Faculty Working Papers

PRICING OF LIQUIDITY FOR PREFERRED STOCKS ON THE NEW YORK STOCK EXCHANGE

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#662

College of Commerce and Business Administration
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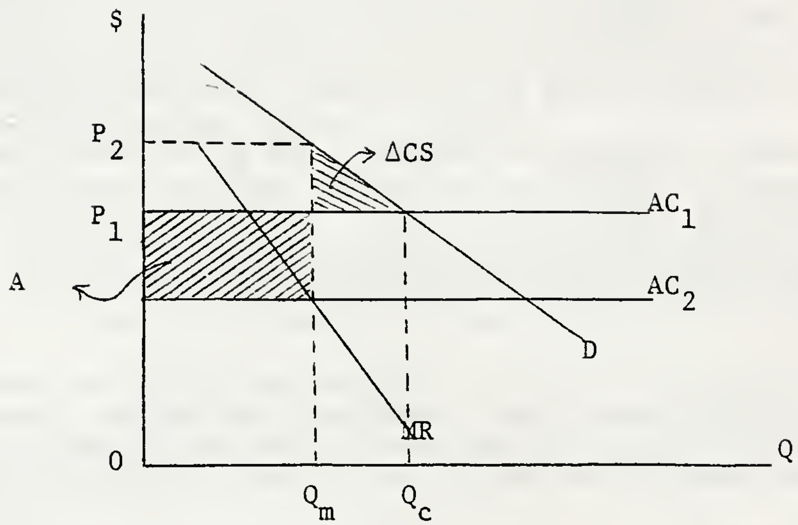

Figure 1

Faculty Working Papers

AN ANALYSIS OF THE RELATIONSHIP BETWEEN PUBLISHED INTERIM ACCOUNTING EARNINGS AND FUTURE INTERIM ACCOUNTING EARNINGS

William S. Hopwood, Assistant Professor, Department of Accountancy
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Summary

This study compares interim based quarterly EPS forecasts of certain statistical model with those of financial analysts. The findings indicate that the forecasts of the analysts are more accurate but the degree of the advantage depends upon which the quarter the base period ended in.

AN ANALYSIS OF THE RELATIONSHIP BETWEEN PUBLISHED INTERIM ACCOUNTING EARNINGS AND FUTURE INTERIM ACCOUNTING EARNINGS

The relationship of published interim accounting earnings to future accounting earnings is an area of immediate importance to policy making boards, such as the FASB and the SEC, in their current consideration of such issues as interim financial accounting and reporting and management forecasts. In the former consideration, the relationship is incorporated in two of the potential objectives of interim reporting [FASB, 1978, p. 15]. In the latter, the accuracy of forecasts of future earnings based on past earnings alone and on more comprehensive input variables should serve as benchmarks against which the more comprehensive management forecasts could be measured. In addition, this relationship is important to much of the empirical research associated with the investment decision process since this research extensively incorporates forecasts of either annual or quarterly accounting earnings as a measure of earnings expectations.

This paper examined the relationship of future earnings to forecasts of these variables based on past earnings as the sole input variable and on multiple input variables. Future earnings can be classified, as previously done by the FASB [1978, p. 15], as the annual earnings figure or a future earnings figure other than the annual figure. In this project we focused on future quarterly earnings figures that varied from one to five quarters ahead of a published earnings figure.

Previous empirical research such as Brown and Rozeff [1978] and Collins and Hopwood [1980] demonstrated that the more comprehensive financial analysts' models are superior to the univariate models in predicting both earnings of a future quarter and annual earnings. Univariate and multivariate models then were included in this study to provide a comparison of the importance of the published accounting earnings figure relative to other variables incorporated into the forecasts. We focused on the particular time frame relative to the annual period at which a quarterly earnings figure was published to provide for the comparison of this incremental effect. It is this focus that differentiated this present research from previous research that examined the relationship between reported earnings and future earnings.

