of the intercept and slope coefficients in the regression of price on V are tested against their respective theoretical values of zero and one.

[e] These are the equilibrium price coefficients implied by the median parameter estimates of the information dynamics (panel A), the sample median risk-adjusted discount rate of 11.78 percent, and equations $V_{1.0}$ and $V_{1.1}$.

Panel B of table 2 presents the ratio of implied value (V_1) to actual price for all firms in the sample in 1996 (where 1996 is chosen to eliminate hindsight bias). The estimated value is calculated as:

$$V_1 = bv_t + \alpha_0 + \alpha_1 RI_t$$

where α_0 and α_1 are functions of the estimated ω_{10} and ω_{11} as in equations $V_{1.0}$ and $V_{1.1}$. If the model accurately values firms and the market price is correct on average, the expected ratio is 1. However, the median V_1/P is 0.411. This is significantly different from 1, which means that H_{2a} is rejected. The model fails to fully capture the market's expectations of future RI, even on average.[19]

The first four lines of panel C of table 2 are the results of cross-sectional linear regressions of price on the implied value, RI, and/or book value in 1996. The last line of panel C of table 2 presents the equilibrium price coefficients implied by the median parameter estimates of the information dynamics (panel A), the sample median risk-adjusted discount rate of 11.78 percent, and equations $V_{2.0}$, $V_{2.1}$ and $V_{2.2}$. The information in panel C is used to test H_{2b} and H_{2c}. While panel B examines whether V is correct on average, these tests examine whether variation in price is tracked by variation in estimated value. In the simple regression, the coefficient on V_1 (0.392) is significantly less than 1. The adjusted R^2 is 0.384. This supports H_{2b} as V is highly correlated with price. However, the results of a multiple regression of price on RI and book value are inconsistent with H_{2c}. The coefficient on book value is significantly less than 1 and the coefficient on RI is significantly greater than 0.265 (the coefficients implied by the median parameter estimates from LIM1 and V_1). This indicates that the weightings on the information models implied by LIM1 do not give the best linear unbiased estimates of firm price. Also, the adjusted R^2 of the regression of price on V_1 is almost equivalent to that of the regression of price on book value alone, revealing that the implied value does not approximate price any better than does book value alone.

Overall, the results are inconsistent with LIM1 describing the information environment and the valuation process very well. The model of RI significantly underestimates the present value of expected future RI that is implicit in the pricing process. A median value-to-price ratio of less than one is consistent with the value-to-price ratio found in other valuation studies (e.g., Dechow et al. 1998; Frankel and Lee 1998; Lee et al. 1998). Such an understatement of value can only occur because the discount rate is too high, or because the time series of RI is nonstationary. Myers (1998) estimates the risk-adjusted discount rate necessary to account for this magnitude of understatement to be 6.5 percent and finds evidence of nonstationarity in the RI series. Furthermore, from table 2, these value estimates fail to account for 61 percent of the variation in price. Apparently, on average, the market anticipates larger values of future RI than are captured by LIM1. Since the true time series may be affected by accounting conservatism, I now turn to the first model of conservatism.

LIM2

Panel A of table 3 presents the distribution of parameter estimates for the bivariate time series of RI and book value of equity (LIM2). More than 60 percent of the intercepts are positive. The median autoregressive parameter, ω_{11}, is 0.036. While this supports H_{1b}, it is smaller than the estimate from LIM1. However, inconsistent with H_{1b}, approximately 60 percent of the conservatism parameters, ω_{12}, are negative. This indicates that, if accounting

[19] The median V/P is significantly less than that found in Dechow et al. (1998). This is primarily due to the negative intercept.

TABLE 3
The Distribution of Parameter and Value Estimates Under LIM2

Panel A: RI Regression: $RI_{t+1} = \omega_{10} + \omega_{11}RI_t + \omega_{12}bv_t + \varepsilon_{1t+1}$[a]

$bv_{t+1} = \omega_{22}bv_t + \varepsilon_{2t+1}$

Parameters	*Percentile* 20th	40th	50th	60th	80th
RI time series:					
ω_{10}	−0.038	0.013	0.071	0.205	1.530
ω_{11}	−0.003	0.014	0.036	0.053	0.174
ω_{12}	−0.071	−0.016	−0.005	0.000	0.002
bv time series:					
ω_{22}	0.914	1.032	1.061	1.093	1.173

Panel B: Value/Price and Book/Price Comparisons[b]

Variables	20th	40th	50th	60th	80th
V_2/P	0.339	0.549	0.644	0.757	1.179
bv/P	0.319	0.483	0.560	0.637	0.878

Panel C: Implied Price Coefficients and Price Level Regressions[c]

