PREDICTIVE ABILITY OF ANNUAL CASH FLOW UNDER HISTORICAL COST AND CONSTANT DOLLAR ACCOUNTING

by

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ABSTRACT

Recent discussion in accounting literature has emphasised that investors and other users of financial statements are increasingly interested in predicting cash flow. The Financial Accounting Standards Board in its Statement of Financial Accounting Concepts 1 concludes that information about enterprise earnings generally provides a better indication about future cash flow than does information about past cash flow. This implies that there is a relationship between earnings and subsequent cash flow. The Board also states that information about past cash flow may be helpful in predicting cash flow. The ability of constant dollar earnings or cash flow to predict constant dollar cash flow has not been addressed in the accounting literature. This study empirically addresses these issues.

The objectives of this study are (1) to determine the statistical time-series properties of historical cost and constant dollar cash flow and develop univariate forecasting models to forecast cash flow, (2) to determine the direction of any lead relationship between cash flow and income and develop multivariate forecasting models, (3) to compare the predictive ability of the forecasting models within each accounting method, and (4) to compare the predictive ability of the models across accounting methods.

Box-Jenkins procedures are used to determine the time-series properties of annual cash flow. A random walk with drift model is used as benchmark with which to compare the

accuracy of other models.

The major conclusions can be stated briefly. Cash flow appear to follow either an autoregressive or a white noise process. There is no empirical evidence that income is a leading indicator of cash flow. For one-period-ahead predictive ability tests the results are mixed, except the random walk with a drift model utilizing historical cost cash flow performed as well as Box-Jenkins univariate models utilizing constant dollar cash flow. For the two-year-ahead forecasts there is no difference in the accuracy of the prediction models when using historical cost data. When using constant dollar data the Box-Jenkins univariate models out-performed the random walk with a drift model. The Box-Jenkins models utilizing constant dollar cash flow out-performed both models utilizing historical cost cash flow in the two-year-ahead forecasts.

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CHAPTER 1

INTRODUCTION

General Statement and Importance of the Problem

Considerable research has been done on the time-series behaviour of accounting income numbers and its implications for accounting research and security prices. However, very little is known about the process that best describes the time-series behaviour of cash flow.

Traditionally accountants have concentrated on the measurement of earnings with little emphasis on the measurement of cash flow. Attempts to focus attention on cash flow were considered to be an overreaction to the imperfection of the measures of earnings. The Canadian Institute of Chartered Accountants' Handbook (Sec 1540.43) states:

> The amount of cash or other funds provided from operations is not a substitute for or an improvement upon properly determined net income as a measure of results of operations.

These imperfections results mainly from changes in the environment such as inflation, lack of uniformity in accounting procedures, and the identification of accounting exclusively with the measurement of income. Moonitz in the director's preface to Mason (1961, pxi) argued that rather than perfect the earnings figure, some accountants overreacted and this general overreaction normally took the form of giving up measuring complex phenomena such as earnings in favour of primitive ones such as cash flow.

Cash flow, however, have received considerable attention in the last few years. The official accounting bodies' emphasis on cash flow started with the publication of the "Trueblood Report" officially known as the report of the "Study Group on Objectives of Financial Statements". Starting with this publication cash stopped being an offensive word for accountants (Sorter, 1982, p188). The official emphasis on cash flow can clearly be noted in the Study Group's report that in part contained the following:

> An objective of financial statements is to provide information useful to investors and creditors for predicting, comparing, and evaluating potential cash flows to them in terms of amount, timing, and related uncertainty.

and

> An objective of financial statements is to provide users with financial information for predicting, comparing, and evaluating enterprise earning power (AICPA, 1973, p23).

where earnings power is defined as the ability to generate cash. This emphasis on cash flow was later affirmed by the Financial Accounting Standards Board in its <u>Tentative Conclusions on Financial Statements on Business Enterprises</u> (December, 1976b) and <u>Statement of Financial Accounting Concept 1</u> (1978, para 37) as can be evidenced by one of its stated objectives:

> Financial reporting should provide information to help investors, creditors, and others assess the amounts, timing, and uncertainty of prospective net cash inflows

to the related enterprise.

Although the official emphasis is recent, accounting researchers have examined cash flow for a long time. Almost two decades ago, Mason (1961, p42) concluded that cash flow from operations was a valid and useful analytical tool. Cash flow are widely accepted and used in various valuation models in finance.

Despite the importance of future cash flow, only a few studies [e.g. Khumawalla (1978); Brooks (1981)] have dealt with time-series properties of quarterly cash flow and even fewer [Icerman (1977)] have dealt with annual cash flow.

In order to predict future cash flow, the Financial Accounting Standards Board in Statement of Financial Accounting Concept 1 concludes that investors and other users are led "primarily to an interest in information about its earnings rather than information directly about its cash flows" (1978, para 43). The Board states "Information about past cash flows may be helpful in predicting future cash flows" (1981, para 28).

The above Financial Accounting Standards Board statements have two implications relevant for this study. Firstly, information about past earnings leads to prediction of future cash flow. This means a relationship, though not specified by the Financial Accounting Standards Board, exists between past earnings and future cash flow. Secondly, there is a relationship between past cash flow and future cash flow, although it is asserted that this relationship is weaker than the earnings to cash flow relationship.

Since there is no existing empirical evidence for such asserted relationships this study will directly address these issues in an empirical context.

In order to account for the effects of changing prices in accounting reports, the official accounting bodies of both the United States of America and Canada have called for presentation of supplementary constant dollar information in the financial statements. Moreover, the Financial Accounting Standards Board in statement #33, recognising the lack of empirical evidence to support the usefulness of this information, has specifically encouraged further research and investigation into the assessment of the usefulness of both current cost and constant dollar information (para 15). This empirical study is motivated by this call and the gap in the literature on the time-series properties and predictive ability of constant dollar numbers. Therefore, this study will also provide time-series properties of constant dollar annual cash flow and it will examine whether the hypothesized relationships between past earnings and future cash flow exist.

May and Sundem (1976), among others, recognised the importance of time-series properties of accounting signals for alternative accounting methods, and, particularly, the degree to which they differ. Moreover, they have also suggested that the alternative accounting methods be evaluated and selected based on their predictive ability, a criterion advocated by many other researchers in accounting. (eg. Beaver, Kennelly, and Voss, 1968; Hakansson, 1973; Foster, 1977).

As empirical evidence is not available on the degree to which the time-series properties of annual cash flow differ among the two alternative accounting methods, historical cost and constant dollar, this study will also examine the usefulness of the reported annual cash flow as between the two accounting methods via the predictive ability criteron.

Importance of Forecasting Cash Flow

The accounting earnings number is arrived at by a more complex procedure than the cash flow number involving the accruals, deferrals, and allocations which are not required in the calculation of cash flow numbers.

If the accruals, deferrals and allocations were zero, implying perfect synchronisation of revenues and expenses with cash receipts and expenditures, earnings and cash flow would be the same. The accruals not being zero results from a lack of synchronisation due to timing differences such as the lag between the recognition of revenue and the collection of cash. It could be argued that net income is a simulated cash flow, that is cash flow that would have resulted if all accruals, deferrals and allocations had actually occurred in cash. Thus these complex procedures are an attempt to correct for timing differences by assuming that all of the revenues and expenses have already been received and paid in cash.

Staubus (1977) points out that cash flow is the most objective measure since it is not affected by any arbitrary accruals, deferrals and allocations[1]. So if this simulation process is "perfect" then the earnings would be "perfect" simulated cash flow. This raises the question of the importance of these two numbers. Which number is the most relevant for decision makers? Even if the users desire the simulated cash flow, with all the errors introduced due to simulation which is never perfect when trying to depict the real world, do the benefits justify the costs? Since we do not know the users nor their decision models, it is not possible to answer this question on an a priori basis.

However, a choice could be made based on the information content of the two numbers. It is possible that the two numbers convey different information and so both should be provided. Information content can be defined as the ability of the accounting numbers (or any other relevant number) to affect a decision maker's decision. If a decision maker is making an investment decision then the relevant information will be reflected in the stock prices. For example, Foster (1978) notes that in the area of information content, inferences are made about the degree of association between accounting numbers and the security returns. These inferences can only be tested by an appropriate expectation model developed through time-series analysis of the underlying process generating the variable(s) of interest. Studies to test the information content of accounting announcement [e.g. Beaver (1968b), Ball and Brown (1968)] have been reported in the literature.

Staubus (1965) investigated the association between funds flow measures and stock market prices and found that funds flow measures are more associated with prices than is income. Gombola and Ketz (1980) investigated the information contained in various accounting numbers and found that working capital from operations added little to the information contained in the net income figure since it behaved in a similar manner to the net income figure. Cash flow, however, behaved in a significantly different manner than income.

Hence if the information content of cash flow is being examined and if an expectation model selected is inappropriate, then the information content studies would come to erroneous conclusions. However, the expectations model is an abstraction of what the users' models are. For example, in the security market context, since the users' models are not known, a mathematical model would be appropriate only if three conditions are met: the mathematical model predicts the variable of interest accurately; the users efficiently process the information; and the market is efficient in the semi-strong form[2]. If these conditions hold, then the results of the mathematical model will be similar to that of the market. In the development of the mathematical model, Foster (1978) concluded that the prediction of a variable(s) is enhanced by a model incorporating the results of time-series analysis of how a variable behaves over time.

Cash flow forecasts are also important in aiding users such as investors in valuing the securities as well as the firm as a whole. It is also a major premise underlying most valuation models in economics. Both the Financial Accounting Standards Board in its Statement of Financial Accounting Concept 1 and the "Trueblood Report" (AICPA, 1973) have placed the main emphasis on the prediction of future cash flow. Staubus (1977) discusses several common situations where external users use accounting data in their decision making process. In particular they use cash flow and other measures to predict the future capacity of the firm to meet its financial obligations.

The forecasting of accounting numbers such as cash flow is also useful in task allocation in auditing. The auditor could use the most appropriate forecasting model to predict the accounting variable of interest and carry out detailed audit procedures on variables with more than acceptable forecast errors.

Definition of Cash Flow

Cash flow are the result of three business activities, that is, operating, financing and investing. These activities result in different sources and uses of cash flow, i.e., cash flow from operations, cash obtained from borrowing and used to retire debt and cash obtained and paid to shareholders, and cash obtained from disposal of assets and cash used for maintaining and expanding capacity. This study will examine only the operating activity rather than net cash flow from all activities since this represents a measure of enterprise performance.

The central operations are the means by which the company carries out its activities of earning excess cash flow so that it is able to pay for all resources used up and provide an adequate return to owners. A company must have consistently positive and adequate cash inflow from operations to avoid bankruptcy, recoup investments, and provide for both dividends and growth. Moreover, the higher the future cash flow from operations the less risky the firm, as there is a higher probability that a company is able to withstand adverse operating conditions. However, in the long run the cash flow from operations and net income will be the same[3]. In the short run, though, there will be large differences. In this study, some of the other uses and sources of cash flow will not be considered.

Several studies in the past have used cash flow as one of the variables. The Backer and Grosman (1978) survey found that all security analysts interviewed indicated that they regularly calculate estimated cash flow in evaluating the companies. However, the definition of cash flow is not indicated. They defined cash flow in the empirical section as after-tax net income less extra-ordinary items plus depreciation and amortization plus deferred taxes. Their study showed that cash flow to debt ratio deteriorated considerably over a two year period for downgraded firms. Beaver's (1966) bankruptcy study concluded that cash flow to total debt ratio had one of the strongest predictive powers. It misclassified only 13% of the sample firms for the first year before failure. However cash flow was defined as net income plus depreciation, depletion and amortization. It would have been interesting to see the results if other widely utilized measures of cash flow were used.

In the past, analysts have often used working capital from operation and defined it as cash flow. It is possible that this was used as a surrogate for cash flow since it was very difficult to calculate actual cash flow from operations prior to the disclosures of the statement of changes in financial position by companies. Hence the analysts may have used a short cut method of adding depreciation to net income as a proxy for cash flow from operations.

Cash flow has been defined in different ways in the literature, (i.e. Beaver, 1968a; Financial Accounting Standards Board, 1980, p. 49; Lookabill, 1976). Beaver (1968a) and Backer and Grosman (1978) have defined cash flow as "net income plus depreciation, depletion and amortization", and Lookabill (1976) as "net income plus depreciation and deferred taxes" (p735). In its discussion memorandum on "Reporting Funds Flows Liquidity, and Financial Flexibility", the Financial Accounting Standards Board (1980) defined cash flow as net income adjusted for items not affecting working capital and changes in components of operating working capital (except cash) (p.49). For the purposes of this study cash flow from operations will be defined as after tax income from operations before extra-ordinary items and discontinued operations adjusted for non-working capital transactions and changes in non-cash current assets and non-cash current liabilities. This definition excludes extra-ordinary items and discontinued operations because these items are not recurring items and their inclusion would introduce extraneous data similar to random shocks. Since the values of the prediction models have to be estimated from small samples, inclusion of such extraneous data may bias the results. The above definition requires that the companies in the sample must have the data required to calculate cash flow from operations. These data sets must be available for the entire period under examination (1950-1981).

Research Methodology

The data required for this study is obtained primarily from the COMPUSTAT data base. In addition, information not available on the COMPUSTAT tape is obtained from the Moody's Industrial Manuals, 10K reports and the companies' financial statements. In order to be included in the sample, the companies must have the necessary data items for the entire 1950-81 period for calculating cash flow from earnings and restating historical cost financial statements to constant dollar financial statements. For the purposes of this study, accounting series based on historical cost as well as constant dollar should be constructed. Historical cost financial statements are obtained from the data base. Constant dollar financial statements are estimated using an algorithm similar to Parker's (1977). The algorithm was modified slightly to conform with the recommendations of Financial Accounting Standards Board #33. In addition, the companies should have the same fiscal year end for each of the years from 1950-1981, and should have used only one inventory valuation method in any specific year although the method may change from year to year. The same fiscal year end condition is imposed in order to ensure that the time series are equally spaced and to make the data more comparable and homogeneous. The inventory valuation condition is imposed to facilitate more accurate constant dollar estimation. If different methods are used the amount of inventory valued on each basis would be needed and that information is not available in the data base. A final sample of 64 firms is included in this study.

The primary objectives of this research are (1) to empirically determine the statistical time-series properties of historical cost and constant dollar cash flow and develop forecasting models, (2) to empirically determine the lead relationship between income and cash flow and develop multivariate (transfer function) forecasting models, (3) to compare the predictive ability of these forecasting models within each accounting method, and (4) to test the predictive ability of the forecasting models across the historical cost and constant dollar accounting methods. These objectives are summarized in Table 1.

Using the Box-Jenkins procedures, firm specific univariate cash flow models for each of the accounting methods are determined for the period 1951-1979. Then using these models one-year-ahead, (1980), and two-year-ahead, (1981), forecasts are generated. Then, the base period is updated to include 1980 observation, and again the firm specific univariate models are determined and one-year-ahead forecasts, (1981), are made. As a standard against which to compare these forecasts, a random walk with a drift model is used to generate one-year-ahead and two-year-ahead forecasts for the base period, and one-year-ahead forecasts for the updated base period.

To evaluate the predictive ability of the models, two widely utilized error measures (metrics) are used. The error measures are absolute percentage error and squared percentage error. The parametric test, analysis of variance, and the non-parametric Wilcoxon signed-rank test, are utilized to test the null hypotheses of no difference in their predictive accuracy.

In order to gather evidence regarding the relationship between the earnings and cash flow, the Box-Jenkins transfer function (multivariate) procedure is utilized to obtain the strength and direction of relationship. These relationships are used to build multivariate forecasting models. A detailed description of this procedure is provided in Chapter 3.

Table 1

List of Objectives

Historical Cost	Constant Dollar
1. To determine the time-series properties of cash flow (develop univariate models)	To determine the time-series properties of cash flow (develop univariate models)
Method: Box-Jenkins univariate	Method: Box-Jenkins univariate
2. To determine whether there is a relationship between income and cash flow (develop multivariate models)	To determine whether there is a relationship between income and cash flow (develop multivariate models)
Method: Box-Jenkins transfer function (multivariate)	Method: Box-Jenkins transfer function (multivariate)
3. To determine whether there is difference in the predictive ability of the three forecasting models. (models from (1) and (2) above and RWD)	To determine whether there is difference in the predictive ability of the three forecasting models. (models from (1) and (2) above and RWD)
Method: same as for 4.	Method: same as for 4.

4. To determine if there is a difference in the predictive ability of historical cost and constant dollar accounting methods in predicting future cash flow.

Method:

(a) Forecasts:
- one-year-ahead, 1980, using the base 1951-1979
- two-year-ahead, 1981, using the base 1951-1979
- one-year-ahead, 1981, using the updated base 1951-1980.