The univariate sources were four univariate time series models that incorporated only past earnings. Four models were included because previous research has not demonstrated conclusively that any one of these models was superior. A secondary purpose of this study then was to compare the relative accuracy of the univariate models. The multivariate source was forecasts generated by financial analysts. These forecasts are multivariate in that the financial analysts incorporate other variables in addition to past earnings. This effect has been demonstrated by Collins and Hopwood who concluded that financial analysts' forecasts react to events such as strikes and other changes in a company's environment before the effects of these events are reflected in published earnings. These particular univariate and multivariate models were selected because they were widely available and they utilized published quarterly earnings reports. Management forecasts themselves were not included largely because they were not widely available on an interim basis.

The paper is organized into the following major sections. An analysis of prior research in the area is presented first. The empirical results then are presented followed by the statistical tests. A summary of these results and the conclusions obtained completed the presentation.

PREVIOUS RESEARCH RESULTS

The four univariate models are generated utilizing the time series process suggested by Box and Jenkins [1970].[1] The complete process is a statistical technique that is used to (a) identify, in a parsimonious manner, the most appropriate model consistent with the apparent underlying process that generated the observed time service data; (b) estimate the parameter values for that particular model; and (c) perform diagnostic tests. The process consists of an iterative approach that excludes inappropriate models until the model and its paramter values that best fit the data are selected. Compared to previous time series analyses that were characterized by the individual consideration of many possible models, the Box and Jenkins process permits consideration of a much greater number of models in a more structured approach.

The first univariate model, hereafter designated the BJ model, is a model individually identified and its parameter values estimated for each firm in the study. Thus, the BJ model for each firm is determined from the complete Box and Jenkins process. Since the model is determined from the consideration of a broad generalized model inclusive of all possible combinations of autoregressive and moving average models, the initial expectation might be that forecasts generated from an individually fitted model should be more accurate than forecasts generated from a model that was generally identified for all firms. However, the identification process is both subjective and costly. In addition, the identification of a model from a finite series of data points may not result in the model consistent with the underlying process generating an infinite series, or for a finite period different from the identification period.

Because of these factors and observed empirical results, it has been suggested that a generally identified or premier model, with individual firm estimation of parameter values may generate forecasts that are equal or superior to those generated by the BJ model. If a single model form generates results that are comparable to an individually identified model, it would obviate the need to perform the more subjective and costly identification process required for the latter model. It also would diminish the problem associated with the identification of a model from a finite series of observations.

The models proposed are (1) a consecutively and seasonally differenced first order moving average and seasonal moving average model (Griffin [1977] and Watts [1975]), (2) a seasonally differenced first order autoregressive model with a constant drift term (Foster [1977]), and (3) a seasonally differenced first order autoregressive and seasonal moving average model (Brown and Rozeff [1979a]).[2] In the notation used by Box and Jenkins, these models are designated as (0,1,1) X (0,1,1), (1,0,0) X (0,1,0) and (1,0,0) X (0,1,1), respectively. In this study, they are referred to as the GW, F and BR models.[3] The models are generally identified for all firms with individual firm estimation of the parameter values. Thus, only the parameter estimation portion of the complete Box and Jenkins process is used.

The different forms of a single or premier model form have been suggested based on the diagnostic tests incorporated in the Box and Jenkins process and also on predictive evidence. Watts, who initially suggested a premier model, based this suggestion on evidence that the average cross-sectional autocorrelation function (acf) could be modeled by the (0,1,1) X (0,1,1) model. Griffin also demonstrated that the average acf could be modeled by the (0,1,1) X (0,1,1) model. His suggestion also was prompted by the consistency of the distribution of the Box-Pierce statistic with the existence of white noise residuals. Foster based his suggested model primarily on the evidence that one-quarter ahead absolute percentage errors associated with the F model were lower than these errors generated by the BJ model. However, Brown and Rozeff, Griffin, and Foster himself, note that the F model does not fit the data in that the model fails to incorporate a systematic seasonal lag. Based on the Foster research, Brown and Rozeff proposed a model that incorporated a seasonal moving average component and compared their model with the BJ, F and GW models. Their study was a comprehensive study directed toward the question of whether a premier model existed. On the basis of diagnostic tests, they concluded that their suggested model fit the data as well as the GW model; the F model fit less well. Furthermore, their analysis of mean absolute percentage errors obtained from one, five and nine quarter-ahead forecasts generated by each model led them to conclude that their BR model outperformed the F model at all time horizons and the GW and BJ models at longer horizons. Their results, however, can be criticized as being overstated. They partitioned the test period into 11 periods and examined each period and each pair of models separately. The results for 7 of the 11 periods when the BR model was compared to the BJ model were insignificant and, in fact, for 4 of these 7 periods, the direction of the tests favored the BJ model. The results then must be considered as conditioned by the particular time period.

