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Empirical Tests of the Feltham–Ohlson (1995) Model

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Abstract. This paper tests the Feltham–Ohlson (1995) model by transforming the undefined ‘‘other information’’ variables into expectational variables, as suggested by Liu and Ohlson [Liu and Ohlson (2000). *Journal of Accounting, Auditing and Finance* 15, 321–331]. The signs of the estimated coefficients conform to the model's predictions using panel data techniques, non-parametric estimation, reverse regressions and portfolio regressions. The tests reject the Ohlson model in favor of Feltham–Ohlson. Nevertheless, the estimated leverage coefficient takes a value of three instead of one for most variations of the model. Also, the 1-year-ahead price predictions of the Feltham–Ohlson model are no more accurate than those of the Ohlson model or a naive earnings valuation model.

Keywords: Feltham–Ohlson, equity valuation, conservatism, net operating assets, growth

JEL Classification: M41, G12

This paper tests the Feltham and Ohlson (1995) model based on the extension by Liu and Ohlson (2000). The major stumbling block in testing the Feltham–Ohlson model revolves around the ‘‘other information’’ variables.[1] Since the ‘‘other information’’ variables are undefined *a priori* by the model, it can always be claimed, whatever the results, that the tests of the model are not meaningful because the researcher chose the wrong ‘‘other information’’ variables or failed to incorporate all of the relevant ‘‘other information’’ variables. Liu and Ohlson (2000) employ straightforward linear transformations to show that firm value in the Feltham–Ohlson model can be expressed as a function of *specific* and well-defined expectational variables.[2] In the process, the ‘‘other information’’ variables are suppressed and do not appear explicitly in the valuation equation. Of course, these transformations raise their own challenges since proxies for the expectational variables may not be adequate empirically. As a consequence, this study performs extensive sensitivity analysis of these proxies.

The fundamental importance of the Feltham–Ohlson model is that the model incorporates conservative accounting in the equity valuation process. Empirical studies by Dechow et al. (1999), Myers (1999), and Callen and Morel (2001) and Morel (2003) provide extensive empirical evidence that the Ohlson (1995) model is of limited empirical validity. One possible reason is the restrictive assumption of the

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Ohlson model that accounting is unbiased, whereas US GAAP is strongly biased towards conservatism.[3]

Almost all prior studies that test the Feltham and Ohlson (1995) model – or the somewhat more limited Feltham and Ohlson (1996) model – including Stober (1996), Myers (1999), and Ahmed et al. (2000) appear to reject this model as well. However, most of these empirical studies are subject to the criticism noted earlier, namely, that they fail to adequately account for the "other information" variables in the Feltham–Ohlson framework. They either disregard the "other information" variables altogether or substitute specific historical information for them such as order backlogs. Tse and Yaansah (1999) is an exception in that they use analyst earnings forecasts to substitute for the "other information" variables. However, as pointed out by Ohlson (1999), the Tse–Yaansah study abstracts completely from the information dynamic and, therefore, does not really address the Feltham–Ohlson model.[4]

More recently, Begley and Feltham (2002) extend Feltham and Ohlson (1996) by modeling the "other information" variables as a function of one and two-period-ahead residual income forecasts as well as the current period value relevant accounting variables. They predict that the coefficients on the one-period-ahead and two-period-ahead residual income forecasts should be negative and positive, respectively and they find empirical results consistent with these predictions. Although Begley–Feltham approach is quite innovative, nevertheless, it is also rather restrictive as a test of Feltham–Ohlson (1996). First, and most crucially, Begley and Feltham restrict the leverage coefficient to take on a value of 1.[5] As we shall see, not only is this restriction rejected by the data but imposing this restriction biases the coefficients of the other parameter estimates of the model. Second, Begley and Feltham assume empirically a (temporally and cross-sectional) constant cost of capital of 12%. Regarding the limitation of this assumption, we can do no better than cite Beaver's (1999, p. 37) critique of Dechow et al. (1999) who make a similar assumption in testing the Ohlson model. "Thirty plus years ago, Miller and Modigliani (1966) spent considerable effort to estimate the cost of capital for one industry for 3 years. It is remarkable that the assumption of a constant (discount rate) across firms and time is the best we can do."

There are other papers that implicitly buttress the Feltham–Ohlson models by showing empirically that book values, expected earnings and growth in expected short term and long term earnings are determinants of firm value (e.g., Abarbanell and Bushee, 1997; Frankel and Lee, 1998; Liu and Thomas, 2000; Shane and Brous, 2001). Nevertheless, by adopting the model in piecemeal fashion rather than as a whole construct, it cannot be claimed that the Feltham–Ohlson models have empirical validity based on their findings. In fact, our tests of Feltham and Ohlson (1995) yield decidedly mixed results. On the one hand, the empirical tests reject the nested Ohlson (1995) model in favor of Feltham and Ohlson (1995), thereby confirming the importance of incorporating conservatism into accounting valuation. In addition, the empirical analysis indicates that the signs of the valuation coefficients are consistent with the predictions of the Feltham–Ohlson model for almost all empirical variations of the model, including panel data techniques, non-parametric estimation, reverse regressions, and portfolio regressions. On the other hand, the estimated leverage coefficient – for which the model predicts a value of one – takes on a value of three for all empirical variations of the model. Equally problematic is the finding that 1-year-ahead equity price predictions of the Feltham–Ohlson model are no more accurate than the predictions of the Ohlson model and a naive valuation model.

This paper is structured as follows. Section 1 briefly describes the Feltham and Ohlson (1995) model and the Liu and Ohlson (2000) transformations. Section 2 describes the sample. Section 3 discusses variable measurement. Section 4 reports the empirical results. Section 5 tests the sensitivity of the results to alternative formulations and proxies and Section 6 concludes.

1. Feltham–Ohlson and Liu–Ohlson

There are four primary assumptions underlying the Feltham and Ohlson (1995) model. First, non-arbitrage is assumed to hold so that firm value is the present value of expected dividends conditional on the information dynamic. Second, clean surplus is assumed to hold. Third, (net) financial assets are assumed to be zero net present value investments, so that interest is the product of the risk free rate and beginning of period (net) financial assets. Fourth, abnormal operating earnings and net operating assets (NOA) evolve according to the linear information dynamic:

$$ox^a_{t+1} = \omega_{11} ox^a_t + \omega_{12} oa_t + v_{1t} + \varepsilon_{1t+1} \tag{1}$$

$$oa_{t+1} = \omega_{22} oa_t + v_{2t} + \varepsilon_{2t+1} \tag{2}$$

$$v_{1t+1} = \gamma_1 v_{1t} + \varepsilon_{3t+1} \tag{3}$$

$$v_{2t+1} = \gamma_2 v_{2t} + \varepsilon_{4t+1} \tag{4}$$

where ${ox^a}_t$ = abnormal operating earnings, oa_t = net operating assets (net of operating liabilities), v_{it} = "other information" variables (i = 1,2), ε_{jt+1} = zero mean error terms (j = 1,2,3,4), $\omega_{11}, \omega_{12}, \omega_{22}, \gamma_1, \gamma_2$ = parameters.

Using these four assumptions, Feltham and Ohlson (1995) prove that firm value can be expressed as:

$$P_t = bv_t + \alpha_1 ox^a_t + \alpha_2 oa_t + \beta_1 v_{1t} + \beta_2 v_{2t} \tag{5}$$

where P_t = market value of the firm, bv_t = book value of the firm, R = one plus the firm's cost of capital, $\alpha_1 = \omega_{11}/(R - \omega_{11}) \geq 0$, $\alpha_2 = \omega_{12}R/(R - \omega_{11})(R - \omega_{22}) \geq 0$, $\beta_1 = R/(R - \omega_{11})(R - \gamma_1) > 0$, $\beta_2 = \alpha_2/(R - \gamma_2) \geq 0$.