(b) Error measures (metrics):
- absolute percentage error
- squared percentage error

(c) Tests:
- parametric - analysis of variance
- non-parametric - Wilcoxon signed rank test

RWD - Random walk with a drift. This model is used as low cost alternative to compare with the accuracy of other models.

Organisation of the Study

This section concludes the introductory chapter one.

Chapter two provides the review of literature relevant to this study. It examines cross-sectional studies, firm specific univariate Box-Jenkins studies, transfer function (multivariate) studies, and finally, the studies on predictive ability across accounting methods. Since studies on cash flow are limited, it also briefly reviews studies on other accounting numbers.

Chapter three provides details of the Box-Jenkins univariate and transfer function time-series analysis.

Chapter four provides details on the research methods employed. It discusses the sample selection process, the constant dollar estimation procedure used, the calculation of error metrics, and the predictive ability tests as well as the statistical tests.

Chapter five presents the empirical results.

Chapter six presents the summary, conclusion, and the limitations and implications of this study.

Notes

1. But he also points out that cash flow is subject to the greatest operating manipulations by management while income is subject to the least operating manipulations. The operating manipulations include among others the timing and amount of purchases from and payments to suppliers.

2. The market is said to be efficient in the semi-strong form if the current prices of the securities fully reflect all publicly available information.

3. Technically, the cash flow from operation has to be adjusted for investing activities (e.g. purchases and sales of property, plant and equipment).

CHAPTER 2

LITERATURE REVIEW

This chapter will review the relevant literature in the area of cash flow predictions. Since the number of studies dealing directly with cash flow are limited, studies on other accounting numbers will also be briefly reviewed. This chapter is divided into four sections. The first section will review cross sectional studies. The second section will deal with firm specific Box-Jenkins univariate studies. The third section will deal with the multivariate (transfer function) studies and the last section will review the predictive ability studies on alternative accounting methods.

Cash flow and prediction of cash flow have received considerable attention since the publication of the Trueblood Report (1973) on the objectives of financial statements. The importance of cash flow has been debated for a long time. Mason (1961, p42) stated that cash flow from operations was a valid and useful analytical tool for judging various aspects of the business. However, many accountants perceived the importance of cash flows as being a direct challenge to the supremacy of accrual accounting net income and vehemently opposed it. The comments of Seidman (1961, p31) that "...cash flow figures are dangerous and misleading and the profession will have no part of them " is representative of such opposition. But empirical research done at about the same time showed that users of accounting information wanted cash flow information. A field study report by the National Association of Accountants (1961, p59) stated that "top management is strongly interested in the amount of cash generated by operations ..."

Backer and Grosman (1978) interviewed investors and creditors to find out what ratios they used. A ratio of cash flow to total debt was one of the most widely used. The importance of this ratio was confirmed in their statistical results using discriminant analysis.

Time Series Research

Time series analysis refers to the statistical method of using a historical sequence of past observations of a variable(s) to predict future values of the variable(s) of interest.

Time-series research on accounting numbers started with cross sectional studies on earnings using regressions and correlations. With the introduction of Box-Jenkins univariate procedure to accounting, cross-sectional research on earnings was replicated with improved methodology and/or larger sample sizes. Box-Jenkins computer software coupled with the machine readable data bases such as COMPUSTAT tapes, enabled the research to extend to firm specific analysis. The firm specific time-series analysis was mostly on earnings, starting with annual earnings and later applied to quarterly earnings. At the same time, some sales and expense items were also considered.

Although some studies overlap in the sequence and expansion of this research, they are presented in the section most relevant to area of inquiry.

Cross-Sectional Studies

The search for time-series behaviour of accounting earnings and other accounting numbers was pioneered by Little (1962). His study on earnings per share growth of British firms came to the startling conclusion that earnings growth occurs randomly and so can not be predicted. Later, Little and Rayner (1966) used an improved methodology and larger sample of British firms. They used 441 firms, although the number of firms and years varied with the tests. They reaffirmed the conclusion that "earnings growth occurs in an almost purely random fashion" (p 62). They also investigated the persistence of long-term growth by examining the behaviour of the growth ratio computed as earnings per share divided by a simple average of the earnings per share for the entire period. Applying regression techniques, graphical and correlation analysis, they concluded that it was not possible to find either short-term or long-term consistency of growth in the earnings per share data.

The Murphy (1966 and 1967) studies investigated whether the Little and Rayner's conclusions on the growth rate were applicable to United States firms. He used the natural log of earnings per share to measure the rate of growth in earnings per share. In the 1966 study using correlation metric, he made 468 comparisions of rates and found 6% positive, 25% negative and 69% not statistically different from zero at .10 level. In the 1967 study, he used return on common equity and dividend payout ratios from one period to predict earnings per share in the consecutive period. His correlation results showed 5% positive, 10% negative, and 86% not different from zero at .10 level, thus providing additional evidence supporting the Little and Rayner conclusions.

Lintner and Glauber (1967) also investigated whether the Little and Rayner conclusions on the long-term growth rate in succeeding periods were applicable to American firms. They examined persistence of growth rates on a variety of income measures and sales. Sales was included because it is less affected by the allocation process. Their sample consisted of 323 American companies with positive earnings for each year, selected from the COMPUSTAT tape containing data from 1946-1965 inclusive. They divided the 20 year period into two ten-year and four five-year periods and ran three regressions in each of the periods. They regressed earnings versus time, earnings versus a Federal Reserve Board index of Production against time and earnings versus time and Federal Reserve Board index. Using logarithmic data and defining the regression coefficient as the growth rate, they found that for each of the variables cross-section correlation between the growth rates of successive periods was very small. This implied that there was no evidence of growth rate persistence in the long run. However, when they stratified the firms into five groups on the variability of the growth rates of operating income for 1956-60 period, they found some evidence of growth rate persistence for one subgroup but little evidence for most of them. They were then reluctant to conclude that growth rates could not be predicted and were random.

Like Lintner and Glauber, Trent (1969) also studied the growth rates of accounting variables over time. He used three profitability measures (earnings per share, return on equity, and return on invested capital) and two aggregate measures (sales and common equity). His sample consisted of 459 firms and covered 17 industry classifications. The results were similar to Little and Glauber in that the cross section correlation was insignificant (78% at the .10 level).

Brealey (1969) replicated the Little and Rayner study using 700 American companies over a 14 year period from 1951-64. Unlike Lintner and Glauber, his study examined only the cross-sectional correlation of the short term earnings per share growth rates. He found the correlation to be quite small and negative. His conclusions were similar to Little and Rayner. He also speculated that the random nature of windfall events may have biased the year to year growth towards randomness but the long-term growth might be stable.

Fama and Babiak (1968) also note in their dividend study that the sign of earnings per share changes are nearly independent over time. This is consistent with the earlier results that earnings per share follow a process similar to a random walk.

The Beaver (1970) simulation and empirical study focused on the behaviour of four rates of return series of which three were accounting based. His sample consisted of 57 firms for the 1949-68 period. He simulated the four rates of return series under three different processes. The processes included a pure mean reverting[1] process, a pure random walk[2] process, and a moving average[3] process. Comparing the empirical characteristics of actual series and simulated series, he found that the accounting rate of return series was a mean reverting process, but the mean reversion took several years due to the averaging process of accounting procedures such as depreciation. Thus he concluded that the observed behaviour of accounting based rates of return appear to be a moving average mean reverting process. Jensen (1970), in interpreting Beaver's results, concluded that "Beaver's results on the undeflated income series are consistent with past evidence that accounting earnings seem to be well described by a Random Walk process".

Ball and Watts (1972) examined the time-series properties of four accounting numbers : net income (after extra-ordinary items), earnings per share, net income deflated by total assets, and sales. Based on a sample of 451 firms over the 1947-65 period and using runs test, serial correlation, mean squared successive difference tests, and a 'partial adjustment model', they concluded that earnings per share and deflated net income appear to be a random walk process, and net income and sales appear to follow a submartingale[4] process.

Brooks and Buckmaster (1976) took exception to Ball and Watts conclusion on the undeflated net income series on the grounds that mean and median analysis on the whole sample obscure the process which may be operating in each strata. They stratified the sample based on three criteria: linear regression, modified percentage change, and normalised first difference. Identifying exponential smoothing models for each strata, and applying various tests, they concluded that net income series in the extreme strata did not follow a submartingale process but noted that if the sample was not divided into strata, the process generating net income would have been submartingale.

Lookabill (1976) extended Beaver's analysis of the high-low rate of return of firms using a sample of 65 firms from three different industries with varying risk classes and capital intensities for the period 1950-68. He argued that if an earnings' underlying generating process is an autoregressive process, then a change in earnings will have a greater impact on the firm's valuation when compared to a moving average process. He tested the market rate of return for the portfolio and found it to be mean reverting, but betas of each sub portfolio were not mean reverting. A mean reverting market rate of return would imply a moving average process for the earnings. Therefore, he concluded that the mean reversion in the betas (risk class) could not be used as an explanation for the moving average process for the earnings. He reasoned that the historical cost system and, perhaps, management manipulations induce averaging into the accounting series.

Foster (1977) examined the behaviour of quarterly earnings, sales and expenses series of 69 firms over the 1946-74 period on a cross-sectional basis. He examined the predictive ability of six forecasting models to forecast one-period-ahead for each quarter from 1962-74. The models included two simple seasonal quarter by quarter models, two simple adjacent quarter models, a model suggested by him, and firm specific models identified by using the Box-Jenkins technique. His suggested model had seasonal fluctuations and a trend in the time-series. He utilised three error metrics; average rank, mean absolute percentage error, and mean squared percentage error. He then applied the Friedman analysis of variance test where the rank of one was assigned to the most accurate forecasts in any given period. He concluded that his model had the lowest rank in each quarter. Moreover, Box-Jenkins models were outperformed by his model when considering the earnings series, and there was no difference when considering the sales and expense series.

Griffin (1977) also examined quarterly earnings. His sample consisted of 94 firms. He used four models representing a broad range of linear auto regressive integrated moving average (ARIMA) models. He presented some preliminary evidence and its implications for accounting research and security prices. Applying cross-sectional analysis he concluded that "quarterly earnings may be parsimoniously described as a multiplicative combination of two processes. One reflects the adjacent quarter movement and the other reflects the quarter to quarter movement over time" (p 81). He, however, did not use the models to forecast earnings.

Most of the studies noted above are cross sectional studies based on the assumption that each firm has the same underlying process generating the accounting number series. Due to the various inter-industry and inter-firm differences the studies reviewed below are based on the analysis of time-series properties on an individual firm basis.

Univariate Firm Specific Time-Series Studies

One of the first studies to build ARIMA models on an individual firm basis was by Dopuch and Watts (1972). The study intended to test whether the time-series process of earnings would change due to a switch in the depreciation methods. They found that eight out of eleven firms had a significant change at .05 level in earnings while only one significant change in accounting rate of return. However, there was a dominance of autoregressive models in the models identified for the sample firms.

Lorek, McDonald and Patz (1976) compared the management forecasts of annual earnings with forecasts of the firm specific

Box-Jenkins models. They divided the management forecast errors into two groups, ones with above and ones with below 10% errors. The results showed that the more accurate management group outperformed the Box-Jenkins models, while there was no difference in the predictions of the inaccurate group and the forecasting models. However, when the two groups were combined, the Box-Jenkins models outperformed the management group at .01 significance level.

Icerman (1977) used the predictive ability criterion to examine whether there was a difference in the forecasts of annual cash flows from the six prediction models. The regression models used in the Icerman (1977) study were:

1. Market model
2. Industry model
3. Accounting model
4. Exponential model, and
5. Naive model.

He concluded that none of the regression models used in his study, which are well documented in the literature, performed adequately enough to be useful in practice, although the industry model appeared to be the best, while the accounting model based on ratios was not at all useful. His study can be criticised on the grounds that it selected the variables in the different models on an ad hoc basis rather than in any systematic manner.

Watts and Leftwich (1977) updated and extended an unpublished paper of Watts (1970). They obtained 47 to 67 observations for the annual earnings-available-for-common shareholders accounting series. Their sample consisted of 32 firms in three different industries (ten for railroads, eleven for petroleum, eleven for steel). They fitted four ARIMA models for each firm based on the first 38, 50, 55, and 60 observations of accounting series for the firms that had the required data available. Having identified the models for each firm (selected on the basis of minimum sum of squared residuals) for each period, the models were then used to generate one to five periods ahead forecasts. These one to five period ahead forecasts for each model for each firm were then compared with forecasts of two naive mechanical models, random walk and random walk with a drift. Applying three forecasts error metrics (sum of ranks, sum of square errors, and weighted sum of absolute errors), they concluded that none of the models appeared dominant. However, applying only two of the three criteria, the random walk with a drift appeared to be superior over the ARIMA models. They concluded that since random walk models did as well as Box-Jenkins models, there was no need to develop Box-Jenkins models.

A similar study by Albretch, Lookabill, and McKeown (1977) examined the time-series properties of undeflated earnings and earnings deflated by share holders equity. The study utilized only twenty-five observations for the 1947-75 period to avoid the problems of structural changes. Their sample consisted of 49 firms from three industries. They also compared the one, two, and three-year-ahead predictions from the firm specific models with a random walk with a drift model. Utilizing five error measures, mean relative error, mean absolute relative error, mean squared relative error and average ranking, they found that random walk with a drift performed as well as the firm specific models for the undeflated earnings, and random walk outperformed the firm specific models for the deflated earnings.

Khumawalla (1978) also used the Box-Jenkins univariate procedure to provide the time-series properties of quarterly cash flows for a sample of 29 airline companies. She also compared the aggregation of the data on the predictive ability of quarterly cash flows. Her sample consisted of thirty airlines covering the period 1965-76. The cash flow was defined as cash flow from operations, but she did not include minority interest in the calculation of quarterly cash flows and the whole of subsidiary income recognised under the equity method of accounting was treated as unremitted earnings. The study also compared the predictive ability of the firm specific Box-Jenkins prediction models with the financial analyists' model and four naive mechanical models that have been used in previous research. The mechanical models were used as a standard against which to compare the Box-Jenkins models. The study concluded that the four naive models (two additive and two multiplicative) predicted rather poorly and thus can not be used in practice.

The financial analysts' model performed as well as the Box-Jenkins models. Due to the diversity of the identified Box-Jenkins models, it was not possible to generalise the behaviour of cash flow series.

Brown and Rozeff (1979) compared the predictive ability of earnings per share to predict earnings per share. They used three quarterly forecasting models and the firm specific Box-Jenkins models. The models included a general model proposed by them, the model proposed by Griffin (1977) and the Foster (1977) model. They generated one-period-ahead, five-period-ahead and nine-period-ahead forecasts. Comparing the model forecasts, they concluded that their model outperformed or performed as well as other models over all horizons, while the Foster model performed very poorly.

Multivariate (transfer function) Studies

Cheung (1977) attempted to predict net cash transfers to equities. He defined net cash transfers as dividends, interest paid, net cash from repurchase or sale of all classes of stock, and the net cash from financing activities. He argued that in an all equity firm the cash flow variable is equivalent to cash income less net purchases of assets because this is identical to dividends plus net disbursements from stock transactions. He used the Box-Jenkins procedure to formulate the prediction models for the annual cash flows. His major conclusion was that forecasts of cash flows did not improve with the addition of other accounting data to past cash flows. Cheung's study suffers from several problems, one of them being a definitional one. Firstly, the cash flow definition in his study is neither cash flow to investors nor cash flow from operations. In an all equity firm, cash flow to investors has to take into account the accruals in the current accounts (excluding cash). Secondly, few firms are all equity. Thirdly, his emphasis on the dividend series as a major component leads only to cash flow to owners, which is only one aspect of the firm's activity and hence not enterprise cash flow.

Manegold (1981) investigated the use of multivariate (actually several bivariate) models for predicting future annual earnings. He defined earnings (EBT) as earnings before taxes but excluding non operating income and expenses, and extra-ordinary items. He argued that earnings was an aggregate of several components and each of these components is directly related to some other variable(s). Thus he proposed a component model that disaggregated the earnings into sub-components and built bivariate relationships for each sub-component. The component model forecasts were the aggregation of forecasts from the sub-components. He argued that component model forecasts should be superior to forecasts from univariate Box-Jenkins models on the aggregate earnings number only. His complete model is as follows;

EBT = Operating income before depreciation
and interest expense (OPI).