Lorek [1979] extended the comparison among the four univariate models by analyzing the relative ability to predict annual earnings. The annual forecasts were obtained by aggregating quarterly forecasts. His results indicated that as fewer quarterly forecasts were included in the annual forecast, the univariate time series models performed better than more simplistic models. The BR and the F models, however, performed less well than certain more simplistic models in the earlier part of the year and the F model performed least well of the four univariate models in the latter part of the year. Overall, the GW model was the best performing model. However, based on the inconsistency of his results and the previous studies by Brown and Rozeff, Foster, Griffin, and Watts, Lorek concluded that it may be premature to conclude that a generally identified model is best for quarterly earnings.

In addition to the four univariate model forecasts, this study included forecasts generated by financial analysts. The univariate models can be criticized in that they neglect additional publicly available information that may be potentially useful; financial analysts are not subject to this criticism. Rather, financial analysts have been criticized in that their analysis process may be too detailed and the additional cost incurred may not be justified.

Empirical results that support these assertions were provided by Cragg and Malkiel [1969] and Elton and Gruber [1972]. Both studies concluded that analysts' forecasts were not more accurate than forecasts based on earnings streams alone. The study by Brown and Rozeff [1978], on the other hand, led to the conclusion that financial analysts' forecasts were superior to forecasts generated solely from earnings data. These results, however, have been questioned by Abdel-khalik and Thompson [1977-78] as being overstated due to their temporal nature. Crichfield, Dyckman, and Lakonishok [1978] found that analysts' forecasts became more accurate as the reporting date was approached and that there was no significant systematic bias in the analysts' predictions of earnings changes. Collins and Hopwood [1980] also found that the forecast accuracy of annual earnings generated from the comprehensive models of financial analysts and those from univariate models increased in a linear trend as the annual forecast included fewer quarterly forecasts. The study further concluded that the models that incorporated multiple variables provided more accurate forecasts than the univariate models, but the difference in forecast accuracy decreased as the end of the annual period approached. This study then provided additional evidence that forecasts based on input in addition to past earnings were more accurate. However, it did not focus on forecasts of future quarterly earnings. Brown and Rozeff [1979b] did examine the quarterly earnings variable. They concluded that forecasts of quarterly earnings in an annual period were more accurate after previous quarterly earnings had been published. However, they noted that this improvement could be attributable to either the published earnings or additional input data.

Thus, while there is evidence that forecasts that incorporated more than past earnings are more accurate, there is little evidence that has examined the relative importance of past earnings. In the present study the analysis of the relative accuracy of financial analysts' forecasts to the univariate models' forecasts by quarter of origin provided this evidence. In addition, the relative accuracy of the univariate models' forecasts also provided for the determination of the existence of a premier univariate model.

EMPIRICAL RESULTS

General Questions

The preceding sections highlight the recent attention given to the question of whether a univariate model provides equal or superior forecasting results to those of a model that incorporates more potentially useful information. An additional question is whether a single generally applied univariate model provides equal or superior forecasting results than an individual firm identified model. In order to examine these questions, two forecast error metrics were calculated.[4] The first metric was the mean absolute percentage forecast error (MAPFE) which is specified as:

$$\frac{|A_{it} - P_{itn}|}{|A_{it}|}$$

where A_{it} = actual earnings per share for firm i in quarter t,

P_{itn} = predicted earnings per share for firm i in quarter t, generated by model n

This metric was selected because it is a measure that establishes relative comparability of forecast errors between firms that produce earnings per share that are different in absolute scale. Since equal weight is assigned to all forecast errors it assumes a linear loss function. However, because of the possibility that outliers might not be best represented by a linear loss function, an outlier adjusted mean absolute percentage forecast error metric (OAMAPFE) also was utilized. This adjustment consisted of assigning the value of 3.8 to all forecast errors that had a value greater than 3.8.[5] The resultant error metric then assumed a linear loss function that was truncated for outliers.