The major problem with testing or implementing valuation equation (5) is that the "other information" variables, v_{1t} and v_{2t}, are undefined and unknown *a priori*. To finesse this problem, Liu and Ohlson (2000) substitute expectational variables for the "other information" variables via the linear relationships:[6]

$$v_{1t} = E_t[ox^a_{t+1}] - \omega_{11} ox^a_t - \omega_{12} oa_t \tag{6}$$

$$v_{2t} = E_t[oa_{t+1}] - \omega_{22} oa_t \tag{7}$$

Substituting equations (6) and (7) into equation (5), Liu and Ohlson derive (after extensive manipulation), the potentially testable valuation equation:

$$P_t = fa_t + \lambda_1 E_t[\Delta ox_{t+1}] + \lambda_2 E_t[ox_{t+1}] + \lambda_3 oa_t + \lambda_4 E_t[\Delta oa_{t+1}] \tag{8}$$

where fa_t = net financial assets, $E_t[\Delta ox_{t+1}]$ = expected change in next period's operating earnings, $E_t[ox_{t+1}]$ = expected next period's operating earnings, $E_t[\Delta oa_{t+1}]$ = expected change in next period's NOA.

Deflating equation (8) by contemporaneous NOA yields the equation to be estimated:

$$\begin{aligned} P_t/oa_t = \delta_0 + \delta_1 fa_t/oa_t + \delta_2 E_t[\Delta ox_{t+1}]/oa_t \\ + \delta_3 E_t[ox_{t+1}]/oa_t + \delta_4 E_t[\Delta oa_{t+1}]/oa_t + \varepsilon_t \end{aligned} \tag{9}$$

where fa_t/oa_t can be interpreted as a leverage variable and $\mathrm{E}_t[\Delta oa_{t+1}]/oa_t$ is the expected growth in next period's NOA.[7]

We test the Feltham and Ohlson (1995) model primarily by reference to the values and signs of the δ_k parameters (k = 0,1,2,3,4) in equation (9). Following Liu and Ohlson (2000), the underlying theory dictates that the estimated parameters take on the signs $\delta_0 \geq 0, \delta_2 \geq 0, \delta_3 > 0, \delta_4 > 0$ and the value $\delta_1 = 1$. To examine whether the data are driven by conservative accounting, we also test the Ohlson (1995) model and contrast the results with Feltham–Ohlson. Since the Ohlson model is nested within Feltham–Ohlson, it is straightforward to show that the Ohlson model imposes two additional restrictions on the δ_k parameters, namely, $\delta_4 = 0$ and $\delta_0 = 1 - \delta_3(R - 1)$. This is demonstrated in Appendix A.

2. The Sample

The data for this study are obtained from the intersection of annual Compustat, monthly Center for Research in Security Prices (CRSP), and analysts forecast files, IBES, for 1990 to 2001. Merging these files yields an initial sample of 49,131 (9,611) firm-year (firm) observations.

The following data items are used to construct the variables used in this study: cash and cash equivalents (DATA1), total assets (DATA6), long term debt (DATA9), interest expense (DATA15), investments and advancements (DATA32), debt in current liabilities (DATA34), interest income (DATA62), preferred shares (DATA130), short-term investments (DATA193), total liabilities (DATA181), and notes payable (DATA206).

One of the principal problems in testing Feltham–Ohlson is the distinction between NOA and net financial assets, and between operating earnings and financial earnings. The model posits that only NOA are subject to conservative accounting since, on average, their market values exceed their book values, whereas financing activities are zero net present value investments.[8] This distinction is problematic on both theoretical and empirical grounds. Theoretically, one can argue that all assets of a non-financial firm are operating since non-financial firms typically hold financial assets in order to facilitate operational transactions such as the acquisition of inventory or Property Plant and Equipment (PP&E).[9] Empirically, financial statements do not distinguish between operating and financial activities even if the distinction is theoretically meaningful. To the extent possible, we follow Penman (2000) in distinguishing between operating and financial data.

More specifically, the variables of interest in this study are computed from the Compustat data items as follows:

Financial assets = DATA1 + DATA32 + DATA193

Financial liabilities = DATA9 + DATA34 + DATA130 + DATA206

Operating assets = DATA6−financial assets

Operating liabilities = DATA130 + DATA181−financial liabilities

Net operating (financial) assets = Operating (financial) assets−Operating (financial) liabilities

Excluding financial institutions (SIC 6000), observations with market value of equity less then $10M, and requiring non-negative financial assets, financial liabilities, operating assets, operating liabilities, NOA and one lag of net operating assets reduces the sample to 22,586 (5,248) firm-year (firm) observations.

Finally, we require non-missing data of operating earnings, change in operating earnings and expected growth in net operating assets.[10] In addition, to mitigate the

Table 1. Sample selection procedure.

1	Firm-year (firm) observations on the intersection of IBES, COMPUSTAT and CRSP for 1990 to 2001	49,131 (9,611)
2	Firm-year (firm) observations after deleting regulated and financial firms (10,208), observations with market value less then 10M (679), and observations with negative or missing financial assets, financial liabilities, operating assets, operating liabilities, NOA, and one lag of net operating assets (15,473)	22,586 (5,248)
3	Firm-year (firm) observations after deleting missing operating earnings, change in operating earnings, and expected growth in NOA	15,280 (3,689)
4	Firm-year (firm) observations after deleting the top and bottom percentile for each variable in the valuation regression (equation 9)	14,071 (3,451)

effect of outliers we eliminate the top and bottom percentile of each of the variables in the model (equation 9). These restrictions further reduce the sample to 14,071 (3,451) firm-years (firms). Table 1 reconciles the number of observations in the final sample with the data sources and the various filters.

3. Variable Measurement

Earnings in this study are defined as earnings from continuing operations as reported by IBES. The IBES earnings number was chosen rather than one of Compustat's in order to maintain comparability between actual earnings and analyst forecasts when computing the expected change in operating earnings. In the summary description of their history tape, IBES claims that their income from continuing operations number is "adjusted by the IBES Data Center to be comparable to the estimates being made by analysts at that time." Therefore, applying analysts forecasts to income from continuing operations as reported on Compustat is likely to distort the analysis.

The interest rate on debt is defined to be interest expense (DATA15) divided by average financial liabilities. If the computed interest rate has a missing value or is in the bottom or top 5th percentile, we use the median interest rate for that industry instead.

Time varying annual costs of equity capital for each firm are computed by adding time invariant industry risk-premia, as estimated by Fama and French (1997) using a three-factor asset pricing model, to the time varying annualized three month treasury bill rate.

In addition to NOA and net financial assets defined above, the other variables in valuation equation (9) are computed as follows. Expected operating earnings, $E_t[ox_{t+1}]$, is measured as the median consensus analyst forecast of next year's earnings minus expected net interest revenue. The median consensus analyst forecast of next year's earnings is measured as of the first month after publication of the annual financial report. Expected interest revenue is measured as the product of end of current year net financial assets and the computed interest rate on debt. This proxy assumes that analyst earnings forecasts include net interest revenue. Similarly, current period operating earnings is computed as actual earning, as reported by IBES, minus interest revenue, where interest revenue is measured as the product of end of current year net financial assets and the computed interest rate on debt.[11] Growth in expected earnings is defined as the expected change in operating earnings divided by NOA. By definition, the expected change in operating earnings is $E_t[\Delta ox_{t+1}] = E_t[ox_{t+1} - (R\,ox_t - (R-1)c_t)]$, where R is one plus the cost of equity and c_t is free-cash flow.[12] Free cash flows are measured as operating earnings minus the change in NOA.