+ Depreciation (DEP) + Interest expense (INC)

Where he defined:

OPI = Operating Margin (OM) x Sales (Q)

INC = Debt * rate

and the different sub component models were:

OM = f(OM)

Sales = f(industry index)

DEP = f(Gross Investment)

DEBT = f(Gross Investment)

Rate = f(Market rate)

The EBT equation shows that it can be disaggregated into three parts. The next two assumed fixed relationships are calculations which show that operating income is a product of an operating margin and sales and that interest expense is a product of interest rate and debt outstanding. The first of the sub component models is a univariate model where the forecast of operating margin is obtained from the past values of operating margins using the Box-Jenkins univariate procedure. The last four models are bivariate models where the forecast of the output variable is obtained from the past values of the output variable and another input variable that is a leading indicator of the output variable.

His sample consisted of 27 firms, from each of three industries (food, chemical and steel) over a period 1955-1974. The forecasts from these models were then combined to obtain the forecast for EBT for the component based model . He was, however, unable to show the superiority of the component based model forecasts as compared to the univariate model.

Another study by Brooks (1981) compared the predictive ability of quarterly cash flows for a sample of 30 firms. The sample period was from 1964 to 1978. He used univariate and transfer function Box-Jenkins procedure to develop forecasting models. He defined cash flow for the quarter as earnings from operations for the quarter plus depreciation and amortization in the quarter plus a quarter of the annual change in the deferred taxes. The input series in his multivariate model was earnings before extra-ordinary items. The study found that,

1. the addition of earnings series to cash flow series in a multivariate setting did not improve the prediction of cash flows that were obtained from past cash flow series alone in a univariate setting. Thus there was no statistically significant difference between the two Box-Jenkins forecasting models.
2. examining the residuals from the earnings univariate model and cash flow univariate model, on a firm by firm basis, the residual mean square error was smaller for the earnings model than cash flow model, thus indicating that earnings model "fit" the earnings data better than cash flow model to cash flow data.
3. for twenty four out of thirty firms, the univariate models for the cash flow series are identical in form to the earnings series, and

4. the lag term for all thirty transfer functions was zero.

Several comments can be made on these results. The definition of cash flow is inappropriate since all accruals and deferrals have not been included. The definition is a proxy for working capital from operations rather than cash flow from operations. Moreover, his examination of the residual sum of squares showed that the earnings model 'fit' the data better than cash flow models. The earnings models had a lower residual sum of squares as compared to cash flow models. This may have been due to the definition he used which introduced random shocks on the cash flow series. He was able to find transfer function relationships for all of his sample of 30 firms. This is surprising given his disturbing observation that twenty four of thirty earnings models were identical in form to cash flow models. This means that the same underlying process generates both series and so one series can not be used in a Box-Jenkins transfer function to predict the other. Lastly, the lag of zero implies that there is a contemporaneous relationship between the earnings and cash flows. Since the models of the cash flow series and earnings series are identical for twenty four out of thirty firms and there is a lag of zero for all thirty firms, this may mean that there is a third variable which is the leading indicator of both of them. This can also be observed from the table of transfer functions (p 128-9) that show that eighteen out of thirty models had only one significant cross correlation at zero (CCF(0)). This again indicates that a third variable may be a leading indicator of both series.

Finally, the study did not compare the results of the univariate cash flow model to a mechanical naive model. The naive models have been used in several studies as a minimum standard against which to compare the results of the Box-Jenkins univariate model. If there was no difference in the predictive ability of random walk with a drift and the univariate Box-Jenkins models, then transfer function modeling, especially with earnings models being identical to cash flow models for most of the firms, may be inappropriate.

Hopwood and McKeown (1981) compared the forecasts from two transfer function relationships to the forecasts from the quarterly earnings per share models identified in the literature as being representative of the process generating the earnings per share series. The transfer function relationship included earnings per share and a market index of earnings per share. The market index was a weighted average earnings per share of all firms in the sample except the firm being modelled. The two transfer functions were similar, except that one of them had an extra term included on theoretical reasons. The major conclusion of the study was that the transfer function models outperformed univariate quarterly earnings models.

The above survey of the literature reveals that the number of studies in accounting on transfer functions are limited. Hopwood and Newbold (1980) in their survey article comment that there are many interesting issues that have not been resolved.

The exploitation of multivariate methods, which is as yet in its infancy in the area of accounting, is one of them. (p. 142).

Studies on Predictive Ability of Alternative Accounting Methods

Simmons and Gray (1969) simulated four sets of income series for the historical cost, constant dollar and replacement cost. Each set of income series was based on assumed price changes. By using a simple linear extrapolation of past income they forecasted future values of the same series. The predictive ability results of the four series were inconclusive.

Frank (1969) also examined the predictive ability of income numbers. He used historical cost and replacement cost income series. The replacement cost income series was utilized to predict both historical cost and replacement cost income, while the historical cost income series was utilized to predict only the historical cost income. He concluded that there was not much difference in the predictive ability of the two methods.

McKenzie (1970) compared the predictive ability of four income measures to predict its own values. He used simple linear regression models to predict the variables. The four income measures included net income and operating income from historical cost, and net income and operating income from constant dollar. Comparing the predictive ability across different methods, he concluded that the historical cost numbers provided better predictions of their own values.

Lorek, McKeown and Picur (1975) simulated historical cost income, business profit, current operating profit, and net realisable value series for 70 firms. They then used Box-Jenkins techniques to identify firm specific models. Based on their identification, they concluded that pure moving average models dominated the total number of models identified across accounting methods. They had identified 74% pure moving average, 23% mixed models and only 3% autoregressive models.

McKeown and Shalchi (1983) used the firm specific Box-Jenkins univariate procedure to test whether there was a difference in the predictive ability of two alternative accounting methods, the historical cost and constant dollar, in forecasting annual earnings both undeflated and deflated by total assets and retained earnings. Nondeflated earnings measures were defined as follows:

1. historical cost earnings before extra-ordinary items (HCA-NI);
2. Constant dollar earnings before extra-ordinary items (including monetary gains and losses) (GPPA-NI);
3. Constant dollar earnings before extra-ordinary items (excluding monetary gains and losses) (CDA-NI).

The deflated earnings measures were defined as follows:

1. HCA-NI deflated by historical cost beginning total assets (HCA-RA);
2. GPPA-NI deflated by constant dollar beginning total assets (GPPA-RA);

3. CDA-NI deflated by constant dollar beginning total assets (CDA-RA);

4. HCA-NI deflated by historical cost beginning stockholders' equity (HCA-RE);

5. GPPA-NI deflated by constant dollar beginning stockholders' equity (GPPA-RE);

6. CDA-NI deflated by constant dollar beginning stockholders' equity (CDA-RE).

Their sample consisted of 47 firms for the period 1952-1979. The major conclusions were that (a) for earnings values (i) the predictions from GPPA were generally inferior to the other two and (ii) there was no statistical difference in the predictions of HCA and CDA ; (b) for the NI deflated by equity, (i) in all cases HCA outperformed GPPA although only three out of six were statistically significant ; (ii) in all cases but one HCA outperformed CDA but the differences were not statistically significant and (c) for the net income deflated by total assets, (i) in all cases HCA outperformed GPPA, (ii) in all but one case HCA outpeformed CDA but differences were only statistically significant for one case (iii) the forecasts of GPPA were found to be inferior to the other two. However, they note that the results were mixed and no single accounting method outperformed its counterparts in all cases.

This chapter has reviewed the studies on time-series properties and the predictive ability of historical and constant dollar annual cash flow. It has also reviewed the multivariate (transfer function) studies to predict cash flow. Since the number of studies on cash flow are limited, related studies on other accounting numbers were included. The review has shown that there is a big gap in the literature on the time series properties of cash flow, especially constant dollar cash flow. Similarly, there is also a need for research on multivariate (tranfer function) relationships between cash flow and income measures for both accounting methods. This study has attempted to narrow the gap.

The next chapter briefly describes the Box-Jenkins time series procedures used in this study. It also describes some of the naive forecasting models used in previous research.

Notes

1. The expected value of a mean reverting process is a constant. It can be described as:

$$X_t = u + a_t$$

and

$$E(X_t / X_0, \ldots\ldots, X_{t-1}) = u$$

where:

u is a constant.

a_t is the error term. It is an independently and identically distributed random variable with zero mean and constant variance.

2. The expected value of a random walk process is the same as the last known observation. It can be described as:

$$X_t = X_{t-1} + a_t$$

and

$$E(X_t / X_0, \ldots\ldots, X_{t-1}) = X_{t-1}$$

where:

a_t is the error term. It is an independently and identically distributed random variable with zero mean and constant variance.

The expected value of a random walk with a drift process is the same as the last known observation plus a constant term.

3. A pure moving average may be described as:

$$X_t = a_t - \theta_1 a_{t-1} - \ldots\ldots\ldots - \theta_q a_{t-q}$$

where:

a_t is the error term. It is an independently and identically distributed random variable with zero mean and constant variance.

and a pure auto regressive model may be described as

$$X_t = \phi_1 X_{t-1} - \ldots\ldots\ldots - \phi_p X_{t-p} + a_t$$

4. A martingale process is composed of an expected element and a random element. The characterisation is normally in terms of the expected element as follows:

Let $Y_1, Y_2, \ldots$ be the observations

(a) Martingale process if : $E(Y_t / Y_1, \ldots Y_{t-1}) = Y_{t-1}$

(b) Submartingale process if : $E(Y_t / Y_1, \ldots Y_{t-1}) \geq Y_{t-1}$

The martingale process is also a random walk, except there are no distributional properties on the error term of the martingale process. However, in the literature, the two are referred to interchangeably.

CHAPTER 3

TIME SERIES ANALYSIS

This chapter is devoted to describing the Box-Jenkins time-series procedures used in this study to determine the underlying time-series properties and relative predictive ability of both historical cost annual cash flow and constant dollar annual cash flow. It also discusses some of the other naive forecasting models used in the literature. As noted earlier, there is a big gap in the literature on time-series properties and the predictive ability of annual historical cash flow and constant dollar cash flow. Box-Jenkins procedure has been utilized in several studies to determine the underlying time-series properties and relative predictive ability of annual and quarterly earnings numbers [Watts and Leftwich (1977), Foster (1977), Albrecht, Lookabill and McKeown (1977), Brown and Rozeff (1979), Lorek (1979)].

The Box-Jenkins procedure is a structured approach to modeling and forecasting. It helps select the most appropriate model from a broad generalized model which is inclusive of all mathematical definitions of time-series with minimum assumptions. It is also the most comprehensive class of model for handling complex patterns with relative ease on the part of the user. The user need not assume any fixed pattern beforehand, but allows the data to reveal the pattern empirically. This comprehensive class is known as the autoregressive integrated moving average (ARIMA) time-series model. The model (ARIMA) has two components, the autoregressive part (AR) and the moving average part (MA). These parts can be with or without differencing (or integrated), and with or without seasonal effects. All the models in this study are annual series and so will be without the seasonal effect.

Mabert and Radcliffe (1974) give two reasons why the Box-Jenkins procedure leads to better forecasts than the traditional methods. Firstly, traditional approaches require the forecaster to select more or less arbitrarily a specific model, whereas the Box-Jenkins procedure begins with a broad generalised set which includes all possible combinations of autogregressive and moving average models. Systematic elimination of inappropriate models results in the retention of the most appropriate ones. Secondly, unlike the traditional trial and error approach, Box-Jenkins procedure presents a rational, systematic approach that leads to the selection of the most appropriate models.

The Box-Jenkins models make the most efficient use of the data and require no a priori assumption about the process generating the data. The structured approach enables the selection of the best time-series model consistent with the process generating the firm's annual cash flow. The Box-Jenkins procedure is used in this study because it has these desirable features.

In order to compare the predictive ability of the Box-Jenkins models, a "naive" mechanical model, random walk with a drift, is also utilized in this study. The random walk with a drift model is easily available at minimum computational cost. If the random walk with a drift model performs as well as the sophisticated models, then, from a cost-benefit point of view, these sophisticated models can not be justified. Since random walk with a drift is one of the models of the ARIMA class, it is possible that the true model is random walk with a drift but due to the sampling error, some other model is selected using the Box-Jenkins procedures. Finally, previous studies on the predictive ability of annual earnings have used the random walk with a drift model for comparison purposes. There seem to be near unanimity that for annual earnings, random walk with a drift is the most appropriate model (Hopwood and Newbold (1980) p 140).

A complete discussion of the Box-Jenkins procedure is not given here since it is readily available [(see Mabert and Redcliffe (1974), Box and Jenkins (1976), Nelson (1973), McCleary and Hay (1980)]. Instead a brief description of the model building process for the univariate ARIMA model and the transfer function (multivariate) model is presented.

Box-Jenkins Univariate Models

A statistical time-series is a single realisation of some underlying stochastic process that follows a probability density function. Each one of the observations is an actual outcome from infinite possible outcomes. With just one observation from an infinite range of outcomes at each time point, it is difficult to model a time-series. Therefore a strong assumption of stationarity is made. The stationarity assumption states that the process generating the time-series at each point in time is the same. This process has constant mean and variance. Since the process generating the time series is the same and it has constant mean and variance, any observed regularities in the past series will continue to hold in the future, and the properties of the process are unaffected by the shifting of the origin. In other words, the underlying stochastic process is invariant with respect to time. This is a very strong assumption and without this assumption, it would not be possible to model a time-series. The distinguishing feature of this stationary stochastic time-series is that the observations of the realisation set are not assumed to be independent.

The Box-Jenkins univariate procedure builds ARIMA models of the time-series around the three process components, Auto Regressive (AR), Integrated (I) and Moving Average (MA). If a time-series exhibits correlation, this systematic pattern can be exploited by appropriate modeling which will transform the stochastic time-series to a series of random errors which conveys no additional information about the generating process. The random errors are called the white noise process. They are assumed to be independently and identically normally distributed (i,i,d) random variables with mean zero and constant variance.

Thus the time-series modeling asserts that the white noise errors pass through a linear generating process and appear as time-series observations. The modeling process then attempts to identify the generating process by identifying a linear filter which when used on the actual observations will transform it into a white noise process with mean zero and constant variance as shown below:

```
                      -----------------
                      |               |
                      | Linear Filter |
    X   ------->      |               |-------> a
    t                 | (ARIMA Model) |         t
time-series           |               |    white noise
                      -----------------
```

If a particular linear filter fails to transform the observations into white noise with mean zero and constant variance, it is rejected as representative of the generating process. Each filter is one model among the class of ARIMA models.

The ARIMA model, using the backshift operator, can be represented as:

$$\phi(B)\ D(B)\ CF_t = u + \theta(B)\ A_t$$

where:

CF_t is the cash flow at time t

B is the backshift operator on CF_t such that

$$B^k CF_t = CF_{t-k}$$

$$\Phi(B) = 1-\phi_1 B^1 - \phi_2 B^2 - \dots - \phi_p B^p$$

$D(B) = (1-B)^d$ where d is the number of regular differencing

$$\theta(B) = 1-\theta_1 B^1 - \theta_2 B^2 - \dots - \theta_q B^q$$

$\phi_1, \dots\dots, \phi_p$:p is the number of autoregressive parameters

$\theta_1, \dots\dots, \theta_q$:q is the number of moving average parameters

u is the mean of the series when d=0 and trend otherwise

A_t is random variable with mean zero and constant variance

The above model is the ARIMA (p,d,q)

where:

p = the number of autoregressive paramaters

d = the number of regular differencing

q = the number of moving average paramaters

McCleary and Hay (1980) point out that for social science series, the autoregressive parameter, p, is no greater than two and, the moving average parameter, q, is also no greater than two. If the model for annual series, has p greater than two, it can be better represented by a low order (no greater than two) moving average model and vice versa. This is because of the duality of the AR and MA models. An AR(1) model is identical to an MA (infinite) model and an MA (1) model is equivalent to an AR (infinite) model.

Box-Jenkins recommend parsimony in the model selection. This means that the model with the smallest possible number of parameters for adequate representation be employed. In this study only three out of 256 models selected for cash flow series have AR or MA parameters greater than two.

As mentioned earlier, the stationarity assumption requires that the time series should have constant mean and variance. A time-series that does not require differencing because it neither drifts nor trends, is said to be stationary in the homogeneous sense (in mean). Most economic series are not stationary in the homogeneous sense. Box-Jenkins point out that for annual economic time-series the order of differencing required will be no more than second order differencing to make it stationary. In the present study, differencing of order one is adequate to make the series stationary in the mean.

However, if the series is not constant in the variance, it can not be made constant by differencing but rather requires nonlinear transformation. Box-Jenkins recommend the Box-Cox (1964) transformation to make the variance approximately constant, before modelling. The purpose of the transformation is to obtain a new transformed series which has an approximately constant variance and normal errors. This will allow parsimonious modelling.

In this study, the following general nonlinear Box-Cox power transformations are used:

$$Y_t = \begin{cases} [CF_t + S]^P & \text{when} \quad P \neq 0 \\ \log\,[CF_t + S] & \text{when} \quad P = 0 \end{cases}$$

Where:

Y_t is a transformed observation at time t

CF_t is cash flow at time t

S is a shift parameter (constant) to make all values of CF_t positive since power transformation can not be used on negative value(s).