Sample of Firms

The sample of 50 firms (Appendix A) were selected randomly from 205 calendar year-end firms whose reported quarterly earnings data was available from 1951 through 1974. These observations were obtained primarily from The Value Line Investment Survey.[6] The analysts' forecasts also were obtained from this investment survey. The test period commenced with the first quarter of 1970 and ended with the fourth quarter of 1974.

The initial identification of the BJ models and the estimation of the parameter values of all four univariate time series models were derived from the earnings series, adjusted for stock splits and stock dividends, from 1951-1969. Forecasts subsequent to the forecast originating with the first quarter of 1970 were obtained through a process of reidentifying the BJ model and reestimating the parameter values of all models. Therefore, the minimum number of observations used for identification and estimation was 76 observations. This forecasting method, based on a reidentification and reestimation process, conducted for each forecast time origin, was included to provide a more relevant comparison between the univariate models and the financial anslysts. The analysts consider information that is currently available when they make their forecast; the univariate models, therefore, should include the most current earnings information that is available when their forecasts are generated. McKeown and Lorek [1978] have demonstrated that this rationale is supported empirically. Their results indicate that univariate model forecasts are improved when more recent observations are included through a reidentification and reestimation process.

Forecast Accuracy By Quarter of Origin

Table 1 contains a comparison of the means and distributions of the MAPFE metric by model and quarter in which the forecast originated. Table 2 contains the same data for the OAMAPFE metric. The number of quarter ahead forecasts vary from quarter to quarter. This was because the financial analysts generally publish forecasts for all 4 quarters in the first quarter of each year, forecasts for the remaining quarters of the year in the second and third quarters, and forecasts for both the fourth quarter and all quarters of the next year in the fourth quarter. Forecasts originated in the first, second and third quarter included the forecasts originated in the respective quarter of the years 1970 through 1974. The forecasts originated in the fourth quarter included the fourth quarter forecasts in the years 1970 through 1973. The comparison thus relates to both forecasts that originated in a particular quarter and forecast accuracy relative to the time horizon over which the forecast was made.

Analysis of the mean values contained in Table 1 indicated that the multivariate models generally generated the lowest error across all quarter ahead forecasts when the forecasts were originated in either the first quarter for all quarters of the current year or in the fourth quarter for all quarters of the next year. Thus, models that incorporate data in addition to past earnings are best able to forecast quarterly earnings prior to the issuance of the first quarter's earnings report. The only exceptions are the BR model's forecasts for the third quarter originated in both the first and the fourth quarter. The greatest difference in forecast errors occurs in the forecasts for the first quarter.

Table 1

Comparisons of Means and Variances of MAPFE by Model, Quarter in Which the Forecast Originated and Number of Quarters Ahead For Which the Forecast Was Made

Quarter of Origin	Model	Forecast Quarter 1-ahead		2-ahead		3-ahead		4-ahead		5-ahead	
First	FA	.29	(.67)	.31	(.59)	.53	(1.40)	.53	(1.19)		
	BJ	.62	(4.32)	.39	(.84)	.56	(1.39)	.62	(1.95)		
	BR	.58	(4.58)	.39	(1.06)	.48	(1.05)	.61	(1.77)		
	F	.64	(4.73)	.44	(1.38)	.58	(1.49)	.67	(2.79)		
	GW	.71	(6.38)	.45	(1.59)	.53	(1.25)	.68	(2.53)		
Second	FA	.26	(.52)	.53	(1.53)	.54	(1.26)				
	BJ	.25	(.32)	.51	(1.33)	.59	(1.85)				
	BR	.27	(.49)	.43	(.96)	.58	(1.68)				
	F	.31	(.79)	.54	(1.42)	.66	(2.76)				
	GW	.29	(.82)	.45	(1.07)	.61	(2.33)				
Third	FA	.47	(1.51)	.49	(1.20)						
	BJ	.44	(1.32)	.54	(1.72)						
	BR	.37	(.94)	.53	(1.53)						
	F	.49	(1.46)	.63	(2.70)						
	GW	.37	(.99)	.52	(1.86)						
Fourth	FA	.35	(.74)	.30	(.46)	.30	(.60)	.58	(1.69)	.56	(1.29)
	BJ	.44	(1.32)	.72	(5.16)	.43	(1.23)	.62	(1.59)	.64	(1.90)
	BR	.42	(1.24)	.55	(3.37)	.39	(.96)	.54	(1.16)	.67	(1.93)
	F	.51	(2.46)	.54	(2.72)	.43	(1.23)	.65	(1.67)	.84	(3.54)
	GW	.43	(1.54)	.79	(6.46)	.49	(1.71)	.65	(1.63)	.81	(2.66)