Liu and Ohlson suggest using analyst forecasts of long-term earnings growth rates as a proxy for the expected growth in net operating assets. The empirical results appear to validate this suggestion. The median (mean) difference between the median consensus analyst forecast of the long-term earnings growth rate and the actual growth in NOA is 17% (30%). By contrast, the median (mean) differences between the other proxies for the expected growth in NOA – discussed further below in the sensitivity analysis section – and the actual growth in NOA are around 22% (45%). Therefore, except in the sensitivity analysis section, the expected growth in NOA is measured by the median consensus analyst forecast of the long-term earnings growth rate.

4. Empirical Results

4.1. Summary Statistics

Panel A of Table 2 lists summary statistics for key variables. The first five variables are the variables of the valuation model (equation 9). The expected growth in NOA, as proxied by the mean expected long term growth in earnings, is 17%. The mean expected change in deflated operating earnings is 2.4%. The mean expected return on NOA is 12%. Although the mean of the ratio of net financial assets to net operating assets is positive, the median is negative, indicating that financial liabilities are greater than financial assets for most firms in the sample. Panel A also provides descriptive statistics on market value of equity, the book to market ratio and the (forward) earnings to price ratio. The mean and median earnings to price ratio are around 0.06, indicating price to earnings ratio of 16.

Panel B of Table 2 provides Pearson and Spearman correlations between the independent variables of equation (9). None of the correlations exceed 0.50. Still, some of the correlations are high which is not unexpected in a levels valuation model such as the Feltham–Ohlson and Ohlson models. Nevertheless, these correlations are substantially smaller in comparison to other studies involving these models both because of the normalization and, more importantly, because two of the variables are in first-difference form. Furthermore, no evidence of multicollinearity was found in the regressions that follow based on the diagnostics suggested by Belsley et al. (1980), including conditioning and DFITS statistics.

4.2. Parameter Estimation – Panel Data Regression and Non-Parametric Estimation

Panel A of Table 3 presents the results of a random effects generalized least squares (GLS) regression of equation (9) adjusted for firm-wise heteroscedasticity. The Lagrange multiplier (LM) test statistic of 5,519 far exceeds the 95% critical value of 3.84 for a chi-squared with one degree of freedom, indicating that a single constant term is inappropriate for the data and that panel data techniques are required. A Hausmann test statistic of 7.43 is less than the 95% critical value of 9.49 for a chi-squared test with four degrees of freedom, suggesting that a random effects model is a better choice for analyzing the panel data over a fixed effects model.[13]

The restrictions imposed by the Ohlson model as derived in the Appendix A, namely, $\delta_4 = 0$ and $\delta_0 = 1 - \delta_3(R - 1)$, are strongly rejected by the data. More specifically, assuming constant cross sectional and intertemporal costs of capital (R)

Table 2. Summary statistics.

	Mean	SD	Q1	Median	Q3
Panel A: Distribution of key data[a]					
Market value normalized by net operating assets	3.143	5.030	0.804	1.561	3.184
Growth in NOA	0.170	0.074	0.120	0.153	0.207
Change in operating earnings normalized by NOA	0.024	0.086	−0.012	0.006	0.030
Return on NOA	0.124	0.158	0.069	0.100	0.149
Net financial assets normalized by NOA (leverage)	0.011	0.969	−0.890	−0.260	0.117
(Forward) Earnings to price ratio	0.062	0.050	0.034	0.057	0.081
Book to market ratio	0.633	0.655	0.303	0.483	0.738
Market value ($000)	1,876	5,831	139	405	1,264

	fa_t/oa_t	$E_t[\Delta ox_{t+1}]/oa_t$	$E_t[ox_{t+1}]/oa_t$	$E_t[\Delta oa_{t+1}]/oa_t$
Panel B: Pearson/Spearman correlation coefficients[b]				
fa_t/oa_t	1.00	0.31 (0.00)	0.13 (0.00)	0.36 (0.00)
$E_t[\Delta ox_{t+1}]/oa_t$	0.46 (0.00)	1.00	0.19 (0.00)	0.05 (0.00)
$E_t[ox_{t+1}]/oa_t$	0.24 (0.00)	0.20 (0.00)	1.00	0.19 (0.00)
$E_t[\Delta oa_{t+1}]/oa_t$	0.29 (0.00)	0.16 (0.00)	0.07 (0.00)	1.00

[a]Panel A shows a partial distribution of the variables of equation (9).

1. SD = standard deviation.

2. Qj = Quartile j.

3. Growth in net operating asset is the median analyst forecast of the long-term earnings growth rate.

4. Change in operating earnings is the median analyst forecast of next period earnings minus actual earnings as reported on IBES.

5. Return on operating earnings is the median analyst forecast of next period earnings minus net financial income normalized by net operating assets.

6. (Forward) Earnings to price ratio is the 1-year-ahead earnings forecast as reported on IBES deflated by market value of equity.

[b]Panel B shows Pearson and Spearman correlations among the independent variables of equation (9) and their respective p-values in parentheses. Pearson (Spearman) correlations are above (below) the diagonal.

1. oa_t = NOA at time t.

2. fa_t = net financial assets at time.

3. ox_t = Operating Earnings in period t.

4. fa_t/oa_t = leverage variable.

5. $E_t[\Delta ox_{t+1}]/oa_t$ = expected change in operating earnings deflated by NOA.

6. $E_t[ox_{t+1}]/oa_t$ = expected return on net operating assets.

7. $E_t[\Delta oa_{t+1}]/oa_t$ = expected growth in NOA.

ranging from 6 to 12% as well as Fama–French time-varying firm-level costs of capital estimates, the restrictions imposed by the Ohlson model are rejected in favor of the unrestricted Feltham–Ohlson model using standard F tests or Wald test, respectively, at less than the 1% significance level.[14]

If the Feltham–Ohlson model has empirical content then the parameters should satisfy the conditions $\delta_0 \geq 0, \delta_1 = 1, \delta_2 \geq 0, \delta_3 > 0, \delta_4 > 0$ as prescribed by the model.[15] Except for the δ_1 parameter (and the intercept perhaps), the results of Panel A of Table 3 are consistent with the theory. Specifically, on the basis of standard *t*-tests, the parameters δ_2, δ_3 and δ_4 are positive and highly significant. The intercept term is negative contrary to expectations but only marginally significant. More problematic is the highly significant δ_1 parameter value of 3, which is significantly different from the predicted value of 1 for any reasonable significance level.

In addition to the (parametric) regression, we also estimate the parameters of equation (9) non-parametrically, lest the data are inconsistent with the standard normality assumption. Sets of five observations are drawn from the sample (with replacement) and the five $\delta_i (i = 0, ..., 4)$ parameters are computed for each set. Panel B of Table 3 lists a partial distribution of the parameters based on one million draws.

Table 3. Coefficient estimates of valuation equation (9).