Dependent Variable	*Independent Variables* *Intercept*	V_2[d]	RI_t	bv_t	*Adjusted* R^2
$Price_t$	14.736	0.531	—	—	
	(0.001)	(0.001)			0.392
$Price_t$	14.668	—	—	0.550	
	(0.001)			(0.001)	0.405
$Price_t$	25.504	—	0.951	—	
	(0.001)		(0.001)		0.031
$Price_t$	14.856	—	0.481	0.543	
	(0.001)		(0.001)	(0.001)	0.410
Implied Price Coefficients[e]	0.557	—	0.033	0.909	—

[a] Panel A presents the cross-sectional distribution of coefficient estimates from the time-series residual income (RI) regressions of LIM2, estimated by firm. The five columns are the 20th to the 80th percentile estimates of the parameters. There are 1,982 firms in this panel.

[b] Panel B presents the distribution of value estimates (V_2) divided by market price (P) and book value (bv) divided by market price, as of the end of fiscal year 1996. There are 1,871 firms with the required data available for this year.

[c] Panel C presents the price coefficients obtained by regressing price on V_2, RI and/or bv and the equilibrium price coefficients implied by the median parameter estimates of the information dynamics (panel A). P-values are presented in parentheses. They are determined by comparing the price coefficients with their implied values. The reported regression coefficients are obtained after removing up to two influential observations with Cook's distance greater than 2.

[d] $V_2 = \alpha_0 + \alpha_1 RI_t + (1 + \alpha_2) bv_t$, where α_0 to α_2 are calculated using the firm-specific ω estimates and equations $V_{2.0}$, $V_{2.1}$ and $V_{2.2}$. The significance of the intercept and slope coefficients in the regression of price on V are tested against their respective theoretical values of zero and one.

[e] These are the equilibrium price coefficients implied by the median parameter estimates of the information dynamics (panel A), the sample median risk-adjusted discount rate of 11.78 percent, and equations $V_{2.0}$, $V_{2.1}$ and $V_{2.2}$.

for these firms is conservative, LIM2 does not describe the effect of conservatism on the information dynamics. This finding is consistent with Stober (1996). The median growth parameter, ω_{22}, is 1.061 which is within the bounds required for a closed-form price solution.

Panel B of table 3 presents the distribution of V_2/P in 1996. The estimated value of V_2 is calculated as:

$$V_2 = \alpha_0 + \alpha_1 \, RI_t + (1 + \alpha_2)bv_t$$

where α_0, α_1 and α_2 are functions of the estimated ω_{ij} from equations $V_{2.0}$, $V_{2.1}$ and $V_{2.2}$. If LIM2 holds, the expected value of V_2/P is 1. However, the median V_2/P is 0.644, which is significantly less than 1. This is inconsistent with H_{2a}, and indicates that a large portion of the market's expectation of future RI that is captured by price is not captured by LIM2. However, LIM2 allows for the apparent nonstationarity of RI and provides a better average measure of value than does LIM1.[20]

Panel C of table 3 presents the linear regressions of price on the implied value, RI and book value in 1996, and the implied price coefficients. In the simple regression of price on V_2, the coefficient on V_2 is only 0.531. This is significantly less than 1. Although the implied value is significantly correlated with price, as hypothesized in H_{2b}, the adjusted R^2 is only 0.392, which is slightly less than the adjusted R^2 from the regression of price on book value. It appears that the LIM2 parameter estimates are so noisy that they reduce the precision of the value estimates.

The results of a multiple regression of price on RI and book value are inconsistent with H_{2c}. The coefficient on bv (0.543) is significantly less than the implied value of 0.909 and the coefficient on RI (0.481) is significantly greater than the implied value of 0.033. These results are inconsistent with LIM2 accurately describing the bivariate time series of RI. The median conservatism parameter is negative and the adjusted R^2 from a regression of price on book value and RI is greater than the adjusted R^2 from a regression of price on V_2.

LIM3

Panel A of table 4 presents the distribution of parameter estimates for the multivariate time series of RI, book value of equity and capital expenditures (LIM3). As with LIM2, more than 60 percent of the intercepts are positive which means the valuation equation should have an intercept term. The median autoregressive parameter on RI, ω_{11}, is 0.167. However, LIM3 fails to meet the parameter restrictions of the information dynamics. Contrary to H_{1c}, the median book value conservatism parameter, ω_{12}, is significantly negative (-0.062). However, the median income parameter of conservatism, ω_{13}, is negative as expected.[21,22]

Panel B of table 4 presents the distribution of V_3/P in 1996. The estimated value of V_3 is calculated as:

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[20] As with LIM1, residual serial correlation may be induced by omitting ν_t from empirical estimates of LIM2. The mean (median) residual serial correlation is -0.023 (-0.019). The mean (median) Durbin-Watson statistic is 1.937 (1.958). LIM2 is also estimated after adding lagged values of RI and book values. The mean coefficients on lagged information are small and statistically insignificant. Only 6 (2) percent of the White's test statistics for heteroskedasticity are significant at the 10 (5) percent level.