Table 2

Comparisons of Means and Variances of OAMAPFE by Model, Quarter in Which the Forecast Originated and Number of Quarters Ahead For Which the Forecast was Made

Quarter of Origin	Model	Forecast Quarter 1-ahead	2-ahead	3-ahead	4-ahead	5-ahead
First	FA	.27 (.45)	.31 (.53)	.41 (.76)	.45 (.73)	
	BJ	.32 (.54)	.36 (.55)	.47 (.78)	.47 (.70)	
	BR	.30 (.49)	.35 (.55)	.42 (.70)	.47 (.72)	
	F	.34 (.58)	.37 (.58)	.46 (.77)	.47 (.72)	
	GW	.32 (.53)	.36 (.58)	.44 (.72)	.49 (.76)	
Second	FA	.26 (.47)	.40 (.74)	.45 (.75)		
	BJ	.25 (.32)	.42 (.71)	.44 (.70)		
	BR	.26 (.40)	.39 (.69)	.45 (.71)		
	F	.28 (.40)	.42 (.74)	.46 (.71)		
	GW	.25 (.41)	.39 (.71)	.45 (.73)		
Third	FA	.36 (.71)	.42 (.73)			
	BJ	.35 (.69)	.42 (.71)			
	BR	.33 (.69)	.42 (.70)			
	F	.38 (.75)	.45 (.72)			
	GW	.33 (.70)	.40 (.68)			
Fourth	FA	.33 (.57)	.30 (.46)	.29 (.52)	.42 (.81)	.47 (.78)
	BJ	.36 (.61)	.36 (.57)	.36 (.55)	.49 (.84)	.51 (.77)
	BR	.35 (.61)	.33 (.51)	.34 (.54)	.47 (.82)	.51 (.76)
	F	.37 (.61)	.36 (.61)	.36 (.58)	.50 (.86)	.44 (.83)
	GW	.36 (.64)	.35 (.55)	.38 (.63)	.50 (.86)	.54 (.85)

In the forecasts originated in the first quarter, the FA forecast error of .29 is .29 lower than the next lowest forecast error of .58. In the forecasts originated in the fourth quarter, the FA forecast error of .30 is .24 lower than the next lowest forecast. However, when the forecasts are originated after first quarter earnings are reported, the superiority of the FA model generally disappears. The exception is that the financial analysts generate forecasts for the fourth quarter that are more accurate no matter when in the annual period the forecasts were originated.

The same relative ability generally hold also for the analysis of the distribution measure in Table 1. Prior to the publication of the first quarter's earnings report, the FA model's forecasts were lower in the variance for the first, second and fourth quarters. The difference was most pronounced for the forecasts for the first quarter and forecast variance always was lowest for fourth quarter forecasts no matter when these forecasts were originated.

Comparison of the data for the mean absolute forecast error metric in Table 1 with the outlier adjusted mean absolute forecast error data in Table 2 indicated that the FA model generally retained its relative ability to forecast lower mean values prior to the publication of the first quarter's earnings figure. The financial analysts still generated superior forecasts for the first quarter but the level of superiority greatly diminished when the error metric was adjusted for outliers; the FA forecast error now was only .03 lower for first quarter forecasts that were originated in the first quarter for the current year or the fourth quarter for the subsequent year. This was attributable to the fact that the greatest impact of adjustment for outliers related to the forecast error metric generated by the 4 univariate models for the first quarter; the forecasts generated by the financial analysts were not changed appreciably for adjustments attributable to outliers. Analysis of these outlines indicated that their existence was not attributable to the fact that the denominator (actual earnings) in the error metric calculation was close to zero. The existence of the outliers generated by the univariate models then tended to exist because of the models' inability to respond to economic events not captured in published earnings.