Parameters	Predicted Sign or Value	Coefficient Estimates	*t*- or χ^2-Values	*p*-Values (One Tailed)
Panel A: Coefficient estimates from a random effects GLS regression adjusted for heteroscedasticity[a]				
δ_0	≥ 0	−0.172	−1.755	0.079
δ_1	1	3.005	86.50	0.000
δ_2	≥ 0	4.287	12.96	0.000
δ_3	> 0	7.800	43.92	0.000
δ_4	> 0	11.981	26.09	0.000
LM-$\chi^2(1)$	–	–	5,519	0.000
Hausman-χ^2 (4)	–	–	7.43	0.115

Parameters	Mean	25%	Median	75%
Panel B: Coefficient estimates from non-parametric estimation[b]				
δ_0	0.330	−2.825	0.673	4.149
δ_1	2.946	−0.206	2.325	5.773
δ_2	5.803	−27.244	0.424	28.496
δ_3	14.741	−7.430	9.645	27.973
δ_4	5.978	−11.133	3.101	21.536

[a] Panel A shows coefficient estimates from a random effects GLS regression adjusted for heteroscedasticity of equation (9):

$$P_t/oa_t = \delta_0 + \delta_1 fa_t/oa_t + \delta_2 E_t[\Delta ox_{t+1}]/oa_t + \delta_3 E_t[ox_{t+1}]/oa_t + \delta_4 E_t[\Delta oa_{t+1}]/oa_t + \varepsilon_t.$$

1. fa_t /oa_t = leverage variable.
2. $E_t[\Delta ox_{t+1}]/oa_t$ = expected change in operating earnings deflated by NOA.
3. $E_t[ox_{t+1}]/oa_t$ = expected return on net operating assets.
4. $E_t[\Delta oa_{t+1}]/oa_t$ = expected growth in net operating assets.
5. LM = Lagrange Multiplier Test statistic distributed approximately $\chi^2(1)$.
6. Hausman = Hausman Test Statistic distributed approximately $\chi^2(4)$.

[b] Panel B of Table 3 shows a partial distribution of the parameter estimates of equation (9) based on a non-parametric approach. One million sets of five observations are drawn from the sample (with replacement) and the five $\delta_i (i = 0, \ldots, 4)$ parameters are computed for each set.

With the exception of the intercept, the signs of the mean and median parameter estimates are similar to those of Panel A. In contrast to the sign of the parametric estimate, the sign of the intercept from the non-parametric estimation is consistent with the model. Therefore, in terms of their signs, the non-parametric parameter estimates are fully consistent with the Feltham–Ohlson model. The values of the non-parametric parameter estimates are somewhat different from those of the parametric estimates. Nevertheless, like its parametric counterpart, the mean and median non-parametric estimates of the leverage coefficient (δ_1) are close to 3 instead of 1.

Liu and Ohlson (2000) derive the δ_i parameters of equation (9) from linear transformations of the original parameters (ω_{ij}'s and γ_i's) of the Feltham–Ohlson model. In applying these transformations, they derive alternative parameters (θ_i's and κ_i's). If the Feltham–Ohlson model has empirical content, the estimated $\theta_i, \kappa_i, \gamma_i$ and ω_{ij} parameters should have signs and values consistent with the model. Using the δ_i estimates from Table 3 and a cost of capital of 12%, we reverse engineer the Feltham–Ohlson model to derive the θ_i, κ_i, γ_i and ω_{ij} parameters, recognizing that several of the original ω_{ij} parameters and γ_2 cannot be (uniquely) identified.[16] Using the parametric estimates from Table 3, Table 4 shows the theoretical relationships among the various parameters, the estimated signs of the parameters and Wald tests of significance of the parameters. The table shows that the signs of all of the θ_i and κ_i parameter estimates are consistent with the model predictions.

Table 4 also provides the parameter estimates (derived from this reverse engineering process) for two of the original Feltham–Ohlson parameters, namely, ω_{11} and γ_1. The other parameter estimates could not be identified and even the two latter parameters could only be identified up to a quadratic.[17] Because of the quadratic

Table 4. Parameter estimates from the Liu–Ohlson transformations [a].

Parameters (Liu–Ohlson)	Predicted Sign	Coefficient Estimate	Wald Statistic
$\theta_1 = -\delta_2(R-1)$	≤0	−0.514	−12.962
$\theta_2 = (\delta_3 + \delta_2)(R-1)$	>0	1.450	34.083
$\theta_3 = \delta_0 - \delta_4 - 1$	<0	−13.153	−24.292
$\theta_4 = \delta_4$	>0	11.981	26.088
Parameters (Liu–Ohlson)	Predicted Sign	Coefficient Estimate	Wald Statistic
$\kappa_1 = -\delta_2$	≤0	−4.287	−12.962
$\kappa_2 = \delta_3 + \delta_2$	>0	12.087	34.083
$\kappa_3 = \delta_0 - \delta_4 - 1 + \delta_3(R-1)$	<0	−12.217	−22.494
$\kappa_4 = \delta_4$	>0	11.981	26.088
Parameters (Feltham–Ohlson)	Predicted Value	Coefficient Estimate	Wald Statistic
ω_{11}-Estimate 1	$0 \leq \omega_{11} < 1$	1.056	223.801
ω_{11}-Estimate 2	$0 \leq \omega_{11} < 1$	0.336	20.004
γ_1-Estimate 1	$0 \leq \gamma_1 \leq 1$	−0.330	−4.979
γ_1-Estimate 2	$0 \leq \gamma_1 \leq 1$	1.002	385.725

[a]Shows the (parametric) estimates and the associated Wald test statistics of the Liu–Ohlson parameters (θ_i and κ_i) and the original Feltham–Ohlson parameters (γ_i and ω_{ij}) that are identified. The Wald statistic tests if the parameters (θ_i, κ_i, γ_i and ω_{ij}) are significantly different from zero. All Wald statistics in this table are uniformly significantly different from zero at less than the 1% (two-tailed) significance level.

relationship, each of the estimates of ω_{11} and γ_1 are a pair and are not independent of each other. Estimate 1 is inconsistent with Feltham–Ohlson because the γ_1 estimate is negative and the ω_{11} estimate is significantly greater than 1. Estimate 2 is somewhat consistent with model. The ω_{11} ($=0.336$) lies between 0 and 1 as predicted. However, the γ_1 ($=1.002$) estimate is statistically greater than 1 contrary to the model. Nevertheless, the value of 1.002 is unlikely to be economically greater than 1.

4.3. Reverse Regression Approach

To mitigate measurement error in the expected growth rate in net operating assets, the following reverse regression of the valuation equation (9) is estimated:

$$E_t[\Delta oa_{t+1}]/oa_t = \rho_0 + \rho_1 fa_t/oa_t + \rho_2 E_t[\Delta ox_{t+1}]/oa_t + \rho_3 E_t[ox_{t+1}]/oa_t + \rho_4 P_t/oa_t + \eta_t \tag{10}$$

where η_t is a white noise innovation term, $\rho_0 = -\delta_0/\delta_4$, $\rho_1 = -\delta_1/\delta_4 = -1/\delta_4$, $\rho_2 = -\delta_2/\delta_4, \rho_3 = -\delta_3/\delta_4$, and $\rho_4 = 1/\delta_4$. Panel A of Table 5 presents the results of a fixed effects GLS reverse regression of equation (10) adjusted for firm-wise heteroscedasticity. The LM test statistic of 10,767 far exceeds the 95% critical value of 3.84 for a chi-squared with one degree of freedom, strongly indicating that a single constant term is inappropriate for the data. A Hausman test statistic of 249 is much larger than the 95% critical value of 9.49 for a chi-squared test with four degrees of freedom, suggesting that a fixed effects model is a better choice for analyzing the panel data over a random effects model.[18] If the Feltham-Ohlson model has empirical content then the parameters should satisfy the conditions $\rho_0 \leq 0$, $\rho_1<0$, $\rho_2 \leq 0, \rho_3<0, \rho_4 > 0$ and $\rho_1 = -\rho_4$. Overall, the results of the reverse regression are not consistent with Feltham-Ohlson model. Two of the parameter estimates have the wrong sign (ρ_0 and ρ_3) and a t-test rejects the equality of ρ_1 and $-\rho_4$.