P is the transformation parameter.

If the variance of the time-series is increasing or decreasing with the level of the series, then the logarithmic transformation of the Box-Cox family of power transformations will dampen the series variance and make it approximately constant. Apart from the special case of natural logarithm, other special cases include the square root when P = 0.5, the reciprocal when P = -1, and the square root inverse when P = -0.5. The appropriate selection of P will depend on the pattern exibited by the variance of the time-series. Failure to make the variance approximately constant may lead to inappropriate model selection, inefficient parameter estimates and may bias the forecasts.

The P is initially selected using the procedure of range-mean plots as suggested by Jenkins (1979). The procedure involves dividing sequentially the time-series into several groups, calculating the range and mean of each group, and plotting these ranges and means. The shape of the range-mean plot is compared with a few[1] theoretical range-mean plots and an approximate transformation parameter is selected. Jenkins (1979, p97) cautions that unusual values of P should be avoided in order to make it easier to interpret the model and the forecasts. Then, the best P from a small set of P's is selected at the time of model estimation, using the maximum likelihood function[2].

Since there is an absence of any theoretical work on the selection of S, values of S are selected depending on the time-series being considered. Power transformations require that the value of $(CF_t + S)$ be positive. If all values of CF_t are positive for any given series, then S is set to zero. In other cases, the value of S is selected such that the value of the largest negative observation is positive after S is added.

The Box-Jenkins procedure for univariate time-series analysis involves a three step iterative procedure for identification, estimation and diagnostic checking. The first step in the identification stage is to make the time-series stationary by differencing and/or Box-Cox transformations where appropriate. The auto correlation function and the partial auto correlation function are examined to see if the series are stationary. Once the series are stationary the second step in the identification stage involves determining the p and q of the ARIMA model by examining the time-series sample autocorrelation function (SACF) and sample partial autocorrelation function (SPACF). The SACF and SPACF are compared to the theoretical correlations ACF and PACF, and a tentative model is identified. Since the SACF and SPACF will not exactly match the theoretical correlations due to sampling error, a tentative model is selected and estimated. The third step involves diagnostic checking. This step involves examining the parameter estimates to ensure they are within the stationarity and invertibility conditions, and that the parameter estimates are statistically significant.

If they are not statistically significant, then they are dropped from the model and the model may be reidentified. The next step involves the examination of the residuals. The residuals must be distributed as white noise with mean zero and constant variance. Since the ACF of white noise is expected to be uniformly zero, the SACF of the residuals is examined to ensure that none of SACFS for lags greater than one are statistically significant. There might be one or two statistically significant ones by chance alone in about 30 lags, but these should not be at the first few lags. The Box-Pierce Q-statistic of the residuals (Box-Pierce, 1970), a measure to test the significance of the residual correlation taken as a whole, is also examined. The Q-statistic, which follows a Chi-Square distribution with k-p-q degrees of freedom, is accepted only if its value is within 0.05 significance level. If the computed Chi-Square is smaller than the value from the Chi Square table for the given degrees of freedom, it means that the autocorrelation function of the residuals is not significantly different from zero, and the residuals are randomly distributed. This means that the model selected is a good one because only random errors (white noise with mean zero and constant variance) remain.

Moreover, the mean of the residuals must statistically be significantly different from zero. Where competing models are identified and estimated and satisfy the diagnostic checks, then the best model is selected on the basis of residual mean square error and the Q statistic.

If the estimated model fails the diagnostic checks, then the model is reidentified, reestimated and rediagnosed until an appropriate model is selected.

Box-Jenkins Transfer Function (Multivariate) Models

Box-Jenkins transfer function (multivariate) procedure incorporates the structural relationship between the output series and the input series into a transfer function model. The relationship between the output series, Y_t, and the input series, X_t, can be written as[3]

$$(1-d_r B^r)Y_t = (W_0 - W_s B^s)X_{t-b} + e_t$$

where:

Y_t is a stationary output series value at time t

X_t is a stationary input series value at time t

$$(1-d_r B^r) = (1-d_1 B-d_2 B^2 - \ldots\ldots -d_r B^r$$

$$(W_0 - W_s B^s) = (w_0 - w_1 B^1 - w_2 B^2 - \ldots\ldots -w_s B^s)$$

b is the delay lag in input

r is the output series operator of order r

s is the input series transfer function operator of order s

This model has r + s + 1 terms. There are r terms of lagged Y_t in the model and s+1 terms involving X_t. It incorporates and uses both the past values of the input series and the past values of the output series to forecast future output series.

Similar to the univariate Box-Jenkins procedure, the transfer function (multivariate) procedure also follows the iterative process of identification estimation and diagnostic checking. The identification stage involves the selection of the values of the r, s, b and w_0 terms by examining the sample cross-correlation function (CCF) between the input and output series and comparing it with theoretical cross-correlation. The cross-correlation function measures not only the strength of the relationship but also the direction.

But before the cross-correlation function is computed, the within series correlation has to be removed in order to be able to see the between series correlation. If the within series correlation is not removed, then the cross correlation function is not interpretable.

There are two approaches to remove the within series correlation, a general (double prewhitening) approach which prewhitens both original series by their own identified, estimated and diagnosed filters (ARIMA model), and the simplified (single prewhitening) approach which filters both series by a common filter, the filter of the input series.

Pierce (1977, p15) lists some possible causality patterns and the associated restrictions of the cross-correlation function at lags k. The word "causality" is used only in the sense of indicator series. If a series, cash flow, can be predicted by another series, income, then income is said to be the leading indicator or causor of cash flow. The causality patterns are listed in Table 3.1.

Comparing these relationships and restriction of patterns of CCF at lag k with the sample CCF, the values of a tentative model can be identified. Below is a sample of models that can be identified based on the patterns of cross correlation function (CCF) :

1. When s = 0, b = 0 and $w_0 = 1$, the value of r, the number of lagged terms of Y_t, can be identified by examining the CCF. The value of s = 0 means there is only one (s+1) term involving X_t and and the value of b = 0 means there is no delay lag in the input. For any r the CCF will behave like an auto-correlation function (ACF) of an auto-regressive of order r (AR(r)), e.g. for r = 1, CCF will behave like an ACF of AR(1), the correlations decline exponentially to zero.
2. When s = 0, and $w_0 = 1$, the CCF will behave like an ACF of an AR(r) but will be lagged b periods. Thus the ACF pattern of AR(r) will start at b (normally the value of b is lag at which the first significant correlation occurs). The CCF's at lags < b are not significant.

TABLE 3.1

Conditions on Cross-Correlations of Prewhitened Series for Causality Patterns

Relationship	Restriction on CCF(K) of Prewhitened Series
1. NI indicator of CF	CCF(k) $\neq 0$ for some $k > 0$
2. CF indicator of NI	CCF(k) $\neq 0$ for some $k < 0$
3. Instantaneous causality	CCF(0) $\neq 0$
4. Feedback	CCF(k) $\neq 0$ for some $k > 0$ and some $k < 0$
5. CF does not cause NI	CCF(k) $= 0$ for all $k < 0$
6. Unidirectional causality, NI to CF	CCF(k) $\neq 0$ for some $k > 0$ and CCF(k) $= 0$ for all $k < 0$
7. CF and NI are instantaneously related but in no other way	CCF(k) $= 0$ for all $k \neq 0$ and CCF(0) $\neq 0$
8. CF and NI are independent	CCF(k) $= 0$ for all k

CF : Cash flow series
NI : Income series
CCF : Cross-correlation function of CF and NI series

3. When $w_0 = 1$, the CCF will behave like an ACF of AR(r) but will be lagged b+s periods. Thus CCF at lags < b will not be significant, significant CCF (b), CCF (b+1) to CCF (b+s) will have no clear pattern even if significant and ACF pattern of AR(r) will start from lags > b+s. Therefore s is the difference between first significant cross correlation and when AR(r) pattern starts.

Once a tentative transfer function model has been identified, the model is estimated. The noise term remaining after the transfer function has to be transformed into white noise with mean zero and constant variance. To do this, univariate modeling procedure is followed on the noise series. Then the whole model is estimated and diagnostic checks are made. The first step is to test the residuals for white noise with mean zero and constant variance as explained under the univariate section. If residuals are autocorrelated, then the noise model is misspecified and another noise model has to be identified and the complete model is re-estimated and re-diagnosed. Secondly, the prewhitened input series is cross correlated with the residuals. If there is any sign of correlation, then the transfer function is misspecified, and identification has to start again. Apart from these, all the parameter estimates must be statistically significant and otherwise acceptable to be included. To be acceptable the parameters must be within bounds to system stability and invertibility conditions.

Martingale Processes

An observation from the time series may be thought of as being composed of partly an expected deterministic element and partly an unexpected random element. The martingale process can be characterised by the form of the deterministic portion of the process. This process can be written as:

Let $Y_1, Y_2, \ldots$ be the observations

$$Y_t = Y_{t-1} + a_t$$

and $$E(Y_t / Y_1, \ldots Y_{t-1}) = Y_{t-1}$$

where

Y_{t-1} is the most recent actual value.

a_t is a random variable with no distributional properties.

The submartingale can be characterised as:

and $$E(Y_t / Y_1, \ldots Y_{t-1}) \geq Y_{t-1}$$

If the cash flow follows a martingale process, then the changes in the cash flow will be statistically independent over time, and as such, will behave like random numbers. Thus a martingale process can be identified by examining the changes in the cash flow. They should have zero serial correlation. Moreover, for forecasting purposes, past series of cash flow would be irrelevant since the expected value of the next period is this period's cash flow.

The martingale process can be written in a ARIMA (p,d,q) as ARIMA (0,1,0), but the submartingale can not be written. This is because the direction of value is known but the magnitude of the change is not known. Note that the ARIMA (0,1,0) is actually a random walk model.

Random Walk Model

The random walk is a special case of the ARIMA (p,d,q) model. It is characterised as ARIMA (0,1,0). It can be written as:

$$Y_t = Y_{t-1} + a_t$$

and differencing this will result in

$$(Y_t - Y_{t-1}) = a_t$$

where:

a_t is a random variable with mean zero and constant variance.

When the random walk model has a drift, the model has an additional constant term. Therefore, the expectation of the changes in the series will be a constant. Random walk with a drift model is used in this study as a minimum cost base to compare with the accuracy of the more sophisticated Box-Jenkins models. These models have been used in the literature (e.g. Watts and Leftwich (1977); Albretch, Lookabill and McKeown (1977)).

Mean Reverting Process

In a mean reverting or constant expectation process, the expected value of the next period is a constant. This process can be written as:

$$X_t = u + a_t$$

and

$$E(X_t / X_0, \ldots\ldots, X_{t-1}) = u$$

where:

u is a constant.

a_t is the error term. It is an independently and identically distributed random variable with zero mean and constant variance.

The mean reverting process is a special case of the Box-Jenkins models. In the ARIMA (p,d,q) form, the mean reverting process can be described as an ARIMA (0,0,0) process with a constant. In the identification stage of the Box-Jenkins procedure, the process can be identified by examining the auto correlation function and partial auto correlation function, both $ACF(k) = 0$ and $PACF(k) = 0$ for all $k > 0$.

If the cash flow follow a mean reverting process, it implies that the average periodic cash flow are stable over time and the actual cash flow will revert to the mean. If, in any period, the cash flow are higher than the mean, then in the next period, on average, the cash flow will be lower than the mean. This tendency to revert back to the mean results in negative dependencies in the changes of cash flow.

This chapter has described the Box-Jenkins univariate and multivariate (transfer function) procedure that is used in this study. It also described other naive models that have been used in the literature. The next chapter will discuss the research methodology in detail.

Notes

1. In this study the P is resticted to 1, 0.5, 0, -0.5 and -1.

2. This is performed by the Time Series Package developed by David Pack and distributed by Automatic Forecasting Systems.

3. For details refer to chapter 11 of Makridakis and Wheelwright (1978).

CHAPTER 4

METHODOLOGY

This chapter describes the methodology utilized in this study. The first section explains the sample selection process and data collection procedures. The second section presents the procedure for generating cash flow series from the financial statements. The third section provides a brief review of the generation of constant dollar accounting statements and, finally, the last section provides a detailed discussion of the hypotheses tested, the error metrics utilized and the statistical tests used in this study.

Sample Selection

The data required for this study covering the period 1950 to 1981 is obtained primarily from the two COMPUSTAT tapes[1]. Other information required but not available on the tapes is obtained from the Moody's Industrial Manuals, the 10-K reports, as well as companies' annual financial statements and directly from the companies. The following criteria are used to select the sample:

1. Companies should have all data items[2] required for calculating cash flow from operation and for restating historical cost financial statements into constant dollar accounting financial statements for the entire period

1950-1981.

2. The companies should have the same fiscal year end for each of the years 1950-1981.
3. The companies should have used only one inventory valuation method in each year under consideration, i.e. a combination of inventory valuation methods in any given year is not permitted.
4. The companies should have used one of either first in first out, last in first out, specific identification or average cost inventory valuation methods[3].

The first requirement is crucial in obtaining historical and constant dollar cash flow series. The second requirement is imposed to ensure the time series observations are equally spaced, and to allow the constant dollar financial statements of the companies in the sample to be more homogeneous and comparable. The third requirement is imposed due to lack of information regarding the composition of historical cost inventories when more than one inventory valuation methods are used. Detailed information on the composition of inventories of such companies are not available and such information is necessary for the constant dollar adjustments. The last restriction is imposed for computational efficiency. Algorithms for constant dollar adjustment for inventory valued on valuation methods specified above are available and are easy to apply, while algorithms for other methods such as retail inventory valuation, standard costing, etc. have not been developed and adequate information on these methods is not readily available from the published accounting records.

Prior to investigation of the data base, no information is available as to how many firms with complete data sets would be available. A detailed search of 2442 firms on the COMPUSTAT tapes produced only 13 companies with complete data sets. The criterion of complete data sets was relaxed and the search based on the other two crucial criteria produced 104 firms. The final sample of 64 companies is built up from the original thirteen by including companies whose missing data are available from other data bases mentioned earlier. All companies in the final sample have December 31 year end.

As a result of the above procedure, a final sample of 64 firms covering the 1950-1981 period is selected for the current research. The list of sample companies is presented in Table 4.1.

This selection process is not equivalent to random sampling of firms from all available firms since only the firms on the COMPUSTAT tape meeting the criteria of availability of complete data sets, fiscal year end and the inventory valuation method for the entire sample period are selected. Moreover the sample has a "survivorship" bias because failed firms are excluded together with firms that are recently organised. Thus the results of this research are only applicable to firms meeting the above criteria and not universally applicable to all firms.