The differences in variance also greatly diminished for the first quarter forecasts of the univariate models when the error metric was adjusted for outliers. In addition, a difference in variances between the OAMAPFE metric for the first and second quarter forecasts and those of the third and fourth quarter was evident for all 5 models. The higher variances of the third and fourth quarter forecasts also maintained irrespective of the quarter in which the forecasts originated.

Among the univariate models, no model demonstrated a degree of superiority by consistently ranking as the lowest mean generated during each quarter for the various quarter ahead forecasts.

The data in Tables 1 and 2 also illustrated the pattern of quarter ahead forecasts generated in each of the 4 quarters of the year. For the outlier adjusted error metric in Table 2 there is a direct relationship between the level of the forecast error and the time horizon over which the quarterly forecasts were made. Inspection of Table 1 indicated that this relationship also exists for the mean absolute percentage forecast error with the exception of the forecast errors of the 4 univariate models for the first quarter forecasts. This again indicated the univariate model's inability to respond to economic events prior to their effect on a published earnings figure.

SUMMARY AND CONCLUSIONS

The results of this study should be considered in relation to certain limitations. First, noncalendar reporting firms, firms formed since 1951 and firms which ceased in existence were excluded from the study. Second, the results were conditioned on 2 error metrics. The paper also was limited to the 5 models included and the definition of the future earnings variable as future quarterly earnings. Finally, the paper only considered forecast accuracy. There was no consideration of the additional costs associated with a more comprehensive model.

When the question of the existence of a premier model was considered, the evidence indicated that there was little justification for the additional cost and effort necessary to individually identify and estimate the parameter values of a model for each firm. However, the evidence to suggest that any of the 3 premier models was superior was not conclusive. The univariate model proposed by Brown and Rozeff generated the lowest or second lowest mean and variance for each of the 14 quarterly forecasts included in the study, but, for certain of these forecasts, either the GW model or the F model provided a lower mean or variance.

When the relative importance of published accounting earnings data was considered relative to other sources of information, the results indicated that consideration of information in addition to past earnings increased forecast accuracy. This was consistent with the results of the empirical research of Brown and Rozeff [1978] and Collins and Hopwood [1980].

This additional information especially impacted on forecast accuracy of forecasts generated prior to the publication of accounting earnings for the first quarter of an annual period and was applicable to both forecasts for future quarters of that year and the forecast for the annual period. However, the value of the additional sources of information diminished following the publication of the first quarter's earnings announcement. The exception was applicable to forecasts for the fourth quarter for which the forecasts generated by the financial analysts were the most accurate no matter when in the annual period they were generated.

When forecasts for the first and fourth quarters generated by the financial analysts were considered separately, they indicated that fewer outliers were generated by the FA model for the first quarter than for the fourth quarter. This was evidenced by the differences between the MAPFE metric and the OAMAPFE metric for the respective quarter. Tables 1 and 2 also indicated that the means for the fourth quarter forecasts were higher than those for the first quarter. One reason for these differences might have been that the level of earnings for the first quarter was affected more by situations that were known external to the firm while earnings for the fourth quarter were affected more by internal situations such as fourth quarter accounting adjustments. The financial analysts thus were more capable of incorporating the effects of external events that were publically known. These results relative to forecasts of future interim earnings are consistent with the annual earnings results found by Collins and Hopwood [1980].

The data represented in Tables 1 and 2 also indicated that, with the exception of the forecasts generated by all 4 univariate models for the first quarter, there was a direct relationship between mean forecast accuracy and the time horizon over which the forecasts were made. A final consideration was that the smallest forecast ereror for any quarterly forecast for any model exceeded 25 percent.

The implication of these results suggested that current sources of financial forecasts, including the more comprehensive models utilized by financial analysts may have limited usefulness. One suggested improvement might be management forecasts that were required on a semi-annual basis. The first forecast would incorporate information in addition to past earnings and be published prior to the issuance of a first quarter's earnings report. The second forecast would include additional information especially information about events internal to the firm and would be required prior to the issuance of the earnings report for the third quarter.

FOOTNOTES

[1]Since this process has been the subject of a growing amount of research, we will omit a detailed specification of the process. Interested readers are directed to Box and Jenkins [1970] or Nelson [1973].

[2]The inclusion of a model is not meant to imply that the author's intent was a search for a premier model. In fact, the work of Foster, Griffin and Watts are characterized better as studies of the time series properties of accounting data.