Since the coefficient estimate of the leverage variable in equation (9) did not take on the theoretically correct value, we also estimate a reverse regression with leverage as the dependent variable, namely,

$$fa_t/oa_t = \pi_0 + \pi_1 P_t/oa_t + \pi_2 E_t[\Delta ox_{t+1}]/oa_t + \pi_3 E_t[ox_{t+1}]/oa_t + \pi_4 E_t[\Delta oa_{t+1}]/oa_t + \eta_t \tag{11}$$

where η_t is a white noise innovation term, $\pi_0 = -\delta_0, \pi_1 = 1, \pi_2 = -\delta_2, \pi_3 = -\delta_3$, and $\pi_4 = -\delta_4$. Panel B of Table 5 presents the results of a fixed effect GLS reverse regression of equation (11) adjusted for firm-wise heteroscedasticity. If the Feltham–Ohlson model has empirical content then the parameters should satisfy the conditions $\pi_0 \leq 0, \pi_1 = 1, \pi_2 \leq 0, \pi_3 < 0, \pi_4 < 0$. Overall, the results of this reverse regression are also not consistent with Feltham–Ohlson model. The parameter estimate for the deflated change in operating earnings (π_2) has the wrong sign and the value of the market value coefficient is significantly different from 1.

Table 5. Reverse regressions[a].

$E_t[\Delta oa_{t+1}]/oa_t = \rho_0 + \rho_1 fa_t/oa_t + \rho_2 E_t[\Delta ox_{t+1}]/oa_t + \rho_3 E_t[ox_{t+1}]/oa_t + \rho_4 P_t/oa_t + \eta_t$				
Parameters	Predicted Sign	Coefficient Estimates	t- or χ^2-Values	p-values (one tailed)
Panel A: Coefficient estimates of valuation equation (10):				
ρ_0	≤ 0	0.164	117.320	0.000
ρ_1	< 0	−0.002	−3.174	0.002
ρ_2	≤ 0	−0.054	−9.283	0.000
ρ_3	< 0	0.014	4.183	0.000
ρ_4	> 0	0.004	24.59	0.000
LM-$\chi^2(1)$	–	–	10,767	0.000
Hausman-$\chi^2(4)$	–	–	249	0.000

$fa_t/oa_t = \pi_0 + \pi_1 P_t/oa_t + \pi_2 E_t[\Delta ox_{t+1}]/oa_t + \pi_3 E_t[ox_{t+1}]/oa_t + \pi_4 E_t[\Delta oa_{t+1}]/oa_t + \eta_t$				
Parameters	Predicted Sign or Value	Coefficient Estimates	t- or χ^2-Values	p-Values (One Tailed)
Panel B: Coefficient estimates of valuation equation (11):				
π_0	≤ 0	−0.286	−14.597	0.000
π_1	1	0.121	88.036	0.002
π_2	≤ 0	1.877	29.615	0.000
π_3	< 0	−0.451	−12.091	0.000
π_4	< 0	−0.227	−2.424	0.015
LM$\sim \chi^2(1)$	–	–	4,243	0.000
Hausman$\sim \chi^2(4)$	–	–	185	0.000

[a]Shows coefficient estimates from fixed effects GLS reverse regressions adjusted for heteroscedasticity of equations (10) and (11).

1. fa_t/oa_t = leverage variable.

2. $E_t[\Delta ox_{t+1}]/oa_t$ = expected change in operating earnings deflated by NOA.

3. $E_t[ox_{t+1}]/oa_t$ = expected return on NOA.

4. $E_t[\Delta oa_{t+1}]/oa_t$ = expected growth in NOA.

4.4. Forecasting Approach

Using an alternative testing procedure, we also investigate the relative power of the Feltham–Ohlson valuation model (equation 9) to predict 1-year-ahead equity values by comparison to the Ohlson model and a naive valuation model. If the Feltham–Ohlson has empirical content, it should provide more accurate 1-year-ahead equity value predictions by comparison to alternative models. Because of potential coefficient instability, we estimate the coefficients for the Feltham–Ohlson and Ohlson models using from 1 to 10 years of data.

The Feltham–Ohlson predictions are obtained as follows. First, the model is estimated cross-sectionally on an annual basis for each of the years 1991 to 2000. The regression for each year is then applied to next year's firm-level data to obtain 10 years of one year-ahead firm-level market value forecasts. For example, the regression coefficients estimated from the 1991 cross-section are used together with 1992 values of the independent variables to predict firm-level market values for

1992. These predicted market values (based upon 1 year's cross-section) are compared to actual market values. Three error metrics are computed for each year's predictions: average percentage prediction errors, absolute percentage prediction errors, and squared percentage prediction errors.[19] Similarly, the regression coefficients from the 1992 cross-section together with 1993 values for the independent variables are used to estimate 1993 market values and so on for all years 1992 to 2001, 10 years in total.

In a similar fashion, the Feltham–Ohlson model is estimated cross-sectionally using 2 years of pooled data from the years 1991 to 2000. The coefficients from each regression are then applied to next year's firm-level data to obtain 9 years of one-year-ahead market value forecasts. For example, the regression coefficients estimated from the 1991 and 1992 cross-sections are used to predict firm-level market values for 1993. Again, the three prediction error metrics are computed using these 2 years of pooled data. Firm-level predictions using 2 years of pooled data are obtained for 1993 to 2001. This procedure is further continued using 3 years of pooled data and so on until all the data from 1991 to 2000 are pooled to predict 2001 firm-level market values. Panel A of Table 6 lists the median prediction error metrics for the 1-year-ahead predictions based on 1, 2, and up to 10 years of pooled data, respectively.

A similar prediction approach is employed to forecast firm values based on the Ohlson valuation model. The median prediction error metrics for the Ohlson model are listed in Panel B of Table 6.

Table 6. Median prediction error metrics of the Feltham–Ohlson, Ohlson and Naïve valuation models[a].

	1	2	3	4	5	6	7	8	9	10
Panel A: Feltham–Ohlson model										
Average percentage prediction error	−0.14	−0.15	−0.15	−0.16	−0.18	−0.19	−0.21	−0.17	−0.14	−0.09
Absolute percentage prediction error	0.53	0.54	0.54	0.54	0.55	0.56	0.58	0.56	0.51	0.45
Squared percentage prediction error	0.28	0.29	0.29	0.29	0.30	0.31	0.34	0.32	0.26	0.21
	1	2	3	4	5	6	7	8	9	10
Panel B: Ohlson model										
Average percentage prediction error	−0.25	−0.25	−0.25	−0.26	−0.29	−0.34	−0.31	−0.34	−0.39	−0.25
Absolute percentage prediction error	0.48	0.47	0.48	0.49	0.51	0.56	0.54	0.51	0.49	0.48
Squared percentage prediction error	0.23	0.23	0.23	0.24	0.26	0.31	0.29	0.26	0.24	0.23

	FF	6%	8%	10%	12%
Panel C: Naive valuation model					
Average percentage prediction error	0.46	0.06	0.30	0.44	0.46
Absolute percentage prediction error	0.48	0.40	0.39	0.46	0.47
Squared percentage prediction error	0.23	0.16	0.15	0.21	0.23

[a]Shows average, absolute and squared percentage 1-year-ahead prediction error metrics averaged over the sample firms for each of the Feltham–Ohlson, Ohlson and naïve valuation models. The numbers (1,...,10) refer to the number of years of pooled data used to estimate the model. The naïve valuation model capitalizes next period's forecasted earnings by the current period cost of capital estimate. In addition, to time-varying Fama–French (FF) firm-level cost of capital estimates, the table also shows prediction errors for constant costs of capital ranging from 6 to 12%.

