An Examination of Hypotheses Concerning Earnings Forecast Errors

Albert Eddy
Loyola College of Maryland

Bruce Seifert
Old Dominion University

Abstract

This paper examines Value Line's earnings prediction errors using a research design that incorporates the fact that forecast errors are likely to be time dependent. The results support the hypotheses that the prediction error is smaller the lower the financial leverage of the firm, the smaller the past variability of earnings, the larger the firm, and the more recent the forecast. In addition, the more favorable the expected price performance of the underlying stock as measured by Value Line's timeliness index, the smaller the prediction error.

Introduction

Earnings estimates are critical to finance and accounting. For example, they play a key role in valuation models. Many securities analysts spend considerable time estimating earnings. Investors pay close attention to earnings. There is ample evidence that when earnings announcements differ from what is expected, stock prices react significantly (Brown, 1978; Rendleman, Jones, and Latone, 1982; Watts, 1978).

This paper examines a number of hypotheses concerning earnings prediction errors. This research tests whether earnings forecast errors are associated with:

- The financial leverage of the firm;
- The previous variability of earnings;
- The size of the firm;
- How current is the forecast; and
- Value Line's timeliness index.

Because previous research has shown that prediction errors are likely to be time dependent, the current research design is structured to incorporate this fact.

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Hypotheses Development

The findings of a number of studies are helpful in the formation of hypotheses. Basi, Carey, and Twark (1977, p. 736), for example, hypothesize that forecasts of earnings should be more accurate when "(1) earnings are more stable, (2) firms are larger, older and less risky, (3) information is more detailed, and (4) time until target date is shorter." These authors also find support for the hypotheses that forecasts are more accurate for: utilities than for non-utilities; NYSE firms than for AMEX firms; companies than for analysts; later dates than earlier dates. Their results, however, have been challenged by Albrecht, Johnson, Lookabill, and Watson (1977).

O'Brien (1988) finds that the most current forecast is more accurate than either the mean or median of a group of forecasts. Crichfield, Dyckman, and Lakonishok (1978) also find that accuracy is improved as the reporting date approaches. These results suggest that timeliness is an important attribute of forecasts.

Daley, Senkow, and Vigeland (1988) hypothesize and find a positive correlation between the variance of analysts' forecasts (disagreement among analysts) and the size of the unexpected earnings. Their results indicate that uncertainty is associated with the forecast error.

Firm size appears related to the accuracy of the forecast. Bamber (1986), using a sample of 397 companies, shows that firm size is negatively correlated with the absolute value of unexpected earnings. Atiase (1980, 1985) argues that information production in order to identify mispriced securities is an increasing function of firm size. More information is generated for large firms which should lead to smaller errors in earnings.[1]

Prior research (Brown, Hagerman, Griffin, and Zmijewski, 1987a; Brown and Rozeff, 1978; Collins and Hopwood, 1980; and O'Brien, 1988) generally has shown that analysts' forecasts of earnings are more accurate than time series forecasts.[2] Numerous authors have examined why analysts' forecasts are generally better, and the results from these studies are useful in the development of the present hypotheses. Brown, Richardson, and Schwager (1987, p. 50), for example, model and test why analysts' forecasts should be superior to random walk time series forecasts. They argue that superior forecasts should be "positively related to the dimensionality of the analysts' information set and

[1]See also related papers by Bathke, Lorek, and Willinger (1989); Collins, Kothari, and Rayburn (1987); and Freeman (1988).

[2]Studies (Brown, Hagerman, Griffin, and Zmijewski, 1987b; Fried and Givoly, 1982; Givoly and Lakonishok, 1984) also have shown that excess stock returns are generally more highly correlated with errors of analysts' forecasts than with errors of time series forecasts. This result is consistent with the view that analysts' forecasts provide a better proxy for market earnings expectations than do time series forecasts.

negatively related to both the variance of information observations and the correlation among the information variables." The dimensionality of the analysts' information set is estimated by firm size, the variance of the information observations is estimated by the dispersion of analysts' forecasts, and the number of lines of business serves as a proxy for the correlation of the variables. The results concerning firm size and the dispersion of analysts' forecasts strongly agree with the predictions of their model.