[3]The F model differs from the model proposed by Foster in that the drift term is excluded based on evidence provided by Brown and Rozeff [1978] that this term is significant.

[4]The selection of an error metric assumes that a certain utility function is the most appropriate for evaluating alternative forecasting sources. This selection is arbitrary since little is known about the utility function of the users of earnings forecasts. In addition, a more complete analysis would require specification of the loss function specific to the investment decision.

[5]The selection of the value of 3.8 as an indication of an outlier was based on a visual analysis of the frequency distribution of the absolute percentage forecast error metric. In a recent paper the authors [1979] also examined outlier classification schemes defined in terms of standard deviations. The outlier observations and the results of the corresponding statistical tests did not differ from those obtained from the present outlier classification scheme.

[6]The earnings figure used was the eps figure reported in <u>The Value Line Investment Survey</u>. During the test period this eps figure was the primary eps figure excluding extraordinary items. For certain firms the Compustat Tapes were utilized to obtain the fourth quarter eps for 1974.

APPENDIX A

Listing of Sample Firms

1. Abbott Laboratories
2. Allied Chemical
3. American Cyanamid
4. American Seating
5. American Smelting
6. Bethlehem Steel
7. Borg-Warner
8. Bucyrus-Erie
9. Clark Equipment
10. Consolidated Natural Gas
11. Cooper Industries
12. Cutler - Hammer
13. Dr. Pepper
14. Dupont
15. Eastman Kodak
16. Eaton Corporation
17. Federal - Mogul
18. Freeport Minerals Co.
19. General Electric
20. Gulf Oil
21. Hercules, Inc.
22. Hershey Foods
23. Ingersoll - Rand
24. International Business Machines
25. International Nickel Co.
26. Kansas City Southern Industries
27. Lehigh - Portland
28. Mead Corporation
29. Merck and Company
30. Mohasco Corp.
31. Moore McCormack
32. Nabisco, Inc.
33. National Gypsum
34. National Steel
35. Northwest Airlines
36. Peoples Drug Stores
37. Pepsico, Inc.
38. Rohm and Haas
39. Safeway Stores
40. Scott Paper
41. Square D
42. Stewart - Warner
43. Texaco, Inc.
44. Trans World Airlines
45. Union Carbide
46. Union Oil (Cal.)
47. U.S. Tobacco
48. Westinghouse Electric
49. Weyerhaeuser, Inc.
50. Zenith Radio

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TIME SERIES MODELS FOR CORPORATE EARNINGS: AN ILLUSTRATION OF THE USE OF POWER TRANSFORMATIONS

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Summary In the recent accounting literature there has been much interest in the construction of ARIMA models as tools for forecasting corporate earnings. Our examination of data of this kind indicates that power transformations of the observed earnings are frequently desirable. In this note we illustrate the model building procedure for two quarterly series of earnings, incorporating into the usual methodology a technique for finding an initial estimate of the transformation parameter, which in turn facilitates the identification of an appropriate ARIMA structure.

Key words: Time series model building, Transformation of data.

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TIME SERIES MODELS FOR CORPORATE EARNINGS: AN ILLUSTRATION OF THE USE OF POWER TRANSFORMATIONS

Summary In the recent accounting literature there has been much interest in the construction of ARIMA models as tools for forecasting corporate earnings. Our examination of data of this kind indicates that power transformations of the observed earnings are frequently desirable. In this note we illustrate the model building procedure for two quarterly series of earnings, incorporating into the usual methodology a technique for finding an initial estimate of the transformation parameter, which in turn facilitates the identification of an appropriate ARIMA structure.

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1. INTRODUCTION

A good deal of recent interest in the Accounting literature has focussed on procedures for forecasting corporation earnings. The Financial Accounting Standards Board (1977), in their conceptual framework project, has emphasized the importance of such forecasts.[1] One line of attack of this problem has been through the construction of univariate time series models, using the methodology of Box and Jenkins (1970). This approach has been discussed by, for example, Foster (1977), Griffin (1977) and Lorek (1979). Much of the research has concentrated on two questions: do corporate earnings streams have a common structure? (that is, can one find a single model from the general autoregressive integrated moving average class which predicts well for a wide range of corporations?); and how do the forecasts from time series models compare with those of financial analysts and management? Some discussion on the latter point is contained in Abdel-khalik and Thompson (1977-78), Brown and Rozeff (1978) and Collins and Hopwood (1980). For either question, it is clearly desirable to accumulate evidence of the time series behavior of a large sample of corporate earnings series. We therefore use earnings series as examples of applications of the technique set forth in the present paper. It should be emphasized that our primary objective is not to argue for or present evidence favorable to individually identified ARIMA models for accounting earnings, but rather we desire to demonstrate a technique applicable to a wide range of decision oriented problems. We could have used simulated series, but we wished to demonstrate the technique in a real world context.