[21] LIM3 models conservatism of capital investments. As an additional test, I redefine investment as research and development expenditures and rerun tests on 25 pharmaceutical manufacturers. The results for this subsample do not differ materially from the results reported in this section.

[22] The mean (median) residual serial correlation is -0.049 (-0.044) and is statistically insignificant. Only 2 (1) percent of the White's test statistics for heteroskedasticity are significant at the 10 (5) percent level.

TABLE 4
The Distribution of Parameter and Value Estimates Under LIM3

Panel A: RI Regression:

$$RI_{t+1} = \omega_{10} + \omega_{11}RI_t + \omega_{12}bv_t + \omega_{13}capx_t + \varepsilon_{1t+1}{}^{a}$$
$$bv_{t+1} = \omega_{22}bv_t + \omega_{23}capx_t + \varepsilon_{2t+1}$$
$$capx_{t+1} = \omega_{33}capx_t + \varepsilon_{3t+1}$$

	Percentile				
Parameters	*20th*	*40th*	*50th*	*60th*	*80th*
RI time series:					
ω_{10}	−0.224	0.221	0.530	0.926	2.404
ω_{11}	−0.118	0.083	0.167	0.251	0.451
ω_{12}	−0.196	−0.092	−0.062	−0.030	0.041
ω_{13}	−0.579	−0.151	−0.048	0.011	0.322
bv time series:					
ω_{22}	0.610	0.721	0.757	0.794	0.863
capx times series:					
ω_{33}	0.540	0.860	0.987	1.117	1.548

Panel B: Value/Price and Book/Price Comparisons[b]

Variables					
V_3/P	−0.127	0.627	0.924	1.272	2.669
bv/P	0.306	0.477	0.553	0.630	0.876

Panel C: Implied Price Coefficients and Price Level Regressions[c]

Dependent Variable	*Independent Variables* *Intercept*	$V_3{}^{d}$	RI_t	bv_t	$capx_t$	*Adjusted* R^2
$Price_t$	12.570	0.324	—	—	—	
	(0.001)	(0.001)				0.335
$Price_t$	19.860	—	—	—	0.014	
	(0.001)				(0.001)	0.147
$Price_t$	8.410	—	—	1.033	—	
	(0.001)			(0.001)		0.477
$Price_t$	22.248	—	1.424	—	—	
	(0.001)		(0.001)			0.019
$Price_t$	8.121	—	0.926	0.975	0.007	
	(0.001)		(0.001)	(0.001)	(0.001)	0.532
Implied Price Coefficients[e]	4.732	—	0.176	0.798	−3.766	—

[a] Panel A presents the cross-sectional distribution of coefficient estimates from the time-series residual income (RI) regressions of LIM3, estimated by firm. The five columns are the 20th to the 80th percentile estimates of the parameters. There are 1,908 firms in this panel.

[b] Panel B presents the distribution of value estimates (V_3) divided by market price (P) and book value (bv) divided by market price, as of the end of fiscal year 1996. There are 1,872 firms with the required data available for this year.

[c] Panel C presents the price coefficients obtained by regressing price on V_3, RI, bv and/or capx and the equilibrium price coefficients implied by the median parameter estimates of the information dynamics (panel A). P-values are presented in parentheses. They are determined by comparing the price coefficients with their implied values. The reported regression coefficients are obtained after removing up to one influential observation with Cook's distance greater than 2.

[d] $V_3 = \alpha_0 + \alpha_1 RI_t + (1 + \alpha_2)bv_t + \alpha_3 capx_t$, where α_0 to α_3 are calculated using the firm-specific ω estimates and equations $V_{3.0}$, $V_{3.1}$, $V_{3.2}$ and $V_{3.3}$. The significance of the intercept and slope coefficients in the regression of price on V are tested against their respective theoretical values of zero and one.

[e] These are the equilibrium price coefficients implied by the median parameter estimates of the information dynamics (panel A), the sample median risk-adjusted discount rate of 11.78 percent, and equations $V_{3.0}$, $V_{3.1}$, $V_{3.2}$ and $V_{3.3}$.

$$V_3 = \alpha_0 + \alpha_1 RI_t + (1 + \alpha_2)bv_t + \alpha_3 capx_t$$

where α_0, α_1, α_2 and α_3 are functions of the estimated ω_{ij} from equations $V_{3.0}$, $V_{3.1}$, $V_{3.2}$ and $V_{3.3}$. The median V_3/P is 0.924, which is close to the LIM3 hypothesized value of 1.