Other studies have examined the advantage that analysts have relative to time series forecasts. Fried and Givoly (1982) argue that the advantage may be related to a larger information set used by analysts and also to the use of more timely information. Brown, Hagerman, Griffin, and Zmijewski (1987a) show that securities analysts' forecasts are superior to univariate time series models (have less error). They attribute this difference to a contemporaneous advantage (better use of existing information) and a timing advantage (more recent information). Kross, Ro, and Schroeder (1990) relate the analysts' advantage to firm characteristics. They find the advantage is associated with the variability in the earnings time series, the amount of coverage in the *Wall Street Journal Index*, and a timing advantage. They do not find, however, the advantage relates to either firm size or the number of lines of business of the firm.

Research by Brown, Hagerman, Griffin, and Zmijewski (1987a) and O'Brien (1988) also has shown that forecast errors from a sample of firms are time dependent. Unanticipated economic events, for example, may cause forecast errors to be correlated. Hypotheses concerning prediction errors should be examined in the context that these errors are probably not independent. Many studies, however, have not controlled explicitly for nonindependence. The current research design is structured to see if the size of the forecast errors is related to a particular time period and/or a set of hypothesized variables and whether there are interactive effects between the specific time periods and the set of hypothesized variables.

Four hypotheses motivated by the results of prior research concerning prediction errors are examined. The first is that the greater the financial leverage of a firm, the greater is the prediction error. Greater financial leverage should cause greater variability in earnings which should lead to larger prediction errors.

A second hypothesis is that past variability of earnings should be associated with the size of the prediction error. Assuming that past variability in earnings is an indicator of future variability, then firms that have exhibited little variability in the past should have, all things being equal, smaller prediction errors. A finding of a significant relationship between past variability of earnings and the prediction error would be consistent with the results of Kross, Ro, and Schroeder (1990).

The third main hypothesis is that the prediction error will be related inversely to the size of the firm. It is assumed that small firms generally have less information about them than large firms. With less available information, prediction errors on average will be larger for small firms than for large firms that are studied closely. Previous researchers generally have shown a significant relationship between firm size and prediction errors. The recent findings of Kross, Ro, and Schroeder (1990) question these results; there is a need to further examine this hypothesis.[3]

The fourth hypothesis concerns how current is the prediction. The closer a forecast is made to an earnings announcement, the larger and the more up-to-date is the information set, which implies that the prediction error will tend to be smaller than for a forecast made at an earlier date. If the results show that there is a significant association between the time horizon of the prediction and the forecast error, this would be consistent with the findings of previous research (Basi, Carey, and Twark, 1977; Collins and Hopwood, 1980; Kross, Ro, and Schroeder, 1990; McDonald, 1973).

In addition Value Line's timeliness ranking is examined. This measure represents the expected price performance of the underlying security over the next 12 months. It considers a number of earnings-related factors. The buy/sell recommendation implied in the timeliness ranking is followed closely by the investment community, and this recommendation has been the subject of academic research. Therefore, it would be interesting to see if there is any relation between prediction errors and Value Line's timeliness ranking.

Sample Selection

To examine the hypotheses above, a sample of firms and earnings announcements is obtained according to the following criteria. First, firms were listed on the Compustat primary, supplementary, tertiary, or research annual industrial files in 1986. The research files were included to avoid *ex post* sample selection bias that occurs when samples are restricted to successful firms. Utilities (industry codes between 4800 and 5000) and financial institutions (industry codes between 6000 and 7000) were excluded in order to make the sample more homogeneous. Second, firms were available on the CRSP daily stock master file. Third, firms had quarterly earnings predictions reported by Value Line for all or part of the period between 1983 and 1985. Fourth, quarterly

[3]It should be mentioned again that Kross, Ro, and Schroeder were trying to explain the advantage analysts have over time series models. Their research question is related to the current topic (explaining the size of analysts' prediction errors), but the two issues are not the same. A finding that firm size is related to the prediction error, therefore, is not necessarily inconsistent with their (Kross, Ro, and Schroeder) results.

earnings per share (e.p.s.) announcements were reported in the *Wall Street Journal Index* between 1983 and 1985. The four criteria resulted in an initial sample of 6,729 earnings announcements representing 776 different firms.[4]

The forecast earnings errors are generated by comparing the announced quarterly earnings to the predicted earnings from Value Line. When a firm announced its earnings, Value Line was searched to find the most up-to-date prediction just prior to the announcement of the earnings. The median difference between the prediction date and the announcement date of the earnings is 34 trading days.