Table 4.1

List of Firms in the Sample

Firm	Company Number	Company Name	Industry Code
1	356714	Freeport McMoran Inc	1499
2	618448	Morrison-Knudsen	1600
3	487836	Kellogg Co	2000
4	629525	Nabisco Brands Inc	2000
5	143483	Carnation Co	2020
6	24069	American Bakeries Co	2050
7	693715	Pabst Brewing Co	2082
8	77491	Belding Heminway	2200
9	547779	Lowenstein (M.) Corp	2200
10	626320	Munsingwear Inc	2250
11	501026	Kroehler Mfg Co	2510
12	29465	American Seating Co	2520
13	809877	Scott Paper Co	2600
14	398784	Grolier Inc	2731
15	580645	McGraw-Hill Inc	2731
16	2824	Abbott Laboratories	2830
17	812302	Searle (G.D.) & Co	2830
18	832377	Smithkline Beckman Corp	2830
19	859264	Sterling Drug Inc	2830
20	48825	Atlantic Richfield Co	2911
21	907770	Union Oil Co of California	2911
22	216831	Cooper Tire & Rubber	3000
23	608302	Mohawk Rubber Co	3000
24	219327	Corning Glass Works	3221
25	156879	Certain-Teed Corp	3290
26	565020	Manville Corp	3290
27	224399	Crane Co	3310
28	637844	National Steel Corp	3310
29	760779	Republic Steel Corp	3310
30	912656	U S Steel Corp	3310
31	574599	Masco Corp	3430
32	253651	Diebold Inc	3499

(Continued)

Table 4.1 (Continued)

List of Firms in the Sample

Firm	Company Number	Company Name	Industry Code
33	118745	Bucyrus-Erie Co	3530
34	149123	Caterpillar Tractor Co	3531
35	867323	Sundstrand Corp	3560
36	122781	Burroughs Corp	3570
37	459200	Intl Business Machines Corp	3570
38	878895	Tecumseh Products Co	3580
39	31105	Ametek Inc	3620
40	620076	Motorola Inc	3662
41	860486	Stewart-Warner Corp	3662
42	171196	Chrysler Corp	3711
43	97023	Boeing Co	3721
44	539821	Lockheed Corp	3760
45	770519	Robertshaw Controls	3820
46	71892	Baxter Travenol Laboratorie	3841
47	731095	Polaroid Corp	3861
48	984121	Xerox Corp	3861
49	746384	Purolator Inc	4210
50	105425	Braniff International Corp	4511
51	210795	Continental Air Lines Inc	4511
52	276191	Eastern Air Lines	4511
53	667281	Northwest Airlines Inc	4511
54	893364	Trans World Corp	4511
55	902550	Ual Inc	4511
56	957586	Western Air Lines Inc	4511
57	24735	American Broadcasting	4830
58	124845	CBS Inc	4830
59	252435	Di Giorgio Corp	5140
60	299209	Evans Products Co	5211
61	370064	General Host Corp	5411
62	776338	Ronson Corp	3630
63	313549	Federal-Mogul Corp	3714
64	604059	Minnesota Mining & Mfg Co	3861

Generation of Annual Cash Flow Series

For the purposes of this research, cash flow is defined as cash flow from operations. The data items, together with the respective COMPUSTAT data number, used to calculate cash flow are shown below:

	COMPUSTAT Data #
Net income before extra-ordinary items and discontinued operations	18
+ Depreciation and Amortization	14
+ Deferred Taxes	50
+ Minority Interest	49
+ Decreases in Non-Cash Current Assets	1 and 4
+ Increases in Non-Cash Current Liabilities	5

The above definition is a proxy for the cash flow from operations since the correct definition should similarly adjust for unremitted earnings of unconsolidated subsidiaries. It is not possible to get this item from either the COMPUSTAT tape for years prior to 1971, Moody's Industrial Manuals, 10-K reports or the companies' annual financial statements. Therefore, it is necessary to estimate it. The procedure employed in this study involved a series of steps. Since the investment and advances in subsidiaries on equity basis is available on the COMPUSTAT tape, three alternatives are considered to approximate the unremitted earnings numbers. The three possible alternatives are :

1. Take the difference of the end of the year and the beginning of the year investment account and treat the amount as being unremitted earnings. This, in effect, results in netting the amount of unremitted earnings with the amount of net

additional investments during the year.

2. Take only the positive difference of the end of the year and the beginning of the year investment account. This is the same as (1) above except, where the amount of net investments decrease more than the amount of its share of earnings of unconsolidated subsidiaries during the year, assume that all earnings are remitted.

3. Assume all earnings are remitted and thus ignore unremitted earnings from above the calculation of cash flow.

A preliminary correlation investigation of actual cash flow for 1971-1980 and the three proxy cash flow indicated that the last approach had the highest correlation coefficient in the majority of cases and so it is selected for this study.

It should be noted that two previous studies on cash flow, Icerman (1977) and Khumawala (1978) have treated the whole of subsidiary income recognized under the equity method as unremitted earnings. This study takes the opposite view and regards the whole of subsidiaries earnings as remitted. This view seems reasonable based on the correlations performed for years when precise determination was available. Moreover, treating the whole of the subsidiaries income as unremitted implies that the subsidiaries will never remit any earnings over its life time. Thus it seems seems reasonable to say that the cash flow calculation utilized in this study is an appropriate estimate for the actual cash flow numbers that could be made from publicly available information.

Constant Dollar Accounting Adjustments

In this study cash flow series for both historical cost as well as constant dollar are constructed. This requires complete historical cost and constant dollar financial statements for each firm over the entire 1950-1981 period. Historical cost financial statements for each of the 1950-1981 years is obtained from the COMPUSTAT tapes. Constant dollar financial statements are not publicly available due to the absence of any requirement prior to FASB #33 to disclose such information. For the current study an acceptable estimation of the constant dollar financial statements for each firm for each of the years of the sample period is required. Such constant dollar estimation techniques have been developed and used in the literature [e.g. Peterson (1971), Davidson and Weil (1975), Parker (1977)] and validated by Ketz (1978). Ketz (1978) compared the accuracy of the three constant dollar estimation algorithms and concluded that there are minor differences in accuracy among the three estimation procedures, and as such each estimation procedure is acceptable for constant dollar adjustment. In this study an estimation technique similar to Parker's (1977), but modified to make it in general conformity with FASB #33 is used[4]. In accordance with FASB #33 the Consumer Price Index is used in this study.

Research Design

After the sample of 64 firms is selected, the historical cost financial statements of each company are adjusted for constant dollar in the dollars of 1981. It is the primary objective of this study to provide empirical information regarding the time-series properties of historical cost and constant dollar annual cash flow. The study will determine the relationship between income and cash flow, and develop multivariate forecasting models. The study will also compare the relative predictive ability of the different prediction models, random walk with a drift, Box-Jenkins univariate and transfer function models, within and across accounting methods.

Once the cash flow and net income series for the period 1951-1979 are calculated for each of the 64 firms for historical cost and constant dollar accounting methods, firm specific Box-Jenkins univariate models are identified and the required parameters are estimated for each of the cash flow series across the two accounting measurement methods. These firm specific Box-Jenkins models for cash flow are then utilized to generate one-step-ahead, F(1980/1951-1979), and two-step-ahead, F(1981/1951-1979), forecasts of cash flow. Then the base period of 1951-1979 is updated by one year to include 1980 data. The firm specific Box-Jenkins models for cash flow are then reidentified and reestimated based on data for 1951-1980. These models are then utilized to generate one-step-ahead forecasts of cash flow for the year 1981, F(1981/1951-1980).

The firm specific net income series models are also needed in this study. The reason is that to identify a transfer function (multivariate relationship) between cash flow and net income series, the within series correlation in each series has to be removed in order to be able to examine the between series correlation through the cross correlation. The process of removing the within series correlation is called "prewhitening" when the series own ARIMA filter is used, and is called "filtering" when another series filter is used. The cross correlations of the "filtered" cash flow and "prewhitened" net income series are then used to identify the order of the parameters and the lag in the transfer function modeling.

As mentioned before, this study also compares the relative predictive ability of the three prediction models, random walk with a drift, univariate Box-Jenkins model, and Box-Jenkins transfer function model, for each of the historical cost and constant dollar accounting method, to predict one and two period ahead cash flow. To evaluate the models' accuracy, two widely utilized error measures are used in this study. The error measures are absolute percentage error (APE) and squared percentage error (SPE). These error measures have been widely used to test the prediction accuracy of the forecasts (e.g Foster (1977); Brown and Rozeff (1979)).

The absolute percentage error measure assumes a linear loss function on the part of the decision maker while the squared percentage error assumes a quadratic loss function. In a linear loss function assumption the loss incurred by the decision maker is proportional to the size of the prediction error. Under the quadratic loss function assumption, the loss increases more than proportionately (square of the error) with the increase in the prediction error. Both error measures assume that there is no difference in the relative importance of a positive and a negative error of the same magnitude. If these assumptions do not hold, then the ability to generalize from this study is limited. However, given the state of knowledge in this area, it is impossible to specify the theoretically correct loss function of the users of the forecasts. The formal description of these measures is presented in Table 4.2.

A problem is encountered in using the two error measures. When the actual value of cash flow approaches zero, the error measures become very large. In order to avoid a few large errors to unduly influence the statistical results, these few large errors are truncated at 200% for APE and 400% for SPE (i.e. Error values of APE and SPE greater than 200% and 400% are set to 200% and 400% respectively.) This truncation technique has been used previously by researchers using the two error metrics (e.g. McKeown and Shalchi (1983)).

Based on the above error metrics a set of statistical hypotheses are developed. As mentioned earlier, for each forecasting model, three forecast errors are generated. The absolute percentage error and squared percentage error metrics are tested over each of the three forecast periods and two

Table 4.2

Formal Description of Error Measures

The absolute percentage error measure is defined as:

$$APE = \left| [F_t - A_t] / A_t \right|$$

and the squared percentage error is defined as:

$$SPE = [APE]^2$$

where:

F_t is the cash flow forecast for period t

A_t is the actual cash flow for the period t accounting methods are employed. This resulted in seventy-eight statistical hypotheses. Rather than list all seventy-eight hypotheses here, Table 4.3 presents the complete list of null hypotheses with indexed variables, while only three general hypotheses are presented here.

H_o 1: There are no differences in the predictive ability of the two prediction models, BJU and RWD, to predict the annual cash flow.

H_o 2: There are no differences in the predictive ability of the two prediction models, TF and BJU, to predict annual cash flow.

H_o 3: There are no differences across accounting methods, HC and CD, in the predictive ability of the different prediction models, RWD, BJU, and TF, to predict their respective annual cash flow.

The above hypotheses were tested for each forecast period and each accounting method.

To test the above hypotheses, both non-parametric and the parametric tests are used. The non-parametric Wilcoxon signed rank test (Siegel (1956)) is chosen because it does not make any restricted assumptions with regard to the distribution of the data being analysed. The Wilcoxon matched pairs signed-rank test utilizes information about the direction, as well as the relative magnitude of the differences. It gives more weight to pairs which show a large difference than ones with small differences. According to Siegel (1956, p83), when the assumptions of the parametric t test are met, the power of the Wilcoxon matched pair signed-rank test compared to the t test is

Table 4.3

Complete List of Hypotheses using Indexed Variables

Ho (1,F,M)	:	Hc (F,M,Rwd)	=	Hc (F,M,Bju)
Ho (2,F,M)	:	Hc (F,M,Bju)	=	Hc (F,M,Tf)
Ho (3,F,M)	:	Cd (F,M,Rwd)	=	Cd (F,M,Bju)
Ho (4,F,M)	:	Cd (F,M,Bju)	=	Cd (F,M,Tf)
Ho (5,F,M)	:	Hc (F,M,Rwd)	=	Cd (F,M,Rwd)
Ho (6,F,M)	:	Hc (F,M,Rwd)	=	Cd (F,M,Bju)
Ho (7,F,M)	:	Hc (F,M,Rwd)	=	Cd (F,M,Tf)
Ho (8,F,M)	:	Hc (F,M,Bju)	=	Cd (F,M,Rwd)
Ho (9,F,M)	:	Hc (F,M,Bju)	=	Cd (F,M,Bju)
Ho (10,F,M)	:	Hc (F,M,Bju)	=	Cd (F,M,Tf)
Ho (11,F,M)	:	Hc (F,M,Tf)	=	Cd (F,M,Rwd)
Ho (12,F,M)	:	Hc (F,M,Tf)	=	Cd (F,M,Bju)
Ho (13,F,M)	:	Hc (F,M,Tf)	=	Cd (F,M,Tf)

where

F are the forecasts:
- F(1980/1951-1979) are one-year-ahead forecasts for the base period,
- F(1981/1951-1979) are two-year-ahead forecasts for the base period,
- F(1981/1951-1980) are one-year-ahead forecasts for the updated base period.

M is the error metric: absolute percentage error and squared percentage error.

Hc is historical cost accounting method.

Cd is constant dollar accounting method.

Bju is the Box-Jenkins univariate prediction model.

Rwd is the random walk with a drift model.

Tf is the transfer function (multivariate) model with cash flow as output variable and income as input variable.

about 95.5 percent for large samples and the efficiency is near 95 percent for small samples.

For the parametric test, analysis of variance is used. The degrees of freedom of the F-statistic are adjusted using a theta factor adjustment procedure suggested by Box (1954). This adjustment is necessary due to the use of repeated, correlated data in each set making the homogeneity of covariance matrix highly critical. This adjustment procedure has also been used in previous published research (Lorek and McKeown (1977), Shalchi (1983)). With the theta factor adjustment, θ , the numerator and denominator degrees of freedom are adjusted and new corrected probability significance levels are obtained.

The analysis of variance test essentially tests whether significant mean differences exist in the prediction errors, while the Wilcoxon signed-rank tests the effect of the magnitude of the differences as well as the sign of the difference.

This chapter has described the sample selection process that resulted in the sixty four firms to be used in this study. The data used in this study will be annual numbers of historical cost and constant dollar accounting methods for the period 1951 to 1981. It also defined the cash flow numbers. It explained how cash flow numbers will be utilized to make one period and two period ahead forecasts for the univariate and transfer function models. Finally it described the two error metrics that will be constructed to test the hypotheses using both non-parametric and parametric tests. The detailed empirical results will be provided in the next chapter.

Notes

1. Each tape contains 20 years of data but periods overlap on the tapes (1950-1969 and 1962-1981).

2. COMPUSTAT data items 1-9, 12, 14, 16, 17, 18, 19, 21, 35, 41, 48, 49, 50 and 59.

3. COMPUSTAT data item #59 should be either 1, 2, 3, or 4 i.e. ≤ 4.

4. Since the constant dollar estimation procedure of Parker (1977) is well documented in his paper and in Shalchi (1981) it is not repeated here.

CHAPTER 5

ANALYSIS OF EMPIRICAL RESULTS

This chapter presents and examines the time-series analysis of historical cost and constant dollar cash flow series. It also presents the results of the transfer function identification process for both the historical cost and constant dollar cash flow. Finally it compares and tests the relative predictive ability of the random walk with a drift, with the Box-Jenkins univariate models and the predictive ability of the different prediction models across accounting methods.

Identified Univariate Time-Series Models

As described in the previous chapter, the Box-Jenkins procedure for univariate time-series analysis is utilised to identify firm specific autoregressive integrated moving average models of the cash flow series for the historical cost and constant dollar accounting methods. Historical cost cash flow series covering the period 1951-1979 are utilized to identify and fit firm specific models and predict one year ahead and two years ahead forecasts. Then the base period is updated by one observation. Firm specific univariate models are again identified and fitted with the expanded base period (1951-1980) and one-year-ahead forecasts are made. The same procedure is adopted for constant dollar cash flow series. This process results in four firm specific models being fitted for each of the sixty-four firms in the sample and thus a total of 256 firm specific models are fitted for the entire sample.

The identification process is not presented here since a complete description would require presentation of both auto-correlation functions and partial auto-correlation functions for each series at each stage of the identification process. Since detailed examples of univariate identification are easily available (Box and Jenkins (1976); Jenkins (1979); Nelson (1973); Mabert and Radcliff (1974); McClary and Hay (1980)), only identified models and the model estimates are presented here. This analysis is presented for historical cost cash flow series followed by the constant dollar cash flow series.

Results of the Univariate Historical Cost Cash Flow Series

A summary of the cash flow models identified and estimated for the base period and the updated base period for each of the sixty-four firms in the sample is presented in Table A.1 and Table A.2 in the appendix.

As there are no seasonal factors, because all series in this study are annual series, the specified (p,d,q), the constant term and the Box-Cox transformation parameter completely describe each model. The value p in (p,d,q) specifies the order of autoregressive operators employed, although the number of non-zero statistically significant autoregressive parameters utilized in the model may be less than p. The value q specifies the order of the moving average operator employed and, just like p, the number of non-zero statistically significant parameters utilized in the model may be less than q. According to McClary and Hay (1980), for social science series the value of p or q would be no more than two since a higher order p model can be better represented by a lower order q model. In this study, except for three out of 256 models identified, all values of p or q are no more than two. The value d denotes the order of differencing to make the series stationary. According to Box and Jenkins, for annual economic time series the value of d would normally be no more than two. In this study the first order differencing is adequate to make all series stationary. The constant term represents the mean of the series when d=0 and trend of the series otherwise. The constant term is estimated at the same time as other parameters are estimated and is included only if statistically significant.

The Table 5.1 summarizes the frequency of historical cost cash flow models identified for the base period (1951-1979) and the updated based period (1951-1980). For the base period, it can be observed that 32 out of 64 models are pure autoregressive models, the remainder being white noise (14), random walk (10) and moving average (8) in that order, with no mixed models. The constant term is statistically significant for 12 (out of 14) white noise models identified.

Table 5.1

Frequency of
Historical Cost Cash Flow Models

ARIMA Model (p,d,q)	Model Class	1951-1979	1951-1980	Total
(000)	WN	14	14	28
(010)	RW	10	9	19
(100)	AR	8	8	16
(200)	AR	3	3	6
(300)	AR	-	-	-
(110)	AR	17	18	35
(210)	AR	4	5	9
(001)	MA	1	1	2
(002)	MA	-	-	-
(011)	MA	4	4	8
(012)	MA	3	2	5
(013)	MA	-	-	-
Total		64	64	128
Stationary		22	23	45
Transformed only		4	3	7
Differenced only		36	36	72
Diff and Transformed		2	2	4
Total		64	64	128
WN models		14	14	28
RW models		10	9	19
AR models		32	34	66
MA models		8	7	15
Total		64	64	128

WN : white noise
RW : random walk
AR : autoregressive
MA : moving average

For the updated base period, the results are similar. Most of the models are autoregressive (34) followed by white noise (14), random walk (9) and moving average (7). For both periods taken together 83 (out of 128) series are not stationary and require some kind of transformations to make them stationary. Among the autoregressive category, 25 for the base period and 26 for the updated base period are autoregressive models of order 1. Albrecht et al (1977) concluded that annual earnings series follow either an autoregressive or a random walk process and it can be concluded here that historical cost annual cash flow follow either autoregressive or white noise process, a pattern similar to the historical cost annual earnings.