Panel C of table 4 contains the results from linear regressions of price on the implied value, RI, book value and capital expenditures in 1996, and the implied price coefficients. In the simple regression of price on V_3, V_3 has a coefficient of only 0.324; this is significantly less than 1. While statistically significant and consistent with H_{2c}, the adjusted R^2 is only 0.335. V_3 explains approximately 70 percent of the cross-sectional variation in stock price explained by book value.

The results of a multiple regression of price on RI, book value and capital expenditures are inconsistent with H_{2c}. The coefficients on RI, book value and capital expenditures are significantly greater than the coefficients implied by LIM3 (0.176, 0.804 and −3.766, respectively). That is, the weightings implied by the estimated LIM differ greatly from the weightings implied by market price.

LIM4

As a final test using the LIMs to estimate future RI, I examine the usefulness of including an additional source of information into the information dynamics. Contrary to H_{1d}, table 5 shows that, for the median firm, order backlog does not translate into an increase in RI in the following year. This implies that order backlog should not be valued after controlling for current book value and residual income. The autoregressive parameter on order backlog is 0.998. However, adding an additional information variable increases the complexity of the pricing coefficients considerably. Further, the coefficient estimates are likely to be very noisy. Because the effect is small, including additional information such as order backlog is unlikely to improve the accuracy of value estimates for most firms.[23]

Conservatism Parameters

To test whether the failure of the LIMs to describe the effects of conservatism is due to the inclusion of nonconservative firms in the sample (see Stober 1996), I test the relationship between ω_{12} and ω_{13} (the LIM-based conservatism parameters) and C (the market-based conservatism parameter).

Tables 6 and 7 do not support hypotheses H_{3a} and H_{3b}. Panel A of table 6 presents the distribution of estimated LIM2 parameters for the 25 percent of firms with the most conservative accounting (based on C). The median book value conservatism parameter, ω_{12}, for these firms remains negative. If C represents accounting conservatism, then the negative conservatism parameter estimate (ω_{12}) in the full sample is not due to that sample's inclusion of nonconservative and conservative firms.

Panel A of table 7 confirms the previous finding. The book value parameter estimate is negative for more than 60 percent of the firms, suggesting that LIM3 does not accurately describe the book value effect of conservatism. The median estimate of the income effect of conservatism is −0.107, which is statistically significant. However, approximately the same percentage of firms have negative ω_{13} estimates, whether drawn from the full sample or the conservative sample. This suggests that the negative parameter estimates may not be due to accounting conservatism.

Finally, I calculate both Pearson and Spearman correlations between the LIM-based conservatism parameters and the market-based conservatism parameters for both LIM2 and

[23] In analysis not reported in the table, order backlog is added to each of the models, providing similar results.

TABLE 5
The Distribution of Parameter and Value Estimates Under LIM4

Panel A: RI Regression:

$$RI_{t+1} = \omega_{10} + \omega_{11}RI_t + \omega_{12}bv_t + \omega_{13}bklog_t + \varepsilon_{1t+1}$$ [a]

$$bv_{t+1} = \omega_{22}bv_t + \varepsilon_{2t+1}$$

$$bklog_{t+1} = \omega_{33}bklog_t + \varepsilon_{3t+1}$$

	Percentile				
Parameters	*20th*	*40th*	*50th*	*60th*	*80th*
RI time series:					
ω_{10}	−0.048	0.000	0.019	0.070	0.664
ω_{11}	−0.005	0.002	0.013	0.036	0.112
ω_{12}	−0.075	−0.010	−0.004	−0.001	0.005
ω_{13}	−0.014	−0.001	0.000	0.002	0.028
bv time series:					
ω_{22}	0.872	1.031	1.067	1.099	1.184
bklog time series:					
ω_{33}	0.682	0.921	0.998	1.083	1.334

Panel B: Value/Price and Book/Price Comparisons[b]

Variables					
V_4/P	0.184	0.484	0.648	0.836	1.472
bv/P	0.304	0.466	0.551	0.661	0.992

Panel C: Implied Price Coefficients and Price Level Regressions[c]

Dependent Variable	Independent Variables: *Intercept*	*V_4*[d]	*RI_t*	*bv_t*	*$bklog_t$*	*Adjusted R^2*
$Price_t$	17.205	0.150	—	—	—	
	(0.001)	(0.001)				0.176
$Price_t$	15.943	—	—	—	0.042	
	(0.001)				(0.001)	0.025
$Price_t$	10.812	—	—	0.520	—	
	(0.001)			(0.001)		0.468
$Price_t$	19.329	—	0.614	—	—	
	(0.001)		(0.001)			0.206
$Price_t$	14.289	—	0.278	0.300	−0.002	
	(0.001)		(0.438)	(0.001)	(0.861)	0.326
Implied Price Coefficients[e]	0.146	—	0.011	0.920	0.000	—

[a] Panel A presents the cross-sectional distribution of coefficient estimates from the time-series residual income (RI) regressions of LIM4, estimated by firm. The five columns are the 20th to the 80th percentile estimates of the parameters. This panel includes the 924 firms with nonzero order backlog for at least one-quarter of the years they were in the sample.