Two definitions are employed for the prediction error. In the first definition, the earnings forecast error equals the predicted earnings from Value Line less the actual earnings announced in the *Wall Street Journal Index* divided by the absolute value of actual earnings. This is referred to as the percentage error. The second measure is the absolute value of the percentage error. Two different measures are used because in some cases it is useful to know whether the forecast over- or underestimated the earnings, while in other cases the size of the error is the focal point. The two definitions are summarized as follows:

$$\text{Percentage Error} = \frac{(\text{Predicted e.p.s. - Actual e.p.s.})}{|\text{Actual e.p.s.}|}$$

$$\text{Absolute Percentage Error} = \left|\frac{(\text{Predicted e.p.s. - Actual e.p.s.})}{\text{Actual e.p.s.}}\right|.$$

One of the problems using a percentage error forecast is that extremely large numbers can be generated if the denominator used in the measure is relatively small. These outliers can influence simple averages, and it is common practice to delete these observations. To minimize this problem and to minimize typing or transcription errors, all forecasts errors with absolute values exceeding 100 percent were eliminated. The final sample consists of 6,072 observations.[5]

Financial leverage is measured by the ratio of long-term debt plus debt in current liabilities to total assets. These book values are obtained from the Compustat database for 1983. Value Line's index of earnings predictability is used to measure previous variability in earnings. This variable is based on the standard deviation of percentage changes over a ten year period. Value Line ranks firms from 5 to 100 in intervals of 5 with the highest number representing the

[4]The *Wall Street Journal Index* usually did not publish an earnings per share figure during this period when firms suffered losses.

[5]The current conclusions, strictly speaking, apply only to this new sample.

most predictable earnings. Size is measured by the reported value of total assets in 1983. A measure of timeliness is obtained by determining the number of days between the prediction date and the announcement date.

Results

Table 1 presents descriptive statistics for the two definitions of the prediction error. The mean percentage error is -.010, and the mean absolute percentage error is .216. On average, actual announced earnings are a little more than 1 percent greater than predicted earnings.

Table 1 also presents the mean percentage errors for each quarter between 1983 and 1985. The date of reference is the prediction date. The means for the first seven quarters are all negative, while the means for four of the remaining five quarters are positive. The signs of the forecast errors indicate a time dependence, suggesting that unanticipated economic events influence the sign of the error.

To see whether the forecast errors differed significantly from zero, the procedure used by O'Brien (1988) was followed. This approach allows for the fact that forecast errors are likely to be correlated within a particular period. The forecast error for a firm in period t is equal to the average forecast error for the period plus a random error term. This can be shown as follows:

$$pe_{jT} = u_T + e_{jT}$$

where:

pe_{jT} = Percentage error for firm j in period t;
u_T = Average percentage error in period t; and
e_{jT} = Random error term for firm j.

The test for bias compares the grand mean of the estimated period averages ($\overline{u_T}$) with the following standard error:

$$S_{\overline{u_T}} = \frac{m}{T}\left[i' (x'x)^{-1} i\right]^{1/2}$$

where:

$S_{\overline{u_T}}$ = Standard error of the grand mean of the period averages;
i = The vector of ones whose length is the number of periods;
x = The matrix of dummy variables;

m = The square root of the mean square error; and
T = Number of periods.

Ordinary least squares (OLS) with dummy variables is used to obtain the period averages as well as the resulting mean square error. If a quarter is used as the length of the period, the resulting t-statistic is -2.40 which suggests that, on average, actual earnings are significantly greater than predicted earnings.[6] This finding of a significant negative mean error differs from some previous research (Barefield and Comiskey, 1975; Freeman, 1987; Givoly and Lakonishok, 1984) where the average error is not significantly different from zero. Some studies (Collins and Hopwood, 1980; Kross, Ro, and Schroeder, 1990) have shown that actual earnings tend to be less than predicted. The findings in this study, however, indicate that actual e.p.s. are greater than Value Line's predicted e.p.s., on average. Previous studies have used different time periods; hence, the relationship between actual and predicted e.p.s. appears to be dependent on the time period studied. This interpretation seems reasonable given the pattern (negative errors at first followed by mainly positive errors) of mean errors in Table 1.

Tests of the Hypotheses

The absolute value of the percentage error is used to measure the forecast errors in the tests of the hypotheses. The current empirical tests examine whether the size of the error is related to the hypothesized variables. Analysis of variance is used initially to test the hypotheses. For each of the hypotheses a two factor model is used to test for main and interactive effects. The first factor is the hypothesized variable, and the second is the quarter the prediction is made. The second factor is included because the size of the error is likely to be related to the time period. Quarters in which there are many unanticipated economic shocks may produce large forecast errors. In addition to testing for these two main effects, the current research also tests for an interactive effect. The quarter the forecast is made (as a proxy for the amount of unanticipated economic news) may influence the effect of the hypothesized variable on the forecast error.[7]

The first hypothesis examines whether the debt ratio (the sum of long-term debt plus debt in current liabilities all divided by total assets) is related positively to the absolute value of the percentage error. For this test, firm observations are

[6]Similar t-statistics are obtained when the length of the period is defined to be equal to one year.