Various diagnostic checking statistics are used, including the Box-Pierce (1970), Q-statistic, to test the adequacy of the identified and estimated univariate models. The Box-Pierce Q-Statistic tests to see whether a given number, k, of autocorrelations of the residuals taken in a row are white noise with mean zero and constant variance. If residuals are not white noise with mean zero and constant variance, implying that the fitted model is inadequate, then Q statistic, which follows a Chi-square distribution with k-p-q degrees of freedom and adjusted for small samples will be large and exceed the upper limit of the Chi-square distribution. In the present study all calculated Q values are within the upper bounds of Chi-square distribution with k-p-q degrees of freedom at 0.05 significance level. The diagnostic statistic for the residuals of the identified models are presented in the appendix in Table A.3 for the base period (1951-1979) and Table A.4 for the updated base period (1951-1980). The tables list the (k-p-q) degrees of freedom in column two, the calculated Box-Pierce Q-statistic in column three and the probability of the Q-statistic as large as the one calculated appearing, when the series is white noise with mean zero and constant variance, in the last column. A table of Chi-square distribution with the degrees of freedom relevant for this study is presented in Table A.5. The tables show that all models are acceptable at at least 0.05 level of significance. In most cases, the calculated Q-statistic for the given degrees of freedom is far smaller than the value from the Chi-square table at 0.05 level of significance, thus the probability of the Q-statistic occuring as large as the one calculated is greater than 0.05.

The estimated model parameters are also examined for adequacy. They had to be both statistically significant and within the bounds of stationarity invertibility conditions. Where two or more competing models are identified and fitted, Q-statistic, residual sum of squares, plot of residuals and parsimony considerations are used to select the most appropriate model. The parsimony criterion is recommended by Box and Jenkins in model selection. This criterion results in the model with the smallest possible number of parameters for adequate representation to be employed.

Results of the Univariate Constant Dollar Cash Flow Series

The annual constant dollar cash flow models identified and estimated for both the base period and the updated base period for each of the 64 firms in the sample are presented in the appendix in Table A.6 and Table A.7. The Table 5.2 presents the frequency of different models identified and estimated for the entire sample.

With regard to the time-series properties of constant dollar annual cash flow series it can be observed that there are significant white noise models among the models identified although pure autoregressive models still account for about 50% of the total number of models identified. Again there are no mixed models identified for any series.

The result for the base period shows that most of the identified models are either autoregressive (32) or white noise (25) while the remaining (7) are moving average or random walk. Thus, the constant dollar cash flow appear to follow either an autoregressive or a white noise process since 89% of the identified models are autoregressive or white noise processes.

The results of the updated base period are consistent with the base period. There are 30 (47%) autoregressive models identified, 24 (38%) white noise models while the remaining 10 (15%) are moving average (8) or random walk (2).

Among the autoregressive category, 22 for the base period and 20 for the updated base period are autoregressive models of order 1. Moreover, more than half (18) of the autoregressive

Table 5.2

Frequency of
Constant Dollar Cash Flow Models

ARIMA Model (p,d,q)	Model Class	1951-1979	1951-1980	Total
(000)	WN	25	24	49
(010)	RW	2	2	4
(100)	AR	12	12	24
(200)	AR	5	5	10
(300)	AR	1	1	2
(110)	AR	10	8	18
(210)	AR	4	4	8
(001)	MA	1	1	2
(002)	MA	1	-	1
(011)	MA	3	6	9
(012)	MA	-	-	-
(013)	MA	-	1	1
Total		64	64	128
Stationary		41	39	80
Transformed only		4	4	8
Differenced only		15	17	32
Diff and Transformed		4	4	8
Total		64	64	128
WN models		25	24	49
RW models		2	2	4
AR models		32	30	62
MA models		5	8	13
Total		64	64	128

WN : white noise
RW : random walk
AR : autoregressive
MA : moving average

models identified do not require any differencing and for all models identified the majority (80 out of 128) of the series are stationary and thus require no differencing or transforming. The constant term is statistically significant for most of the white noise models identified (21 out of 25).

The diagnostic statistics results are presented in the appendix in Table A.8 for the base period and Table A.9 for the updated base period. All models are acceptable at at least 0.05 level of significance.

In comparison to historical cost, several observations can be made. First there is a drastic increase in the number of stationary series. There are 41 stationary constant dollar cash flow series in the base period and 39 in the updated base period as compared to 22 historical cost cash flow series in the base period and 23 in the updated base period. Thus, constant dollar adjustments seem to stationarize the cash flow series. This may be due to the constant dollar adjustments of rolling forward of the cash flow series. The rolling forward procedure may lead to a stable mean over time. Secondly, only 2 random walk models are identified for constant dollar cash flow series as compared to 10 random walk for historical cost cash flow series, and some of these random walk for historical cost series apparently have been identified as white noise in the case of constant dollar. Constant dollar cash flow series have a significant portion of white noise models (25 out of 64) as compared to historical cost cash flow series (14). Moreover, the autoregressive and moving average models identified are about the same and in both cases the first order autoregressive (1) models dominate.

<u>Multivariate Time-Series Models</u>

The second purpose of this study is to test empirically the lead relationship between cash flow and income as asserted by the Financial Accounting Standards Board (1978; 1981) and develop Box-Jenkins multivariate forecasting models. The univariate models employed in this study use the past stream of cash flow to forecast future cash flow. The multivariate model used in this study incorporates income and cash flow to predict future cash flow. In order to incorporate the income into the Box-Jenkins multivariate analysis, transfer function (Box-Jenkins multivariate) techniques must be used. The transfer function models the relationship between the cash flow and income series for each firm.

In its general form, the transfer function model can be written as:

$$CF_t = S(B)^{-1} \; W(B) \; NI_{t-b} + E_t$$

where:

CF is the cash flow series suitably differenced to obtain stationarity.

NI is the income series suitably differenced to obtain stationarity.

W(B) is the Box-Jenkins univariate model for income series used to reduce NI to white noise.

$S^{-1}(B)$ is the function that reduces relationship between CF and prewhitened NI series to noise series.

E_t denotes stochastic variation not attributable to NI series.

$S^{-1}(B)\ W(B)$ is referred to as the transfer function.

Since the income series is not expected to capture all the variation in the cash flow series, the residuals, E_t, which is the noise of the model may not be white noise. Therefore to reduce E_t to white noise, a univariate Box-Jenkins model has to be modelled for E_t. The Box-Jenkins univariate model for the residuals, E_t, is represented as:

$$E_t = \phi^{-1}(B)\ \theta(B)\ A_t$$

The complete transfer function model can now be represented as:

$$CF_t = S^{-1}(B)\ W(B)\ NI_{t-b} + \phi^{-1}(B)\ \theta(B)\ A_t$$

In order to identify the transfer function, two approaches are available, depending on whether information is available about the direction of lead between the two series. If the direction of lead is from the income to cash flow, and not vice versa, then a simplified (single prewhitening) approach is available. If the direction of lead is not available, then the general (double prewhitening) approach has to be used.

In the general approach, appropriate Box-Jenkins univariate models are identified, estimated and diagnosed for both the cash flow and income series. These models are then used to transform cash flow and income series by their own model to obtain "prewhitened" cash flow and "prewhitened" income series. These new series are, in effect, the residuals series and are white noise with mean zero and constant variance. The Box-Jenkins univariate cash flow model is of the form:

$$\phi(B)\ CF_t = \theta(B)\ y_t$$

where:

CF is the cash flow series suitably differenced to obtain stationarity.

Y is the residual series.

B is the backshift operator on CF_t such that

$$B^k CF_t = CF_{t-k}$$

$$\phi(B) = 1-\phi_1 B^1 - \phi_2 B^2 - \ldots - \phi_p B^p$$

$$\theta(B) = 1-\theta_1 B^1 - \theta_2 B^2 - \ldots - \theta_q B^q$$

Thus the residual, y_t, from the prewhitened cash flow series can be represented as

$$y_t = \phi(B)^{-1} \theta(B) \; CF_t$$

and in short form

$$y_t = W_1(B) \; CF_t$$

Similarly, the residual, x_t, from the income series can be represented as

$$x_t = W_2(B) \; NI_t$$

When single prewhitening is used, W_1 is set equal to W_2 and only one filter, the filter of the independent variable, is used. In double prewhitening approach each series is prewhitened by its own filter (i.e. its own univariate models).

The X_t variable includes only one type of pattern or variation in its generating process. The Y_t, on the other hand, includes the pattern caused by its own process, the variation caused by the generating process of X_t, and the variation caused jointly by previous values of Y_t and X_{t-b}. Therefore, the prewhitening step is necessary to remove this within series variability so that the between-series correlation can be identified, using the cross-correlation function. If the prewhitening step is not performed, sample cross-correlation function is uninterpretable. However, if the variables are prewhitened, an interpretable cross-correlation function can be estimated (McCleary and Hay (1980) p. 243). The cross-correlation function represents a series of correlations between the income residuals, x_t, and the lagged (positive and negative) cash flow residuals, y_t. As described in chapter three the patterns of the sample cross-correlation function can then be compared to theoretical causality patterns and the associated cross-correlation function to identify a tentative transfer function. This process of identification from cross-correlation function is similar to the identification stage of the univariate models from the auto-correlation function.

Prewhitening both cash flow and income series is time consuming and expensive. If the direction of lead is from income to cash flow, then only income has to be prewhitened. This is done on the assumption that if the income is the leading indicator of cash flow then the generating process of income should be similar to that of cash flow. Thus, the cash flow series can be filtered (transformed) by using the income model that is identified and estimated. Then the cross-correlation function between the prewhitened income and filtered cash flow is estimated to identify the transfer function relationship.

In this study, the simplified approach is initially used on the basis of repeated assertions by the Financial Accounting Standards Board (1978 ;1981) that the direction of lead runs from income to cash flow. The general approach of prewhitening both series is also used to check whether the direction of lead is from cash flow to income.

Results of the Transfer Function Modelling of Historical Cost Series

The summary of cross-correlation function results for historical cost series for both approaches is given in Table 5.3 The most significant aspect of these results is that there is no clear empirical evidence of the direction of lead running from income to cash flow. According to the results of cross-correlation function when both series are prewhitened for only 16 (25%) firms income is the leading indicator of cash flow while for 15 (23%) firms cash flow appear to be the lead series. For the 16 firms where income is the leading indicator of cash flow, only income for 10 firms can be used to predict cash flow one or more years ahead because of the lag term. Lag term of

Table 5.3

Summary of Cross-Correlations Between Prewhitened Income and Cash Flow (Historical Cost)

Realtionship	Cash Flow Prewhitened	Cash Flow Filtered
No Relationship	11	15
Instantaneous (lag=0)	8	3
Income causor (lag=0)	6	9
Cash Flow causor (lag=0)	6	12
Feedback (lag=0)	3	3
Income causor (lag≠0)	10	7
Cash Flow causor (lag≠0)	9	9
Feedback (lag≠0)	11	6
Total	64	64
No relationship	11	15
Instantaneous relationship	8	3
Feedback	14	9
Income causor (total)	16	16
Cash Flow causor(total)	15	21
Total	64	64

zero means that one can predict cash flow of next year only if one is given the value of income for next year. Since, in accounting, cash flow series can be approximated from income series if income series is given, transfer function modelling is not necessary to obtain the value of cash flow. An alternative procedure may result in more accurate information being obtained at least cost. The real benefit from transfer function modelling may be realised only if, given past stream of both cash flow and income, one can forecast cash flow one or more years ahead. The same would apply to the situation where cash flow is the lead series. In total, there are 23 (36%) models with lag zero where either cash flow or income are the lead series. Moreover for eight (13%) of the sample firms, there is only one significant spike at lag 0. This may mean that neither cash flow nor income is the lead series but some other exogenous variable that leads both of them.

There is also no relationship for 11 (17%) of the sample firms' series while for 14 (22%) of the firms there is feedback implying that the lead runs both ways, income lead cash flow and cash flow in turn lead income.

The result of the single prewhitening approach is similar to the double prewhitening approach; that is, for the historical cost series investigated in this study no empirical evidence of the direction of lead running from income to cash flow could be found. There is, however, a slight increase in the number of no-relationships between the income and cash flow series and in the number of cash flow series as the lead series. There is a corresponding decline in the instantenous and feedback relationships. The result show that for 15 (23%) of the firm series there are no relationships and that for 21 (33%) series cash flow are the lead series.

Results of the Transfer Function Modelling of Constant Dollar Series

The summary of the cross-correlation functions for the constant dollar series is presented in Table 5.4. The results of the double prewhitening approach show that for only 12 (19%) of the sample firms income can explain the variation in cash flow but for 23 (36%) of the firms cash flow appears to be the lead series. There are 9 (14%) firms for which there is no relationship between cash flow series and income series, and for 10 (16%) of the firms there is only one spike at lag zero. There are 10 (16%) firms where there is lead running both ways from cash flow to income and in turn income to cash flow.

The results of the single prewhitening show a slight increase in the number of firms for which income is the lead series and a corresponding decrease in the firms for which cash flow series is the lead series. For 18 (28%) firms income is the leading indicator of cash flow while for 15 (23%) firms cash flow is the leading indicator of income series. There are 15 (23%) firms for which there is no relationships indicated between cash flow and income series. Moreover, for 5 (8%) there is

Table 5.4

Summary of Cross-Correlations Between Prewhitened Income and Cash Flow (Constant Dollar)

Realtionship	Cash Flow Prewhitened	Cash Flow Filtered
No Relationship	9	15
Instantaneous (lag=0)	10	5
Income causor (lag=0)	5	10
Cash Flow causor (lag=0)	5	5
Feedback (lag=0)	2	3
Income causor (lag≠0)	7	8
Cash Flow causor (lag≠0)	18	10
Feedback (lag≠0)	8	8
Total	64	64
No relationship	9	15
Instantaneous relationship	10	5
Feedback	10	11
Income causor (total)	12	18
Cash Flow causor(total)	23	15
Total	64	64

only one spike at lag zero and for 11 (17%) there is lead running both ways.

When comparing the cross-correlation function results of double prewhitening of historical cost and constant dollar series, the constant dollar has a slightly higher number of firms, 23 (36%), where cash flow is the lead series and a slightly lower number of firms, 12 (19%) where income is the lead series as compared to to 15 (23%) and 16 (25%) respectively for historical cost data. However, when single prewhitening is used the change from the double prewhitening is in the opposite direction. For historical cost the income lead series are the same and there is an increase in cash flow lead series, while for constant dollar there is an increase for income lead series and a decrease for cash flow lead series.

In both cases, historical cost and constant dollar, there is an increase in the no-relationship between the cash flow and income series and the total number of no-relationship series are the same. There is also a decrease in the instanteneous relationship series from double prewhitening to single prewhitening. For feedback series, there is a decrease for historical cost while a slight increase for constant dollar and feedback series is higher for historical cost for double prewhitening approach and lower for single prewhitening approach as compared to constant dollar.

Based on the above results it can be concluded that there is no clear empirical evidence that the lead runs from income to cash flow. In general, future cash flow cannot be predicted given past streams of cash flow and income. Neither is there any evidence that cash flow is the lead of income.

Since the results indicate that income is not the lead series for either accounting method for most of the cash flow series further modeling is not done. As little empirical work has been done on the modeling of transfer function between annual cash flow and annual income, it is difficult to substantiate these results. However, there could be various reasons for the results obtained. Firstly, the sampling error in the auto-correlation function and partial auto-correlation function may result in multiple univariate models being identified and estimated which may not be the process that generates the time-series. Hence, when the time-series are prewhitened, systematic variation in the residuals is introduced resulting in misleading cross correlation function. Secondly, there may have been underlying structural changes in the process that generates cash flow and the model identified has not captured this change. Lastly, even if the correct models are identified, it is possible that the 30 observations used to identify the transfer function relationships may have resulted in sampling errors confounding the true relationships.