The naive valuation model capitalizes next period's expected annual earnings by the (current year) firm's cost of capital. For example, the 1996 estimated market value is computed by taking the consensus analysts forecast of 1997 net income and dividing by the 1996 cost of capital. In addition to the Fama–French (time-varying) firm-level cost of capital estimates, we also use time and firm invariant constant costs of capital from 6 to 12% inclusive. The median prediction error metrics for the naive valuation model for each cost of capital approach are listed in Panel C of Table 6.

The median average percentage prediction error metric in Table 6 indicates that the Feltham–Ohlson and Ohlson models tend to under-predict and the naive valuation model over-predicts. The Ohlson model marginally dominate the Feltham–Ohlson model on the basis of the absolute percentage and squared percentage prediction error metrics, except when all 10 years of data are pooled in which case the Feltham–Ohlson model marginally dominates the Ohlson model. The naive valuation model dominates both the Feltham–Ohlson and Ohlson models for constant costs of capital of 6 and 8%. For the other costs of capital estimates, including the Fama–French estimates, the naïve valuation model and Ohlson model are similar. Although the Feltham–Ohlson model yields smaller average percentage prediction errors than the other models, this metric allows positive and negative errors to cancel, inconsistent with an OLS regression methodology.[20] Overall, the Feltham–Ohlson model does not appear to show better predictive ability than Ohlson and naive valuation models despite its theoretical sophistication in incorporating conservative accounting.

5. Further Sensitivity Analysis

This section reports the results of further sensitivity analysis, undertaken to ensure that the results obtained in the prior section are robust to various regression approaches and variable proxies.

5.1. Portfolio Analyses

Random measurement errors in individual securities tend to cancel each other out in portfolios. To mitigate measurement error, we estimate the model (equation 9) by forming portfolios based alternatively on leverage and on the expected growth in net operating assets. Leverage portfolios are formed by ranking securities by their leverage and dividing the data into percentile portfolios. Each security in the percentile is assumed to have equal weight in the portfolio. The OLS regression of equation (9) is then estimated based on the mean portfolio values. The results (not tabulated) for the leverage portfolio are very similar to those of Table 3 except that that R^2 is much larger, as expected. Again, the leverage variable takes on a value close to 3, and significantly greater than 1. The portfolios based on ranking by the expected growth in NOA (not tabulated) yield results even less consistent with

Feltham–Ohlson. Not only is the leverage value significantly greater than 1 but the deflated change in earnings variable also takes a negative sign.

5.2. *Leverage Analysis*

The leverage value of 3 may be due to corporate tax effects. Firms with extensive debt may benefit from tax shields and, consequently, have larger market values. To account for this, we decompose the leverage variable into separate debt and "other" net financial assets. Debt is computed as the sum of long-term debt, debt in current liabilities, and notes payable. Estimating the model using a random effects GLS regression yields similar results to those reported in Panel A of Table 3 (not tabulated). Specifically, the coefficients of both the debt and other net financial assets are close to 3 and significantly different from 1. In a separate analysis, we perform a reverse regression where the growth in net operating assets is the dependent variable. The coefficient estimates of the explanatory variables other than leverage are almost identical to those of Panel A of Table 5. The coefficient estimate for the "other" net financial assets is similar to the leverage coefficient in Panel A of Table 5. The coefficient on the debt variable is of the wrong sign, being significant and positive. Overall, these results indicate that tax shield effects are not at issue.

We also perform a similar analysis with leverage (net financial assets) separated into positive and negative leverage observations. The aggregate leverage coefficient estimate may be biased if firms with different capital structures have different asset structures. The results (not tabulated) are again quite similar to Panel A of Table 5. The coefficient on positive leverage is approximately 3 whereas the coefficient on negative leverage is approximately 2. Both coefficients are significantly greater than 1.

The leverage coefficient may be an increasing function of the firm's past track record. More profitable firms are better able to access debt financing. To test this conjecture, we compute the geometric annual 5 year equity return for firms that have price data for 1990 and 1995. These firms are then ranked by deciles based on the 5 year return. We repeat this procedure for firms that have price data for 1991 and 1996 and so on ending with firms that have price data for 1996 and 2001. The seven sets of rankings are then stacked. Separate regressions are estimated for each decile ranking using panel data random effects. The results (not tabulated) are weakly consistent with the past track record conjecture. Specifically, the leverage coefficient estimate is not significantly different from 1 for firms in the lowest 5 year return decile and it is the highest (over 6) for firms in the highest 5 year return decile.[21]

5.3. *Proxies for the Expected Growth Rate in NOA*

Undoubtedly, the most crucial variable in the Feltham–Ohlson model is the expected growth rate in NOA. This variable essentially distinguishes Feltham–Ohlson from Ohlson because it captures the relationship between conservative accounting and firm value. Also, the Liu–Ohlson suggested proxy for the expected growth rate in

NOA, namely analysts' long-term earnings growth rate forecast, presupposes that each firm's expected operating profitability and leverage are fairly constant over time. This assumption is likely to be violated for at least some sample firms. Therefore, we investigate the sensitivity of our results to this proxy for expected growth in net operating assets by trying five alternative measures. The results are shown in Table 7. All coefficient estimates are based on random effects GLS regressions of equation (9) adjusted for firm-wise heteroscedasticity. Fixed effects regressions (not tabulated) yield qualitatively similar results.

The first alternative proxy for expected growth in net operating assets is the growth rate implicit in 1-year-ahead consensus analyst's earnings forecasts, that is $\{(E_t[x_{t+1}] - x_t)/x_t\}$, where x_t is actual earnings (as reported by IBES) and $E_t[x_{t+1}]$ denotes analyst earnings expectations. The second alternative proxy is the geometric growth rate implicit in the furthest available consensus analyst's earnings forecast. For example, if the furthest available forecast is the 3 year-ahead forecast; then growth is computed as $\{E_t[x_{t+3}]/x_t\}^{1/3}$. The third alternative proxy is the ex post geometric growth rate in NOA based on the earliest available data. Suppose that the earliest available NOA is at the end of year $t-5$ and we are trying to predict the expected growth rate for year $t+1$ at the end of year t. The expected growth rate for year $t+1$ is $[\mathrm{NOA}_t/\mathrm{NOA}_{t-5}]^{1/5}$.

The next two alternative proxies for the expected growth rate in NOA are based on a time series of past growth rates in NOA. More specifically, assume that

$$E_t[\Delta oa_{t+1}]/oa_t = \phi_0 + \phi_1[\Delta oa_t]/oa_{t-1} + \phi_2[\Delta oa_{t-1}]/oa_{t-2} + \cdots + \phi_n[\Delta oa_{t-n}]/oa_{t-n-1} \tag{12}$$

Table 7. Sensitivity analysis of equation (9)[a].