[7]It is of course possible to use additional factors. Unfortunately as the number of factors increase, degrees of freedom are lost. A model with more variables is tested below with regression analysis.

classified according to their leverage ratios. The observations are put into four equal groups, and the observations with the lowest ratios are placed in the first group. The findings are shown in Table 2. The test for interaction suggests that there is not enough evidence to reject the null hypothesis of no interaction. The two tests for main effects are both significant. There are significant differences in the size of the prediction error according to the amount of leverage and also according to the quarter the prediction is made. Also included in the table are mean prediction errors for the four leverage groups. The table suggests that as the amount of leverage increases, so does the size of the prediction error.[8] A Tukey test shows that the prediction errors for group 4 (the highest leverage ratios) are significantly greater than any of the other three groups at the 5 percent level of significance. These results are consistent with the view that firms with more debt have greater earnings variability which leads to greater prediction errors.[9]

Table 2 presents tests concerning the relationship between past variability of earnings (index of earnings predictability) and prediction errors. The observations are classified into four groups on the index of earnings predictability. The most predictable are placed in the fourth group. The results do not indicate a significant interactive effect. The findings also suggest that the size of the prediction error is influenced separately by a measure of earnings predictability and also by the quarter the forecast is made. The mean prediction errors of the four groups decrease as the measure of earnings predictability increases. A Tukey test shows that the group means are all significantly different from each other. Firms with a past history of large percentage changes in quarterly earnings exhibit greater prediction errors than firms with a history of small percentage changes.

The third hypothesis concerns whether the prediction error is related inversely to the size of the firm. Once again, the observations are placed into four equal groups with group 4 having the largest firms. The analysis of variance results are shown in Table 2. No significant interactive effect is detected. The tests for both main effects are significant. A Tukey test shows that the smallest firms (group 1) have significantly higher prediction errors than any of the other three groups. Small firms tend to have greater prediction errors than large firms. This is probably due to the fact that there is less information generated about small firms.

[8]Regression analysis was also performed for each of the hypotheses. The regression results mirror the results for the analysis of variance for all of the hypotheses.

[9]The results of the analysis of variance indicate that there is an association between leverage and prediction error. This of course does not prove that firms with more debt have greater earnings variability and hence greater prediction errors. There are alternative explanations for an association between leverage and prediction errors.

Table 2 reports results of tests regarding the length of time between the announcement of earnings and the date of prediction. The observations are placed into four equal groups according to the difference in time between the date of prediction and the announcement date of the earnings. (The difference in time is the greatest for group 4.) The results indicate that there is no interactive effect, but the tests for both main effects are significant. The mean prediction errors by the different groups show that as the length of time increases, so does the size of the prediction error. The Tukey test shows that the differences between the groups are generally significant.[10] The results suggest that more recent forecasts have significantly smaller prediction errors than older forecasts. More recent forecasts take advantage of more current and relevant information and thus should exhibit smaller prediction errors.

The other variable analyzed is Value Line's timeliness ranking. This measure is a ranking from one to five that represents Value Line's prediction of expected price performance over the next twelve months. A value of one is the most favorable recommendation, and a value of five is the poorest ranking. Table 2 reports the results of the tests concerning the timeliness of the stock (expected price performance) as measured by Value Line and the prediction error. In this case, the test for interaction is significant at the 5 percent level. The tests for both main effects are also significant. An inspection of the groups means shows that the prediction error increases as Value Line's recommendation worsens. The Tukey test shows that these differences are significant (at the 5 percent level), with the exception of the difference between groups 1 and 2. After reviewing how Value Line constructs this index, it is unclear why the prediction errors are correlated with the ranking of the timeliness index.[11]

All of the empirical tests presented thus far examine only one hypothesized variable at a time. To examine the significance of all of the variables simultaneously, multivariate tests are needed. The results of the regression test with all of the variables plus dummy variables for each of the 12 quarters are reported in Table 3. As a result of having 12 dummy variables, the regression is performed without an intercept term.

The results of the regression test support all of the earlier findings. All of the coefficients on the hypothesized variables have the correct sign, and all are significant at the 1 percent level or better.

[10]The differences between groups two and three and the difference between groups three and four are not significant at the five percent level.