In a study similar to this but only on historical cost quarterly cash flow data, Brooks (1981) is able to model transfer function relationships between cash flow and quarterly earnings. However, his study suffers from several problems. He defined quarterly cash flow as quarterly earnings plus quarterly depreciation and amortization and 1/4 of annual change in deferred taxes. He did not adjust for changes in accruals, deferrals, inventories and minority interest. Falure to adjust for these may have resulted in his cash flow series being a surrogate for earnings rather than the true cash flow. This, perhaps, explains his observations that earnings models "fit" the earnings data better than cash flow models fit the cash flow data when examining the residual mean square. He also found that twenty four (80%) of the series in his sample of 30 firms had univariate models identical in form for cash flow and earnings series. Moreover, the lag parameter is 0 for all thirty transfer functions. Secondly, for 18 (60%) out of 30 cross correlations there is only one significant spike at lag 0. This implies that both the cash flow and earnings occur at the same time and the changes in both may have been due to an unknown exogenous variable. Thirdly, Brooks used the forecasted earnings from the univariate models to predict cash flow rather than the actual earnings, thus biasing the predicted cash flow.

Brooks is unable to show the superiority of transfer functions and other studies on transfer function modeling [e.g. Manegold (1978); Cheung (1977) ; Brooks (1981)] have been unable to show empirically the superiority of transfer function models in general.

Results of the Predictive Ability Comparisons

The third purpose of this study is to compare empirically the relative predictive ability of the Box-Jenkins univariate prediction model with the random walk with a drift model. As mentioned earlier, predictions from random walk with a drift model have been used in previous studies to compare the predictive ability of Box-Jenkins univariate earnings model. This is done on the grounds that random walk with a drift is relatively inexpensive and easy to apply, requiring no expertise on the part of the user. Moreover, for annual earnings series, Box-Jenkins univariate model has not outperformed the random walk with a drift model. In this sense the random walk with a drift model has been established as a standard against which the more sophisticated models can be compared.

Based on the time-series procedure mentioned earlier, four firm specific Box-Jenkins models for each of the firms in the sample are identified and estimated; that is two models for each of the historical cost and constant dollar accounting methods. The first of the firm specific models utilized the base period of 1951-1979 while the second utilized the updated base period of 1951-1980. The identified Box-Jenkins models for the base period are then employed to generate forecasts for one year ahead, F(80/51-1979), and two years ahead, F(81/51-1979), forecasts of their own values. Then the base period is updated by one to include 1980 obsevation, and autoregressive integrated moving average models are then again identified and estimated.

These updated models are then used to generate forecasts for one year ahead, F(81/51-1980), values of their own series.

To evaluate the predictive accuracy of forecasts of annual cash flow from random walk with a drift and Box-Jenkins univariate models, two error metrics, absolute percentage error and squared percentage error, are employed. Both analysis of variance, a parametric test, and Wilcoxon signed rank, a non-parametric test, are performed on both error metrics. The results of these tests are discussed in the next section.

Predictive Ability of the Historical Cost Cash Flow Models

For each of the historical cost cash flow series three forecasts for each of the prediction models, random walk with a drift and the Box-Jenkins univariate, are made. Two of the forecasts, a one year ahead and a two year ahead, are made using the base period 1951-1979 while the third, a one year ahead, is made using the updated base period 1951-1980. Two error metrics, the absolute percentage error and the squared percentage error, are calculated from these forecasts in order to compare the predictive ability of the two forecasting models. The summary statistics of the error metrics are presented in Table 5.5.

The table contains the means and standard deviations for both of the error metrics for each of the prediction models by forecast period. It also contains the Wilcoxon signed rank test significance level. Both parametric and non-parametric tests are employed to test the null hypothesis:

Table 5.5

Wilcoxon Signed-Rank Test
Historical Cost Cash Flow Models

	APE		SPE	
	Mean	Std Dev	Mean	Std Dev
F(80/51-79):				
RWD	.72259	.660	.95067	1.424
BJU	.62551	.572	.71297	1.153
Significance level	.012		.008	
F(81/51-79):				
RWD	.74381	.609	.91861	1.331
BJU	.70632	.528	.77339	1.157
Significance level	.293		.264	
F(81/51-80):				
RWD	.58625	.597	.69492	1.236
BJU	.61649	.506	.63221	1.002
Significance level	.105		.103	

APE : Absolute percentage error
SPE : Squared percentage error
RWD : Random walk with a drift model
BJU : Box-Jenkins univariate model

Significance level show the probability of getting a difference as large by chance alone if, in fact, there is no difference

H_0: The Box-Jenkins univariate time-series utilizing historical cost cash flow as inputs predicts future cash flow as accurately as the naive mechanical model, random walk with a drift.

The results of the non-parametric test, the Wilcoxon signed rank test, indicate that there is a significant difference between the predictive accuracy of the F(80/51-1979) for both absolute percentage error and squared percentage error, and no difference for F(81/51-1979) and F(81/51-1980).

The results of analysis of variance with repeated measures where the time-series models are independent variables and the error of forecasts are dependent variables are presented in Table 5.6 for absolute percentage error and Table 5.7 for squared percentage error.

The degrees of freedom of the F-statistic is adjusted using a theta factor adjustment procedure suggested by Box (1954) to correct for the non-homogeneity of the covariance matrix. The theta factor adjustment tests for the degree of non-homogeneity of the covariance matrix. If the covariance matrix is perfectly homogeneous, then the value of theta will be one and no adjustments are needed. If, however, the covariance matrix is not homogeneous then the value of theta will be less than one. The higher the degree of non-homogeneity of the covariance matrix, the lower will be the value of theta. The theta factor is then used to adjust the numerator and denominator degrees of freedom. The probability of significance is then recalculated with the revised numerator and denominator degrees of freedom. The adjusted probability significance levels are also presented

Table 5.6

Results of ANOVA Tests
Absolute Percentage Error Metric
Historical Cost Cash Flow Models

	Unadjusted ANOVA				Theta Adjustment Factor	Adusted ANOVA		
	D.F N	D.F D	F Ratio	Prob		D.F N	D.F D	Prob
F(80/51-79)	1	63	4.69551	.034	1.0	1	63	.034
F(81/51-79)	1	63	.77442	.382				
F(81/51-80)	1	63	.24180	.625				

Table 5.7

Results of ANOVA Tests
Squared Percentage Error Metric
Historical Cost Cash Flow Models

	Unadjusted ANOVA				Theta Adjustment Factor	Adusted ANOVA		
	D.F N	D.F D	F Ratio	Prob		D.F N	D.F D	Prob
F(80/51-79)	1	63	6.26621	.015	1.0	1	63	.015
F(81/51-79)	1	63	2.96791	.090	1.0	1	63	.090
F(81/51-80)	1	63	.26264	.610				

in the last column of the above table.

The ANOVA results indicate that there is a significant difference between the predictive accuracy of the F(80/51-1979) for both absolute percentage error and squared percentage error error metrics, significant (at .10 level) difference between the predictive accuracy of the F(81/51-1979) for only squared percentage error and no significant difference for F(81/51-1980) for both absolute percentage error and squared percentage error. Thus the null hypothesis can be rejected at .10 level of significance for both error metrics for F(80/51-1979) and only for squared percentage error for F(81/51-1979).

Both the parametric and non-parametric results are consistant for the absolute percentage error metric that there is a significant difference between the predictive accuracy of the F(80/51-1979) and not significant for others.

Thus, it can be concluded that the Box-Jenkins univariate model for the period F(80/51-1979) seems to have lower significant prediction error than random walk with a drift according to each of the error metrics tested. However, several observations can be made here.

1. If the Box-Jenkins univariate models can outperform random walk with a drift for one one-year-ahead forecasts, F(80/51-1979), why does the Box-Jenkins univariate models not outperform random walk with a drift for another one-year-ahead forecasts, F(81/51-1980)?
2. It is interesting to observe that updating the base period

by one observation and reidentifying and reestimating Box-Jenkins univariate firm specific models results in a reduction of the average error for the one-year-ahead forecasts, for absolute (squared) percentage error from .63 (.71) to .62 (.63) which is approximately 2% (11%) reduction. For random walk with a drift the reduction is from .72 (.95) to .59 (.69), which is approximately 19% (27%).

This inconsistency may have been due to two considerations. The first consideration is the small sample sizes of time-series data with which the researchers have to work. Lorek and McKeown (1978) have shown that increasing the accounting data base from twenty-four to fifty-two observations did not significantly improve the predictions except that the predictions from data base with fewer than 24 observations were quite poor. However, increasing the data base results in a trade-off between reduction in the sampling error and increasing the risk of a structural change. A structural change, such as a merger or aquisition, may change the time-series from one stationary process to another. The large sampling error may prevent the correct process from being selected and, even if a correct process is selected, the estimates to be misspecified. Secondly, the results may be period specific and so applicable to only that period or that the period under study is unusual. It could be rationalised that the year 1981 is a year of high interest rates and inflation and, thus, a year of instability for cash flow.

Predictive Ability of Constant Dollar Cash Flow Models

Similar to the historical cost cash flow models discussed in the previous section, for each of the constant dollar cash flow models, three forecasts are calculated. The summary statistics of the error metrics and the Wilcoxon Signed Rank test are presented in Table 5.8. The null hypothesis tested is:

H_0: The Box-Jenkins univariate time-series model utilizing constant dollar cash flow as inputs predicts future cash flow as accurately as the naive model, random walk with a drift.

The Wilcoxon signed-rank test shows that there is a significant diference between the predictive accuracy of the two models over two forecast periods F(80/51-79) and F(81/51-79) for both error metrics absolute percentage error and squared percentage error. Thus, Box-Jenkins univariate model has outperformed random walk with a drift model for these periods. However, using the updated base period, 1951-1980, and forecasting one year ahead, there is no statistically significant difference between the two models.

The results of the parametric (ANOVA) tests presented in Table 5.9 and Table 5.10 are consistent with the non-parametric test.

Table 5.11 represents the summary of both historical cost and constant dollar results. For forecasts, F(80/51-79), comparing the results of constant dollar and historical cost

Table 5.8

Wilcoxon Signed-Rank Test
Constant Dollar Cash Flow Models

	APE		SPE	
	Mean	Std Dev	Mean	Std Dev
F(80/51-79):				
RWD	.78870	.703	1.10791	1.519
BJU	.67864	.633	.85520	1.333
Significance level	.018		.006	
F(81/51-79):				
RWD	.78242	.689	1.07963	1.494
BJU	.57265	.507	.58064	.949
Significance level	.002		.001	
F(81/51-80):				
RWD	.60107	.622	.74250	1.271
BJU	.55381	.504	.55652	.987
Significance level	.496		.407	

APE : Absolute percentage error
SPE : Squared percentage error
RWD : Random walk with a drift model
BJU : Box-Jenkins univariate model

Significance level show the probability of getting a difference as large by chance alone if, in fact, there is no difference

Table 5.9

Results of ANOVA Tests
Absclute Percentage Error Metric
Constant Dollar Cash Flow Models

	Unadjusted ANOVA					Adusted ANOVA		
	D.F				Theta	D.F		
	N	D	F Ratio	Prob	Adjustment Factor	N	D	Prob
F(80/51-79)	1	63	4.36043	.041	1.0	1	63	.041
F(81/51-79)	1	63	10.48665	.002	1.0	1	63	.002
F(81/51-80)	1	63	.40413	.527				

Table 5.10

Results of ANOVA Tests
Squared Percentage Error Metric
Constant Dollar Cash Flow Models

	Unadjusted ANOVA					Adusted ANOVA		
	D.F				Theta	D.F		
	N	D	F Ratio	Prob	Adjustment Factor	N	D	Prob
F(80/51-79)	1	63	6.63185	.012	1.0	1	63	.012
F(81/51-79)	1	63	12.55851	.001	1.0	1	63	.001
F(81/51-80)	1	63	1.51318	.223				

Table 5.11

Summary of Wilcoxon Signed-Rank (and ANOVA) Tests
Random Walk and Box-Jenkins Univariate Prediction Models

	Historical Cost		Constant Dollar	
	APE	SPE	APE	SPE
F(80/51-79)	BJU(BJU)	BJU(BJU)	BJU(BJU)	BJU(BJU)
F(81/51-79)	- -	- (BJU)	BJU(BJU)	BJU(BJU)
F(81/51-80)	- -	- -	- -	- -

- : indicates no difference
BJU : Box-Jenkins univariate model
APE : Absolute percentage error
SPE : Squared percentage error

cash flow models, the ANOVA results are consistent across both accounting methods that the Box-Jenkins univariate model has outperformed the random walk with a drift. For the forecasts, F(81/51-79), the results show that the Box-Jenkins model has outperformed the random walk with a drift under both tests and error metrics when the models utilize constant dollar cash flow series but Box-Jenkins only outperformed under ANOVA test and the squared percentage error metric when the models utilize historical cost cash flow series. Moreover, for another one-year-ahead forecasts, F(81/51-80), there is no statistically significant difference under either accounting method, error metric or test between the two models.

This inconsistency, that for one one-year-ahead forecasts, F(80/51-79), Box-Jenkins outperforms the random walk with a drift models under each of the accounting methods, error metrics and the tests while for another one-year-ahead forecasts, F(81/51-80), Box-Jenkins do not outperform random walk with a drift models, is similar to the one noted earlier.

<u>Predictive Ability of Cash Flow Models Across Accounting Methods</u>

The fourth purpose of this study is to test the predictive ability of cash flow across the historical cost and constant dollar accounting methods.

Again both parametric and non-parametric tests are employed to test the following null hypothesis.

Ho: Time-series models utilizing historical cost cash flow as inputs predict future historical cost cash flow as accurately as the time-series models utilizing constant dollar cash flow as inputs to predict future constant dollar cash flow.

The above hypothesis will be tested for each error metric for each period. This procedure will result in four pairwise comparisons across each prediction model for each forecast period and each error metric.

The results of the Wilcoxon Signed-Rank test are presented in Tables 5.12 to 5.15, and the ANOVA test results are presented in Tables 5.16 to 5.23. These results are summarised in Table 5.24.

The results of the one year ahead forecasts are mixed. Both the Wilcoxon signed rank test and ANOVA test on each error metric show that for the forecasts, F(80/51-79), the prediction from the random walk with a drift utilizing historical cost cash flow series have statistically lower average errors than using the same model but with constant dollar cash flow series. This may mean that prediction models can better utilize the information contained in the historical cost cash flow than constant dollar cash flow. Similarly, for the same forecast period, the prediction model Box-Jenkins univariate utilizing the historical cost cash flow series outperforms the random walk with a drift prediction model utilizing the constant dollar cash flow series. Moreover, the random walk with a drift model or the Box-Jenkins univariate prediction models utilizing historical cost cash flow series performed as well as the Box-Jenkins univariate model utilizing the constant dollar cash flow series. Since the Box-Jenkins model outperformed the random walk with a drift when

Table 5.12

Wilcoxon Signed-Rank Test
Cash Flow Prediction Models Across Accounting Methods

	APE		SPE	
	Mean	Std Dev	Mean	Std Dev
F(80/51-79):				
RWD-HC	.72259	.660	.95067	1.424
RWD-CD	.78870	.703	1.10791	1.519
Significance level	.017		.012	
F(81/51-79):				
RWD-HC	.74381	.609	.91861	1.331
RWD-CD	.78242	.689	1.07963	1.494
Significance level	.280		.543	
F(81/51-80):				
RWD-HC	.58625	.597	.69492	1.236
RWD-CD	.60107	.622	.74250	1.271
Significance level	.287		.278	

APE : Absolute percentage error
SPE : Squared percentage error
RWD : Random Walk with a drift model
HC : Historical cost accounting
CD : Constant dollar accounting

Significance level show the probability of getting a difference as large by chance alone if, in fact, there is no difference

Table 5.13

Wilcoxon Signed-Rank Test
Cash Flow Prediction Models Across Accounting Methods

	APE Mean	APE Std Dev	SPE Mean	SPE Std Dev
F(80/51-79):				
RWD-HC	.72259	.660	.95067	1.424
BJU-CD	.67864	.633	.85520	1.333
Significance level	.167		.149	
F(81/51-79):				
RWD-HC	.74381	.609	.91861	1.331
BJU-CD	.57265	.507	.58064	.949
Significance level	.001		.002	
F(81/51-80):				
RWD-HC	.58625	.597	.69492	1.236
BJU-CD	.55381	.504	.55652	.987
Significance level	.474		.184	

APE : Absolute percentage error
SPE : Squared percentage error
RWD : Random Walk with a drift model
BJU : Box-Jenkins univariate model
HC : Historical cost accounting
CD : Constant dollar accounting

Significance level show the probability of getting a difference as large by chance alone if, in fact, there is no difference

Table 5.14

Wilcoxon Signed-Rank Test
Cash Flow Prediction Models Across Accounting Methods

	APE		SPE	
	Mean	Std Dev	Mean	Std Dev
F(80/51-79):				
BJU-HC	.62551	.572	.71297	1.153
RWD-CD	.78870	.703	1.10791	1.519
Significance level	.005		.003	
F(81/51-79):				
BJU-HC	.70632	.528	.77339	1.157
RWD-CD	.78242	.689	1.07963	1.494
Significance level	.431		.402	
F(81/51-80):				
BJU-HC	.61649	.506	.63221	1.002
RWD-CD	.60107	.622	.74250	1.271
Significance level	.244		.265	

APE : Absolute percentage error
SPE : Squared percentage error
RWD : Random Walk with a drift model
BJU : Box-Jenkins univariate model
HC : Historical cost accounting
CD : Constant dollar accounting

Significance level show the probability of getting a difference as large by chance alone if, in fact, there is no difference

Table 5.15

Wilcoxon Signed-Rank Test
Cash Flow Prediction Models Across Accounting Methods

	APE		SPE	
	Mean	Std Dev	Mean	Std Dev
F(80/51-79):				
BJU-HC	.62551	.572	.71297	1.153
BJU-CD	.67864	.633	.85520	1.333
Significance level	.139		.134	
F(81/51-79):				
BJU-HC	.70632	.528	.77339	1.157
BJU-CD	.57265	.507	.58064	.949
Significance level	.001		.002	
F(81/51-80):				
BJU-HC	.61649	.506	.63221	1.002
BJU-CD	.55381	.504	.55652	.987
Significance level	.021		.023	

APE : Absolute percentage error
SPE : Squared percentage error
BJU : Box-Jenkins univariate model
HC : Historical cost accounting
CD : Constant dollar accounting

Significance level show the probability of getting a difference as large by chance alone if, in fact, there is no difference

Table 5.16

Results of ANOVA Tests
Absolute Percentage Error Metric
HC-RWD and CD-RWD Cash Flow Prediction Models

	Unadjusted ANOVA					Adusted ANOVA		
	D.F N	D.F D	F Ratio	Prob	Theta Adjustment Factor	D.F N	D.F D	Prob
F(80/51-79)	1	63	6.07964	.016	1.0	1	63	.016
F(81/51-79)	1	63	1.69515	.198				
F(81/51-80)	1	63	.24361	.623				

HC-RWD : Random walk with a drift model utilizing historical cost cash flow series.
CD-RWD : Random walk with a drift model utilizing constant dollar cash flow series.