[b] Panel B presents the distribution of value estimates (V_4) divided by market price (P) and book value (bv) divided by market price, as of the end of fiscal year 1996. There are 664 firms with the required data available for this year.

[c] Panel C presents the price coefficients obtained by regressing price on V_4, RI, bv and/or bklog and the equilibrium price coefficients implied by the median parameter estimates of the information dynamics (panel A). P-values are presented in parentheses. They are determined by comparing the price coefficients with their implied values. The reported regression coefficients are obtained after removing up to eight influential observations with Cook's distance greater than 2.

[d] $V_4 = \alpha_0 + \alpha_1 RI_t + (1 + \alpha_2) bv_t + \alpha_3 bklog_t$, where α_0 to α_3 are calculated using the firm-specific ω estimates from V_3 and equations $V_{3.0}$, $V_{3.1}$, $V_{3.2}$ and $V_{3.3}$, and setting $\omega_{23} = 0$. The significance of the intercept and slope coefficients in the regression of price on V are tested against their respective theoretical values of zero and one.

[e] These are the equilibrium price coefficients implied by the median parameter estimates of the information dynamics (panel A), the sample median risk-adjusted discount rate of 11.78 percent, and the modified equations $V_{3.0}$, $V_{3.1}$, $V_{3.2}$ and $V_{3.3}$.

TABLE 6
The Distribution of Parameter and Value Estimates Under LIM2 for the Conservative Subsample

Panel A: RI Regression: $RI_{t+1} = \omega_{10} + \omega_{11}RI_t + \omega_{12}bv_t + \varepsilon_{1t+1}$[a]

$$bv_{t+1} = \omega_{22}bv_t + \varepsilon_{2t+1}$$

Parameters	Percentile 20th	40th	50th	60th	80th
RI time series:					
ω_{10}	−0.045	0.013	0.070	0.192	1.265
ω_{11}	−0.001	0.019	0.035	0.052	0.196
ω_{12}	−0.092	−0.022	−0.006	0.000	0.003
bv time series:					
ω_{22}	0.902	1.021	1.051	1.077	1.152

Panel B: Value/Price and Book/Price Comparisons[b]

Variables	20th	40th	50th	60th	80th
V_2/P	−0.021	0.207	0.367	0.513	1.020
bv/P	0.201	0.291	0.321	0.379	0.518

Panel C: Implied Price Coefficients and Price Level Regressions[c]

Dependent Variable	Independent Variables: Intercept	V_2[d]	RI_t	bv_t	Adjusted R^2
$Price_t$	23.128 (0.001)	0.417 (0.001)	—	—	0.298
$Price_t$	18.357 (0.001)	—	—	0.917 (0.910)	0.455
$Price_t$	33.669 (0.001)	—	0.949 (0.002)	—	0.023
$Price_t$	19.858 (0.001)	—	0.468 (0.421)	0.797 (0.015)	0.458
Implied Price Coefficients[e]	0.549	—	0.032	0.923	—

[a] Panel A presents the cross-sectional distribution of coefficient estimates from the time-series residual income (RI) regressions of LIM2, estimated by firm. The five columns are the 20th to the 80th percentile estimates of the parameters. This panel consists of the 25 percent of firms with the most conservative accounting as estimated by the market-based parameter, C. There are 594 firms in this panel.

[b] Panel B presents the distribution of value estimates (V_2) divided by market price (P) and book value (bv) divided by market price, as of the end of fiscal year 1996. There are 469 firms with the required data available for this year.

[c] Panel C presents the price coefficients obtained by regressing price on V_2, RI and/or bv and the equilibrium price coefficients implied by the median parameter estimates of the information dynamics (panel A). P-values are presented in parentheses. They are determined by comparing the price coefficients with their implied values. The reported regression coefficients are obtained after removing up to one influential observation with Cook's distance greater than 2.