	δ_0	δ_1	δ_2	δ_3	δ_4
1. $E_t[\Delta oa_{t+1}]/oa_t$ = Earnings growth based	−0.04	3.09	4.15	7.43	11.5
on analyst 1-year-ahead earnings forecast	(−0.39)	(87.2)	(12.2)	(41.6)	(29.5)
2. $E_t[\Delta oa_{t+1}]/oa_t$ = Earnings Growth based	−0.03	3.10	4.22	7.37	11.6
on analyst furthest-ahead earnings forecast	(−0.36)	(87.4)	(12.4)	(41.3)	(29.5)
3. $E_t[\Delta oa_{t+1}]/oa_t$ = Ex post geometric growth	0.10	3.08	4.05	7.56	10.6
in NOA for all available data	(1.15)	(85.3)	(12.0)	(41.5)	(27.0)
4. $E_t[\Delta oa_{t+1}]/oa_t$ = Current year	0.18	3.17	4.49	7.19	10.3[b]
ex post growth in NOA	(2.01)	(86.6)	(13.1)	(39.8)	(26.3)
5. $E_t[\Delta oa_{t+1}]/oa_t$ = Perfect foresight	0.21	3.14	3.94	7.87	9.77
1-year-ahead growth in NOA	(2.31)	(88.3)	(12.0)	(44.0)	(25.2)
6. All assets are assumed to be operating	1.03	7.44	13.7	11.8	17.7
	(6.38)	(28.8)	(14.0)	(16.9)	(27.7)
7. Forcing the leverage coefficient to be one	−1.15	1.00	11.9	9.31	15.9
	(10.5)		(34.9)	(47.2)	(31.0)

[a]Shows coefficient estimates (t-values in parentheses) from random effects GLS regressions adjusted for heteroscedasticity of equation (9):

$P_t/oa_t = \delta_0 + \delta_1 fa_t/oa_t + \delta_2 E_t[\Delta ox_{t+1}]/oa_t + \delta_3 E_t[ox_{t+1}]/oa_t + \delta_4 E_t[\Delta oa_{t+1}]/oa_t + \varepsilon_t$ for various proxies of the expected growth in NOA.

[b]Note that this coefficient is equal to $\delta_4\ \phi_1$.

Substituting equation (12) into equation (9), yields the valuation equation to be estimated:

$$P_t/oa_t = \delta_0 + \delta_1 fa_t/oa_t + \delta_2 E_t[\Delta ox_{t+1}]/oa_t + \delta_3 E_t[ox_{t+1}]/oa_t + v_1[\Delta oa_t]/oa_{t-1} + v_2[\Delta oa_{t-1}]/oa_{t-2} + \cdots + v_n[\Delta oa_{t-n}]/oa_{t-n-1} \quad (13)$$

where $v_k = \delta_4 \phi_k, k = 1, .., n$. One proxy assumes a one lag structure ($k = 1$) for past growth rates in net operating assets whereas the other proxy assumes a two lag structure ($k = 2$) for growth rates in NOA. Since the second lag proved to be insignificant, Table 7 describes the results for the one lag structure model only as the fourth alternative proxy.

The fifth alternative measure is based on a perfect foresight model in which actual future growth rates in NOA are assumed to proxy for expected growth rates in net operating assets. Specifically, where the data are available, we use the firm's next period's growth rate in NOA to proxy for last period's expected growth rate. Otherwise, the geometric growth rate relating current NOA to the closest available future period NOA is used to proxy for next period's growth rate.

As can be seen in rows 1 to 5 of Table 7, the estimated coefficients for all regression variables, except perhaps the constant term, are similar to each other irrespective of the specific proxy for the expected growth rate in net operating assets. Also, these estimates are similar to the results of (Panel A) Table 3. In particular, for all proxies, the estimated leverage coefficient δ_1 is approximately 3 and significantly different from the theoretical value of 1.

The analysis in the previous section assumed that it was meaningful theoretically to distinguish between operating and financial assets and that such a distinction could be made empirically. However, this distinction may be arbitrary and all assets may be operating. For example, when non-financial firms hold assets in marketable securities, it may be for operational reasons such as to have liquid resources available to purchase inventory and for future investment in PP&E. Row 6 of Table 7 shows the coefficient estimates of equation (9) based on the assumption that all assets are operating. The results are similar to those of Panel A Table 3 in terms of the signs of the coefficient estimates, although the magnitudes of the coefficient estimates are much larger. In particular, the coefficient for financial leverage is more than 7 and significantly different from 1.

We also re-estimated valuation equation (9) after subtracting the leverage variable from market values. This is equivalent to assuming that the leverage variable has a coefficient of 1 as dictated by the theory. Except for the constant term, the coefficient estimates shown in row 7 of Table 7 are of the same sign but larger than the coefficients of Panel A of Table 3. Nevertheless, the overall results are not consistent with the Feltham–Ohlson model because the constant term is highly significant but with the wrong sign.

Finally, we estimated the model (equation 9) by year, by industry (2-digit SIC) and by year and industry. The results (not tabulated) are very similar to those reported previously. Specifically, the leverage coefficient is around 3 and all other coefficients are positive and significant, except that when the model is estimated by year and industry the mean coefficient on the (deflated) change in earnings variable is negative.

6. Conclusion

The purpose of the study is to investigate the empirical content of the Feltham and Ohlson (1995) model following the suggestions of Liu and Ohlson (2000). The empirical results of this study are decidedly mixed. On the one hand, the nested Ohlson model is rejected in favor of the Feltham–Ohlson, indicating the importance of conservatism in accounting valuation. Also, the signs of the estimated valuation regression coefficients (δ_k) conform to the theoretical predictions of the Feltham–Ohlson model for almost all empirical variations of the model, including panel data techniques, non-parametric estimation, reverse regressions and portfolio regressions. On the other hand, the estimated leverage coefficient – for which the model predicts a value of one – takes a value of three for all empirical variations of the model. In addition, the 1-year-ahead equity price predictions of the Feltham–Ohlson model are often no more accurate than the predictions of the Ohlson model or a naive valuation model.

There are a number of possible explanations for these results. One possibility is that we lack adequate empirical proxies for the expectational variables in the model. Although this is possible, it is also implausible since the sensitivity analysis in this study is comprehensive and the qualitative results for different estimation methods and proxies are quite similar. Another possibility is that multicollinearity is distorting the test results. This is also unlikely because multicollinearity should not affect the overall predictive ability of the model. In addition, the δ_k coefficients, and especially δ_1, are quite stable across different empirical proxies. Yet, it is precisely the estimated value of this latter coefficient that is not consistent with the model. Finally, although the Feltham–Ohlson model incorporates conservative accounting, nevertheless, the model abstracts from many fundamental issues likely to affect security prices such as bankruptcy costs, taxes and signaling to name only a few.[22] The empirical evidence in this study suggests that any model that fails to account for these frictions is unlikely to perform well in explaining security prices.

Appendix A. The Ohlson (1995) Valuation Equation and Liu and Ohlson (2000)

The Ohlson (1995) model obtains from Feltham and Ohlson (1995) by setting $\alpha_2 = \beta_2 = \omega_{12} = 0$. Substituting these values into equation (2) of Liu and Ohlson (2000) yields the parameter values:

$$\mathrm{k}_1 = \alpha_1 - \beta_1\omega_{11}$$

$$\mathrm{k}_2 = \beta_1$$

$$k_3 = 0$$

$$k_4 = 0$$

This implies in turn that the parameters of equation (4) of Liu and Ohlson (2000) take on the values:

$$\theta_1 = (R - 1)k_1$$

$$\theta_2 = (R - 1)k_2$$

$$\theta_3 = -(k_1 + k_2)(R - 1)$$

$$\theta_4 = 0.$$

Thus, the δ_i parameters in equation (9) of this paper take on the values:

$$\delta_0 = 1 + \theta_3$$

$$\delta_1 = 1$$

$$\delta_2 = -\theta_1/(R - 1)$$

$$\delta_3 = [\theta_1 + \theta_2]/(R - 1)$$

$$\delta_4 = 0.$$

Noting that $\theta_3 = -[\theta_1 + \theta_2]$ and substituting δ_3 into δ_0, yields $\delta_0 = 1 - \delta_3(R - 1)$.