This paper arose from the study of a large collection of quarterly time series of corporate earnings (Hopwood, et. al., 1981). It quickly became clear that, for the majority of series in our sample, there was strong evidence of the desirability of a data transformation to induce homogeneity of error variance, although this point had not previously been noted in the Accounting literature. Our empirical results suggested that, for such series, a transformation will generally lead to forecasts of improved accuracy. Accordingly, we considered the class of power transformations of Box and Cox (1964). Denoting by x_t the series to be analyzed, the class of models considered then was

$$\phi(B)\Phi(B^i)(1-B)^d(1-B^4)^D x_t^{(\lambda)} = \theta(B)\Theta(B^4)a_t \tag{1.1}$$

where a_t denotes white noise and the notation is that of Box and Jenkins (1970, ch. 9), with

$$x_t^{(\lambda)} = \begin{cases} (x_t^\lambda - 1)/\lambda & (\lambda \neq 0) \\ \text{Log } x_t & (\lambda = 0) \end{cases} \tag{1.2}$$

Along these lines we considered four possible transformation strategies, with strategy (d) producing the most accurate forecasts:

(a) use no transformation

(b) use the logarithmic transformation

(c) use a power transformation with λ estimated (jointly with other model parameters) by the maximum likelihood estimate $\hat{\lambda}$.

(d) use a decision rule based on the 95 percent confidence interval for λ. If this interval contains $\lambda = 1$ but not $\lambda = 0$, use no transformation. If the interval contains $\lambda = 0$ but

not $\lambda = 1$, use the logarithmic transformation. If the interval contains neither $\lambda = 0$ nor $\lambda = 1$, use $\hat{\lambda}$ (jointly estimated with other model parameters by maximum likelihood). If the interval contains both $\lambda = 0$ and $\lambda = 1$, use whichever is closer to $\hat{\lambda}$.

Under the usual assumption that a_t is Gaussian there is no great difficulty in jointly estimating the parameters of a model from the general class (1.1). However, the initial specification of such a model is complicated by the fact that the autocorrelation structure of $x_t^{(\lambda)}$ and its differences is not independent of the choice of λ. Thus, for example, if the sample autocorrelations and partial autocorrelations of the raw data are employed in the usual way to suggest orders for the autoregressive and moving average operators in (1.1), the chosen model may not be adequate to describe the linear properties of $x_t^{(\lambda)}$ for an "appropriate" λ. This point is established theoretically by Granger and Newbold (1976), while a numerical example in Nelson and Granger (1979) shows that it can be practically important. In our study we found that the problem occurred in about 10 percent of cases.

In the next section, we describe an elaboration of the usual model selection procedure, based on an initial estimate of the transformation parameter λ. This has the dual advantages of providing a surer initial identification of the autoregressive-moving average structure of the model for $x_t^{(\lambda)}$ and of yielding the preliminary estimate subsequently required in the estimation routine. In the final section the procedure is illustrated through the modelling of two corporate earnings series.

2. MODEL IDENTIFICATION

In our analyses of earnings data we have found it valuable to base model selection not on the sample autocorrelations and partial

Notes

[1]We required the firms to be listed during the entire sample period. The Center for Security Price Research (CRSP) monthly tape was used to select NYSE listed firms. A firm was considered listed if it had monthly stock returns available for the entire sample period.

[2]The absolute percentage error is computed as the average of $\left|\frac{\text{Actual EPS} - \text{Predicted EPS}}{\text{Actual EPS}}\right|$. Since this error metric can be explosive when the denominator approaches zero we truncated errors in excess of ten to a value of ten. This operation was done for a very small percentage of the cases.