[d] $V_2 = \alpha_0 + \alpha_1 RI_t + (1 + \alpha_2) bv_t$, where α_0 to α_2 are calculated using the estimated ω and equations $V_{2.0}$, $V_{2.1}$ and $V_{2.2}$. The significance of the intercept and slope coefficients in the regression of price on V are tested against their respective theoretical values of zero and one.

[e] These are the equilibrium price coefficients implied by the median parameter estimates of the information dynamics (panel A), the sample median risk-adjusted discount rate of 11.78 percent, and equations $V_{2.0}$, $V_{2.1}$ and $V_{2.2}$.

TABLE 7
The Distribution of Parameter and Value Estimates Under LIM3 for the Conservative Subsample

Panel A: RI Regression:

$$RI_{t+1} = \omega_{10} + \omega_{11}RI_t + \omega_{12}bv_t + \omega_{13}capx_t + \varepsilon_{1t+1}{}^{a}$$
$$bv_{t+1} = \omega_{22}bv_t + \omega_{23}capx_t + \varepsilon_{2t+1}$$
$$capx_{t+1} = \omega_{33}capx_t + \varepsilon_{3t+1}$$

	Percentile				
Parameters	*20th*	*40th*	*50th*	*60th*	*80th*
RI time series:					
ω_{10}	−0.128	0.180	0.563	1.035	2.718
ω_{11}	−0.210	0.015	0.107	0.177	0.383
ω_{12}	−0.214	−0.082	−0.046	−0.004	0.096
ω_{13}	−0.784	−0.271	−0.107	0.011	0.411
bv time series:					
ω_{22}	0.566	0.695	0.735	0.769	0.835
capx time series:					
ω_{33}	0.879	0.965	0.999	1.027	1.085

Panel B: Value/Price and Book/Price Comparisons[b]

Variables					
V_3/P	−0.154	0.417	0.646	1.014	2.413
bv/P	0.217	0.317	0.381	0.441	0.646

Panel C: Implied Price Coefficients and Price Level Regressions[c]

Dependent Variable	*Intercept*	V_3[d]	RI_t	bv_t	$capx_t$	*Adjusted* R^2
$Price_t$	17.904	0.300	—	—	—	
	(0.001)	(0.001)				0.307
$Price_t$	24.982	—	—	—	0.016	
	(0.001)				(0.001)	0.192
$Price_t$	18.268	—	—	0.968	—	
	(0.001)			(0.068)		0.501
$Price_t$	28.607	—	2.120	—	—	
	(0.001)		(0.004)			0.028
$Price_t$	12.549	—	0.771	1.215	0.008	
	(0.001)		(0.155)	(0.001)	(0.001)	0.566
Implied Price Coefficients[e]	4.728	—	0.106	0.867	−5.938	—

[a] Panel A presents the cross-sectional distribution of coefficient estimates from the time-series residual income (RI) regressions of LIM3, estimated by firm. The five columns are the 20th to the 80th percentile estimates of the parameters. This panel consists of the 25 percent of firms with the most conservative accounting as estimated by the market-based parameter, C. There are 590 firms in this panel.

[b] Panel B presents the distribution of value estimates (V_3) divided by market price (P) and book value (bv) divided by market price, as of the end of fiscal year 1996. There are 452 firms with the required data available for this year.

[c] Panel C presents the price coefficients obtained by regressing price on V_3, RI, bv and/or capx and the equilibrium price coefficients implied by the median parameter estimates of the information dynamics (panel A). P-values are presented in parentheses. They are determined by comparing the price coefficients with their implied values. The reported regression coefficients are obtained after removing up to one influential observation with Cook's distance greater than 2.

[d] $V_3 = \alpha_0 + \alpha_1 RI_t + (1 + \alpha_2) bv_t + \alpha_3 capx_t$, where α_0 to α_3 are calculated using the firm-specific ω estimates and equations $V_{3.0}$, $V_{3.1}$, $V_{3.2}$ and $V_{3.3}$. The significance of the intercept and slope coefficients in the regression of price on V are tested against their respective theoretical values of zero and one.

[e] These are the equilibrium price coefficients implied by the median parameter estimates of the information dynamics (panel A), the sample median risk-adjusted discount rate of 11.78 percent, and equations $V_{3.0}$, $V_{3.1}$, $V_{3.2}$ and $V_{3.3}$.

LIM3. The Pearson correlations for LIM2 are statistically significant. However, the Spearman correlations are significant but in the wrong direction. The findings for LIM3 are similar. Altogether, the findings are inconsistent with the hypothesized LIMs capturing the effects of conservatism.