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Notes

1. The "other information" variables in the Feltham–Ohlson model represent potential omitted correlated information variables that are valuation relevant.
2. Following Ohlson's suggestion, Dechow et al. (1999) use a similar transformation in their tests of Ohlson (1995). However, their forecasting and regression approaches are different from those suggested by Liu and Ohlson (2000) and used in this study. Ohlson (2001) also applies this transformation to the linear dynamics of the Ohlson (1995) model.
3. Fundamentally, the Feltham–Ohlson model differs from the Ohlson model by the inclusion of the expected growth of the firm's operating assets in the valuation equation, in addition to abnormal earnings and book values.

4. In fact, Ohlson argues that without the dynamic the model is devoid of accounting content. Be as it may, the purpose of this study is to test Feltham–Ohlson (1995), and not an alternative model.
5. See Begely and Feltham (2002, p. 11) where they assume that the coefficients on net financial assets and NOA are 1 each.
6. Equations (6) and (7) follow from taking expectations of the first two equations in the information dynamic.
7. Deflation by operating assets yields a natural constant term in the regression, namely $\delta_0 = \lambda_3$. No constant term in the model arises when deflating by any other variable. Of course, one can add an arbitrary constant term to the model but that is not what the model prescribes. The alternative is to regress without a constant term but the constant term is useful because it helps to attenuate the problem of correlated omitted variables.
8. Essentially, splitting the firm's activities into operating and financing activities in the Feltham–Ohlson model derives from the model's need to maintain the M&M assumptions even when cash flows and dividends are not equal.
9. We address this issue in the sensitivity analysis section further below.
10. The next section discusses the measurement of these variables.
11. This approach maintains the consistency between the measure of actual operating earnings and the measure of analyst forecast of operating earnings. This effectively means that the growth rate in earnings is attributable to growth in operating earnings.
12. This definition of $E_t[\Delta ox_{t+1}]$ follows from the underlying theory. See Liu and Ohlson (2000, p. 327). We also measured $E_t[\Delta ox_{t+1}]$ as $E_t[ox_{t+1}] - ox_t$ with qualitatively similar results.
13. We also estimated equation (9) using a fixed effects model with no discernable impact on the results of this study. See Greene (2000, Ch. 14) for panel data models and the relevant test statistics.
14. The Ohlson model is also rejected in favor of the Feltham–Ohlson model in the regressions that follow.
15. The theoretical signs of the parameters presuppose conservative accounting.
16. Using other costs of capital from 6 to 10%, yielded qualitatively similar results.
17. Specifically, κ_1 and κ_2 are solely a function of ω_{11} and γ_1 and, hence, the estimates of κ_1 and κ_2 yield estimates of ω_{11} and γ_1. However, κ_3 and κ_4 are functions of ω_{12}, ω_{22} and γ_2 (in addition to ω_{11} and γ_1), so that ω_{12}, ω_{22} and γ_2 cannot be identified.
18. We also estimated equation (10) using a random effects model with no discernable impact on the results.
19. The average percentage prediction error $= (A_i - F_i)/A_i$; Absolute percentage prediction error$=$ $|(A_i - F_i)/A_i|$; and the Squared percentage prediction error $= [(A_i - F_i)/A_i]^2$, where A_i=actual value and F_i=forecast value.
20. OLS presupposes a quadratic (squared) loss function for which negative and positive errors do not cancel.
21. It is worth noting that although the leverage coefficient is not different from one in the first decile and is the highest in the tenth decile, we do not observe a monotonic relation between the leverage coefficient and the return deciles.
22. These factors are likely to generate a non-linear valuation function.

References

Abarbanell, J. S. and B. J. Bushee. (1997). "Fundamental Analysis, Future Earnings, and Stock Prices". *Journal of Accounting Research* 35, 1–24.

Ahmed, A. S., R. M. Morton and T. F. Schaefer. (2000). "Accounting Conservatism and the Valuation of Accounting Numbers: Evidence of the Feltham-Ohlson (1996) Model". *Journal of Accounting, Auditing and Finance* 15, 271–292.

Beaver, W. H. (1999). "Empirical Assessment of the Residual Income Valuation Model: Comment". *Journal of Accounting and Economics* 26, 35–42.

Begley, J. and G. A. Feltham. (2002). "The Relation between Market Values, Earnings Forecasts, and Reported Earnings". *Contemporary Accounting Research* 19, 1–48.

Belsley, D. A., E. Kuh and R. F. Welsch. (1980). *Regression Diagnostics*. New York: Wiley.

Callen, J. L. and M. Morel. (2001). "Linear Accounting Valuation When Abnormal Earnings Are AR(2)". *Review of Quantitative Finance and Accounting* 16, 191–203.

Dechow, P. M., A. P. Hutton and R. G. Sloan. (1999). "An Empirical Assessment of the Residual Income Valuation Model". *Journal of Accounting and Economics* 26, 1–34.

Fama, E. F. and K. R. French. (1997). "Costs Of Equity". *Journal of Financial Economics* 43, 153–193.

Feltham, G. A. and J. A. Ohlson. (1995). "Valuation and Clean Surplus Accounting for Operating and Financial Activities". *Contemporary Accounting Research* 11, 689–732.

Feltham, G. A. and J. A. Ohlson. (1996). "Uncertainty Resolution And The Theory Of Depreciation Measurement". *Journal of Accounting Research* 34, 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, 283–319.

Greene, W. (2000). *Econometric Analysis*, 4th edn. Prentice Hall.

Liu, J. and J. A. Ohlson. (2000). "The Feltham–Ohlson (1995) Model: Empirical Implications". *Journal of Accounting, Auditing and Finance* 15, 321–331.

Morel, M. (2003). "Endogenous Parameter Time Series Estimation of the Ohlson Model: Linear and Nonlinear Analyses". *Journal of Business Finance and Accounting* 30, 1341–1362.

Myers, J. N. (1999). "Implementing Residual Income Valuation with Linear Information Dynamics". *The Accounting Review* 74, 1–28.

Ohlson, J. A. (2001). "Earnings, Book Values, and Dividends in Security Valuation: An Empirical Perspective". *Contemporary Accounting Research* 18, 107–121.

Ohlson, J. A. (1995). "Earnings, Book Values, and Dividends in Security Valuation". *Contemporary Accounting Research* 11, 661–687.

Ohlson, J. A. (1999). "Discussion of an Analysis of Historical and Future-Oriented Information in Accounting-Based Security Valuation Models". *Contemporary Accounting Research* 16, 381–384.

Penman, S. H. (2000). *Financial Statement Analysis and Security Valuation*. New York: McGraw-Hill.

Shane, P. and P. Brous. (2001). "Investor and (Value Line) Analyst Underreaction to Information about Future Earnings: The Corrective Role of Non-Earnings-Surprise Information". *Journal of Accounting Research* 39, 387–404.

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.

Tse, S. Y. and R. A. Yaansah. (1999). "An Analysis of Historical and Future-Oriented Information in Accounting-Based Security Valuation Models". *Contemporary Accounting Research* 16, 347–380.