[11]For more, see *How to Use the Value Line Investment Survey - A Subscriber's Guide*, p. 52.

Summary and Conclusions

The financial community considers earnings estimates an important factor in securities valuation. Analysts spend considerable resources deriving earnings predictions and are concerned with the accuracy of these predictions. This paper analyzes Value Line's prediction errors and finds that the prediction error is smaller:

- The lower the financial leverage (debt ratio) of the firm;
- The smaller the past variability of earnings (as measured by Value Line's index of earnings predictability);
- The larger the firm; and
- The more recent the forecast.

In addition, one other variable, Value Line's timeliness index (a measure of expected performance) is found to be significantly correlated with the size of the prediction error. These hypotheses are supported using both analysis of variance and regression.

The current research design controls for the fact that forecast errors are likely to be time dependent. The findings indicate that the particular quarter the forecast is made influences the size of the forecast error.

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Table 1
Description of Earnings Forecast Errors

Descriptive Statistics for the Error Terms

Variable	Mean	Standard Deviation	Mode	75% Percentile	Median	25% Percentile
Percentage Error (1)	-0.010	0.318	0	0.111	-0.006	-0.014
Percentage Absolute Error (2)	0.216	0.234	0	0.302	0.125	0.047

Number of observations = 6072

(1) Percentage Error = (Predicted e.p.s. - Actual e.p.s.) / $|$Actual e.p.s.$|$

(2) Percentage Absolute Error = $|$Percentage Error$|$

Mean Percentage Errors by Quarter Between 1983 and 1985

Quarter	Mean
1983:1	-.022
1983:2	-.039
1983:3	-.020
1983:4	-.035
1984:1	-.045
1984:2	-.016
1984:3	-.006
1984:4	.011
1985:1	.042
1985:2	-.004
1985:3	.012
1985:4	.034

Table 2
Analysis of Variance Results

	Variables	F-Value	Probability	Mean Absolute Prediction Errors By Ranked Groups Group 1	Group 2	Group 3	Group 4
Leverage Ratio							
(Long-term debt + debt in current liabilities) / total assets							
Number of observations 5901	Leverage	63.60	0.000				
R^2 .045	Quarter	3.04	0.001				
F-Value 5.88	Leverage x Quarter	1.18	0.226	.187	.183	.200	.287
Index of Earnings Predictability (Value Line measure of past earnings variability)							
Number of observations 5930	Earnings Prediction	172.70	0.000				
R^2 .102	Quarter	3.51	0.000				
F-Value 14.23	Earnings Prediction x Quarter	.73	0.875	.320	.244	.177	.118
Firm Size (Total assets)							
Number of observations 5901	Size	23.54	0.000				
R^2 .026	Quarter	2.54	0.003				
F-Value 3.26	Size x Quarter	1.08	0.339	.261	.206	.206	.185

Table 2 (continued)
Analysis of Variance Results

	Variables	F-Value	Probability	Mean Absolute Prediction Errors By Ranked Groups				
				Group 1	Group 2	Group 3	Group 4	
Length of Time (Number of days between earnings prediction and announcement)								
Number of observations 5639	Length	16.15	0.000					
R^2 .018	Quarter	3.20	0.000					
F-Value 2.18	Length x Quarter	0.45	0.997	.180	.216	.229	.238	
Timeliness (Value Line measure of expected price performance)								
Number of observations 5868	Timeliness	38.54	0.000					
R^2 .042	Quarter	2.02	0.203	Meas=1	Meas= 2	Meas= 3	Meas= 4	Meas= 5
F-Value 4.36	Timeliness x Quarter	1.52	0.016	.159	.172	.215	.266	.331

Table 3
Multiple Regression Test

Number of observations 5304
R^2 of equation .532
F-Value of equation 356.13

Variable	Parameter Estimate*	T-Value
Timeliness	0.0413	12.17
Log Size	-0.0092	-4.32
Length of Time	0.0010	6.73
Leverage	0.1405	5.74
Earnings Predictability	-0.0024	-19.58
1983:1	0.2506	12.15
1983:2	0.2439	11.60
1983:3	0.2137	10.62
1983:4	0.1951	9.43
1984:1	0.2078	10.31
1984:2	0.1773	8.63
1984:3	0.2161	10.57
1984:4	0.2104	10.07
1985:1	0.2291	11.27
1985:2	0.2189	10.58
1985:3	0.2329	11.03
1985:4	0.2381	9.42

*All parameter estimates are significant at the 1 percent level

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