VI. CONCLUSION

This study describes several different attempts to implement residual income (RI) valuation within the confines of alternative linear information dynamics. If the theory is to be used as the basis for estimating firm value, then an internally consistent link between current information and future RI is necessary. Linear models of the link between current and future information ensure consistency and are an integral component of accounting-based valuation. Recent studies modify the linear information models in an attempt to better approximate economic conditions. These modifications frequently lead to internal inconsistencies.

I find that a simple time-series model of RI does not require assumptions that are internally inconsistent, but evidence suggests that this time series is nonstationary. I also find that the theoretical models of conservatism fail to accurately characterize the time series of RI. Although the time series of RI is affected by accounting conservatism, better models of the effects are needed. All models examined here tend to understate firm value and a large portion of the market's expectations of future RI is unaccounted for by these proposed time-series models. Although the models provide information useful for estimating firm value, it appears that estimation errors are extensive and that these models provide noisy estimates of firm value. More thorough modeling of the accounting process adds to the complexity of the valuation model and appears to magnify the estimation error.

Although modifications to the information dynamics can lead to internal inconsistencies, this study provides an example of how conditioning variables can be incorporated into valuation while preserving consistency. Order backlog is included as an example of a conditioning variable. However, the results are discouraging and indicate that order backlog, on average, has a negligible impact on future RI. Caution is warranted when adding variables, since the evidence suggests this can reduce the precision of the value estimates.

Overall, my analysis suggests that the linear information dynamics that I examine do not capture aspects of the market valuation process very well. There are several possible explanations for the inadequacy of the empirical models I examine. First, there are too few observations to make precise estimates of the time-series parameters. Second, the time-series processes of accounting information are likely to be nonstationary due to changes in growth rates, accounting procedures and production technologies. This creates problems for modeling the valuation process and leaves much room for fundamental analysis.

APPENDIX
PROOF THAT DISCONNECTED EARNINGS SERIES IMPLY ARBITRAGE

Price is equal to book value plus the present value of future expected residual income (RI) (Ohlson 1990):

$$P_t = bv_t + \sum_{\tau=1}^{\infty} R^{-\tau} E(RI_{t+\tau}|\Theta_t). \tag{A1}$$

Specifying separate, disconnected patterns for short-run and long-run future RI implies two different functional forms for the relationship between current information and expectations of future RI.

Let $S(\Theta_t,\tau)$ be the function that calculates expected RI τ periods into the future, given information set Θ_t, where τ is between 1 and T, and T is the number of periods described by the short-run dynamics. Similarly, let $L(\Theta_t,\tau)$ be the function that calculates expected RI τ periods into the future for τ greater than T. Firm value at date t can then be written as:

$$P_t = bv_t + \sum_{\tau=1}^{T} R^{-\tau} S(\Theta_t,\tau) + \sum_{\tau=T+1}^{\infty} R^{-\tau} L(\Theta_t,\tau) \tag{A2}$$

where $R = (1 + r)$.

Taking expectations on both sides and looking ahead one period, the expected price at date $t + 1$, based on the information set Θ_t is:

$$E(P_{t+1}|\Theta_t) = E(bv_{t+1}|\Theta_t) + \sum_{\tau=1}^{T} R^{-\tau} E(S(\Theta_{t+1},\tau)|\Theta_t) + \sum_{\tau=T+1}^{\infty} R^{-\tau} E(L(\Theta_{t+1},\tau)|\Theta_t). \tag{A3}$$

Using the clean surplus relation:

$$E(bv_{t+1}|\Theta_t) = bv_t + E(x_{t+1}|\Theta_t) - E(d_{t+1}|\Theta_t),$$

and using the definition of abnormal earnings:

$$E(bv_{t+1}|\Theta_t) = R \cdot bv_t + E(x^a_{t+1}|\Theta_t) - E(d_{t+1}|\Theta_t). \tag{A4}$$

Taking expectations of equation (A2) and substituting equation (A4) for $E(bv_{t+1}|\Theta_t)$:

$$\begin{aligned} E(P_{t+1}|\Theta_t) &= R \cdot bv_t + E(x^a_{t+1}|\Theta_t) - E(d_{t+1}|\Theta_t) \\ &\quad + \sum_{\tau=1}^{T} R^{-\tau} E(S(\Theta_{t+1},\tau)|\Theta_t) + \sum_{\tau=T+1}^{\infty} R^{-\tau} E(L(\Theta_{t+1},\tau)|\Theta_t). \end{aligned} \tag{A5}$$

From the law of iterated expectations, $E(E(\bullet|\Theta_{t+1})|\Theta_\tau) = E(\bullet|\Theta_\tau)$, implying:

$$\begin{gathered} E(S(\Theta_{t+1},\tau)|\Theta_\tau) = S(\Theta_t,\tau + 1) \text{ for all } \tau < T \\ \text{and } E(L(\Theta_{t+1},\tau)|\Theta_\tau) = L(\Theta_t,\tau + 1) \text{ for all } \tau \geq T. \end{gathered}$$

Rearranging terms:

$$\begin{aligned} E[(P_{t+1} + d_{t+1})|\Theta_t] &= R \cdot bv_t + \sum_{\tau=0}^{T-1} R^{-\tau} S(\Theta_t,\tau + 1) \\ &\quad + R^{-T} E(S(\Theta_{t+1},T)|\Theta_t) + \sum_{\tau=T+1}^{\infty} R^{-\tau} L(\Theta_t,\tau + 1). \end{aligned} \tag{A6}$$

All expectations drop out except $E(S(\Theta_{t+1},T)|\Theta_t)$ since $S(\Theta_t,T + 1)$ is undefined.

No arbitrage implies $E(P_{t+1} + d_{t+1}|\Theta_\tau) = R \cdot P_t$, and equation (A6) = R · (2):

$$R \cdot bv_t + \sum_{\tau=0}^{T-1} R^{-\tau} S(\Theta_t,\tau + 1) + R^{-T} E(S(\Theta_{t+1},T)|\Theta_t) + \sum_{\tau=T+1}^{\infty} R^{-\tau} L(\Theta_t,\tau + 1)$$
$$= R\left[bv_t + \sum_{\tau=1}^{T} R^{-\tau} S(\Theta_t,\tau) + \sum_{\tau=T+1}^{\infty} R^{-\tau} L(\Theta_t,\tau) \right].$$

Canceling like terms:

$$E(S(\Theta_{t+1},T)|\Theta_t) = L(\Theta_t,T + 1).$$

Therefore, if price is set using different short-run and long-run RI expectations functions, these functions must be linked such that:

$$E(S(\Theta_{t+1},T)|\Theta_t) = L(\Theta_t,T + 1), E(S(\Theta_{t+2},T)|\Theta_t) = L(\Theta_t,T + 2),...,$$

or $E(P_{t+1} + d_{t+1}) \neq R\ (P_t)$.

REFERENCES

Abarbanell, J., and V. L. Bernard. 1997. Does the U.S. stock market underprice long-term abnormal earnings? Working paper, University of North Carolina at Chapel Hill.

Beaver, W., and S. Ryan. 1998. Biases and lags in book value and their effects on the ability of the book-to-market ratio to predict book return on equity. Working paper, New York University.

Bernard, V. 1994. Accounting-based valuation methods, determinants of market-to-book ratios, and implications for financial statements analysis. Working paper, University of Michigan.

Dechow, P., A. Hutton, and R. Sloan. 1998. An empirical analysis of the residual income valuation model. *Journal of Accounting and Economics*, Forthcoming.

Fama, E., and K. French. 1997. Industry cost of equity. *Journal of Financial Economics* 43 (February): 153–194.

Feltham, G., and J. Ohlson. 1995. Valuation and clean surplus accounting for operating and financial activities. *Contemporary Accounting Research* 11 (Spring): 689–732.

———, and ———. 1996. Uncertainty resolution and the theory of depreciation measurement. *Journal of Accounting Research* 34 (Autumn): 209–234.

Frankel, R., and C. M. C. Lee. 1998. Accounting valuation, market expectation and cross-sectional stock returns. *Journal of Accounting and Economics*, 25 (3): 289–319.

Garman, M., and J. Ohlson. 1980. Information and sequential valuation of assets in arbitrage-free economies. *Journal of Accounting Research* 18 (Autumn): 420–440.

Hamilton, J. 1994. *Time Series Analysis*. Princeton, NJ: Princeton University Press.

Lee, C. M. C., J. Myers, and B. Swaminathan. 1998. What is the fundamental value of the Dow? *Journal of Finance*, Forthcoming.

Myers, J. 1998. Accounting conservatism and finite firm life: Why residual income valuation estimates understate stock price. Working paper, University of Washington.

Ohlson, J. 1990. A synthesis of security valuation theory and the role of dividends, cashflows, and earnings. *Contemporary Accounting Research* 6 (Spring): 648–676.

———. 1995. Earnings, book values and dividends in security valuation. *Contemporary Accounting Research* 11 (Spring): 661–668.

Penman, S. 1997. A synthesis of equity valuation techniques and the terminal value calculation for the dividend discount model. Working paper, University of California at Berkeley.

———, and T. Sougiannis. 1998. The substitution of anticipated earnings for dividends in equity valuation. Working paper, University of Illinois.

Stober, T. 1996. Do prices behave as if accounting book values are conservative? Cross-sectional tests of the Feltham-Ohlson (1995) valuation model. Working paper, University of Notre Dame.