Table 5.17

Results of ANOVA Tests
Squared Percentage Error Metric
HC-RWD and CD-RWD Cash Flow Prediction Models

	Unadjusted ANOVA					Adusted ANOVA		
	D.F N	D.F D	F Ratio	Prob	Theta Adjustment Factor	D.F N	D.F D	Prob
F(80/51-79)	1	63	5.96559	.017	1.0	1	63	.017
F(81/51-79)	1	63	4.60660	.036	1.0	1	63	.036
F(81/51-80)	1	63	.95807	.331				

HC-RWD : Random walk with a drift model utilizing historical cost cash flow series.
CD-RWD : Random walk with a drift model utilizing constant dollar cash flow series.

Table 5.18

Results of ANOVA Tests
Absolute Percentage Error Metric
HC-BJU and CD-RWD Cash Flow Prediction Models

	Unadjusted ANOVA					Adusted ANOVA		
	D.F				Theta Adjustment	D.F		
	N	D	F Ratio	Prob	Factor	N	D	Prob
E(80/51-79)	1	63	8.26293	.006	1.0	1	63	.006
E(81/51-79)	1	63	1.49160	.227				
E(81/51-80)	1	63	.04857	.826				

HC-BJU : Box-Jenkins univariate model utilizing historical cost cash flow series.
CD-RWD : Random walk with a drift model utilizing constant dollar cash flow series.

Table 5.19

Results of ANOVA Tests
Squared Percentage Error Metric
HC-BJU and CD-RWD Cash Flow Prediction Models

	Unadjusted ANOVA					Adusted ANOVA		
	D.F				Theta Adjustment	D.F		
	N	D	F Ratio	Prob	Factor	N	D	Prob
E(80/51-79)	1	63	11.24438	.001	1.0	1	63	.001
E(81/51-79)	1	63	5.15379	.027	1.0	1	63	.027
E(81/51-80)	1	63	.69302	.408				

HC-BJU : Box-Jenkins univariate model utilizing historical cost cash flow series.
CD-RWD : Random walk with a drift model utilizing constant dollar cash flow series.

Table 5.20

Results of ANOVA Tests
Absolute Percentage Error Metric
HC-RWD and CD-BJU Cash Flow Prediction Models

	Unadjusted ANOVA				Theta Adjustment Factor	Adusted ANOVA		
	D.F N	D.F D	F Ratio	Prob		D.F N	D.F D	Prob
F(80/51-79)	1	63	.83969	.363				
F(81/51-79)	1	63	11.74060	.001	1.0	1	63	.001
F(81/51-80)	1	63	.18506	.669				

HC-RWD : Random walk with a drift model utilizing historical cost cash flow series.
CD-BJU : Box-Jenkins univariate model utilizing constant dollar cash flow series.

Table 5.21

Results of ANOVA Tests
Squared Percentage Error Metric
HC-RWD and CD-BJU Cash Flow Prediction Models

	Unadjusted ANOVA				Theta Adjustment Factor	Adusted ANOVA		
	D.F N	D.F D	F Ratio	Prob		D.F N	D.F D	Prob
F(80/51-79)	1	63	.93499	.337				
F(81/51-79)	1	63	9.69198	.003	1.0	1	63	.003
F(81/51-80)	1	63	.82141	.368				

HC-RWD : Random walk with a drift model utilizing historical cost cash flow series.
CD-BJU : Box-Jenkins univariate model utilizing constant dollar cash flow series.

Table 5.22

Results of ANOVA Tests
Absolute Percentage Error Metric
HC-BJU and CD-BJU Cash Flow Prediction Models

	Unadjusted ANOVA					Adusted ANOVA		
	D.F N	D.F D	F Ratio	Prob	Theta Adjustment Factor	D.F N	D.F D	Prob
F(80/51-79)	1	63	1.70288	.197				
F(81/51-79)	1	63	12.84631	.001	1.0	1	63	.001
F(81/51-80)	1	63	2.22525	.141				

HC-BJU : Box-Jenkins univariate model utilizing historical cost cash flow series.
CD-BJU : Box-Jenkins univariate model utilizing constant dollar cash flow series.

Table 5.23

Results of ANOVA Tests
Squared Percentage Error Metric
HC-BJU and CD-BJU Cash Flow Prediction Models

	Unadjusted ANOVA					Adusted ANOVA		
	D.F N	D.F D	F Ratio	Prob	Theta Adjustment Factor	D.F N	D.F D	Prob
F(80/51-79)	1	63	2.47691	.121				
F(81/51-79)	1	63	5.79519	.019	1.0	1	63	.019
F(81/51-80)	1	63	.80746	.372				

HC-BJU : Box-Jenkins univariate model utilizing historical cost cash flow series.
CD-BJU : Box-Jenkins univariate model utilizing constant dollar cash flow series.

Table 5.24

Summary of Wilcoxen Signed-Rank Test (and ANOVA)
Prediction Models Across Accounting Methods

			Absolute Percentage Error		Squared Percentage Error	
			Constant Dollar		Constant Dollar	
			RWD	BJU	RWD	BJU
H		F(80/51-79)				
i		HC-RWD	HC(HC)	--(--)	HC(HC)	--(--)
s		HC-BJU	HC(HC)	--(--)	HC(HC)	--(--)
t	C					
o	o	F(81/51-79)				
r	s	HC-RWD	--(--)	CD(CD)	--(HC)	CD(CD)
i	t	HC-BJU	--(--)	CD(CD)	--(HC)	CD(CD)
c						
a		F(81/51-80)				
l		HC-RWD	-- (--)	--(--)	--(--)	--(--)
		HC-BJU	-- (--)	CD(--)	--(--)	CD(--)

-- : indicates no difference
HC : historical cost
CD : constant dollar
RWD : random walk with a drift model
BJU : Box-Jenkins univariate model

both models utilized either historical cost or constant dollar cash flow series and since the Box-Jenkins model performed as well with cash flow series from either accounting methods, one would expect that Box-Jenkins model utilizing constant dollar would outperform random walk with a drift utilizing historical cost cash flow series, but it did not.

However, for another one-year-ahead forecasts, F(81/51-80), the summary shows that prediction model Box-Jenkins univariate utilizing constant dollar cash flow outperforms Box-Jenkins univariate model utilizing the historical cost cash flow series under only the Wilcoxon signed rank test, while there is no difference under ANOVA. Moreover, comparing random walk with a drift and Box-Jenkins, utilizing historical cost cash flow series with random walk with a drift utilizing constant dollar, the results indicate there is no difference in their predictive ability. The results of both parametric and non-parametric tests are consistent that for one-year-ahead forecasts, F(81/51-80) and F(80/51-79), the random walk with a drift model utilizing historical cash flow series performs as well as the Box-Jenkins model utilizing the constant dollar cash flow series. Further, the parametric tests are consistent that for one year ahead forecasts, the Box-Jenkins model utilizing the historical cost cash flow series performs as well as the Box-Jenkins model utilizing the constant dollar cash flow series. But the non-parametric tests show inconsistent results that for F(80/51-79) there is no difference while for F(81/51-80) the

Box-Jenkins utilizing constant dollar cash flow series outperforms the Box-Jenkins model utilizing historical cost cash flow series.

For the two-year-ahead forecasts, the Box-Jenkins univariate model utilizing constant dollar cash flow can outperform both the random walk with a drift and Box-Jenkins univariate prediction models utilizing historical cost cash flow. This result is consistent with the results shown earlier that Box-Jenkins univariate model outperforms random walk with a drift model when both utilize constant dollar cash flow. Since there is no difference in the random walk with a drift model utilizing constant dollar cash flow and either random walk with a drift or Box-Jenkins univariate models utilizing historical cost cash flow, the Box-Jenkins univariate model utilizing constant dollar cash flow will outperform either of the models utilizing historical cost cash flow.

It can be concluded that for one-year-ahead forecasts the results are mixed and that for two-year-ahead forecasts the Box-Jenkins univariate utilizing constant dollar cash flow outperforms others. The mixed result indicated above is similar to the result obtained earlier that if one model outperforms others in one one-year-ahead forecast, why does it not outperform others on an another one-year-ahead forecast?

The results of this chapter are summarised in Table 5.25. This chapter has firstly presented the time-series analysis of historical cost and constant dollar cash flow series. The

Table 5.25

Summary of Results

Historical Cost	Constant Dollar
1. Cash flow appear to be autoregressive or white noise process.	Cash flow appear to be autoregressive or white noise process.
2. There is no evidence that income is a leading indicator of cash flow	There is no evidence that income is a leading indicator of cash flow
3. For one-year-ahead forecasts, F(80/51-79)	For one-year-ahead forecasts, F(80/51-79)
BJU outperformed RWD	BJU outperformed RWD
For two-year-ahead forecasts, F(81/51-79)	For two-year-ahead forecasts, F(80/51-79)
No difference	BJU outperformed RWD
For one-year-ahead forecasts, F(81/51-80)	For one-year-ahead forecasts, F(80/51-79)
No difference	No difference

4. For one-year-ahead forecasts, F(80/51-79)

Hc (BJU and RWD) outperformed Cda (RWD)
Hc (BJU and RWD) same as Cda (BJU)

For two-year-ahead forecasts, F(81/51-79)

Hc (BJU and RWD) same as Cda (RWD)
Hc (BJU and RWD) outperformed by Cda (BJU)

For one-year-ahead forecasts, F(81/51-80)

Hc (BJU and RWD) same as Cda (BJU and RWD)

BJU : Box-Jenkins univariate models
RWD : Random walk with a drift models
Hc : Historical cost series
Cda : Constant dollar series

The predictive ability results are statistically significant at .10 level conclusions were that the annual historical cost cash flow series appear to follow either an autoregressive or white noise process, pattern similar to the historical cost annual earnings, while the annual constant dollar cash flow series appear to follow either an autoregressive or white noise process. Secondly, it discussed the multivariate time series modeling. The conclusion of this section was that there was no empirical evidence that income was the leading indicator of cash flow and it was not possible to use the Box-Jenkins multivariate time series procedure to incorporate both cash flow and income to improve cash flow forecasts. Thirdly, the predictive ability of the different prediction models utilizing cash flow series from each accounting method was discussed. This section concluded that the results for the one year ahead forecasts were mixed. For the F(80/51-79), the Box-Jenkins model outperformed the random walk with a drift under both accounting methods, while for the F(81/51-80), there was no difference in the prediction models' accuracy. For the two year ahead forecast, there is no difference in the predictive ability of the prediction models utilizing the historical cost cash flow series. However, when the models utilized constant dollar, the Box-Jenkins model outperformed the random walk with a drift. Finally, the chapter analysed the predictive ability of the cash flow models across accounting methods. The results in this were mixed. It concluded that random walk with a drift model utilizing historical cost cash flow series performs as well as Box-Jenkins model utilizing constant dollar for both one year ahead periods.

A summary of the research discussed in this study and a set of tentative conclusions and recommendations are presented in the next chapter.

CHAPTER 6

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary and Conclusions

Considerable research has been done on the time-series behaviour and the relative predictive ability of accounting income numbers mainly because the knowledge of the time-series properties of income is essential for various research in accounting and finance. However, research on the time-series properties and predictive ability of cash flow numbers, despite its increasing importance, has not received much attention. There is increasing emphasis in the literature, particularly in the pronouncements of the official accounting bodies, that the users of the financial statements are primarily interested in predicting future cash flow.

Moreover, the Financial Accounting Standards Board (FASB) has asserted that income numbers are more useful in predicting future cash flow than past cash flow but there exists little empirical evidence for this assertion. Recently, the accounting bodies in the United States of America and Canada have called for the presentation of supplementary constant dollar information. The FASB #33 has specifically encouraged future research into the assessment of this information. Accordingly, this study has attempted to provide empirical evidence on these issues.

The primary objectives of this research were (1) to empirically determine the statistical time-series properties of historical cost and constant dollar cash flow and develop forecasting models, (2) to empirically determine the lead relationship between cash flow and income and develop transfer function (multivariate) forecasting models, (3) to compare the predictive ability of the three forecasting models, the Box-Jenkins univariate, Box-Jenkins transfer function and the random walk with a drift models, within each accounting method, and (4) to test the predictive ability of the three forecasting models across the historical cost and constant dollar accounting methods.

The historical cost data required for this study were obtained primarily from the COMPUSTAT annual industrial tape. Supplementary data bases used were the Moody's Industrial Manuals, and the 10K reports. In order to be included in the sample, the company must have had the necessary data items for calculating cash flow and restating historical cost financial statements into constant dollar financial statements for the entire period 1950-81. In addition, only companies with the same fiscal year-end which had used only one inventory valuation method in each year were included in the sample. A final sample of 64 companies was obtained for this study. The constant dollar financial statements were obtained by restating the historical cost financial statements by a procedure that is in general conformity with the FASB #33.

For each of the 64 firms in the sample firm specific Box-Jenkins univariate models, utilizing the base period data from 1951-1979, were identified for the cash flow series from the historical cost and constant dollar accounting methods. These firm specific identified models were then utilized to generate one-year-ahead, F(80/51-79), and two-year-ahead, F(81/51-79), forecasts of its own series. Then the base period of 1951-1979 was updated by one year to include 1980 data, and Box-Jenkins firm specific models were re-identified and re-estimated and one-year-ahead forecasts, F(81/51-80), were made. The objectives stated in chapter one and the results discussed in chapter five are duplicated in Table 6.1 and Table 6.2 for ease of reference. The conclusions with respect to the time-series properties of cash flow are (1) the annual historical cost cash flow series appear to follow either an autoregressive or white noise process, a pattern similar to the historical cost annual income and (2) the annual constant dollar cash flow series appear to follow either an autoregressive or white noise process.

The second objective of this research was to test empirically the lead relationship between cash flow and income series and develop Box-Jenkins transfer function (multivariate) forecasting models. Both single prewhitening and double prewhitening techniques were used to remove within correlation from the series and the residuals were then cross correlated. The cross correlation results showed that there was no empirical

Table 6.1

List of Objectives

Historical Cost	Constant Dollar
1. To determine the time-series properties of cash flow (develop univariate models)	To determine the time-series properties of cash flow (develop univariate models)
Method: Box-Jenkins univariate	Method: Box-Jenkins univariate
2. To determine whether there is a relationship between income and cash flow (develop multivariate models)	To determine whether there is a relationship between income and cash flow (develop multivariate models)
Method: Box-Jenkins transfer function (multivariate)	Method: Box-Jenkins transfer function (multivariate)
3. To determine whether there is difference in the predictive ability of the three forecasting models. (models from (1) and (2) above and RWD)	To determine whether there is difference in the predictive ability of the three forecasting models. (models from (1) and (2) above and RWD)
Method: same as for 4.	Method: same as for 4.

4. To determine if there is a difference in the predictive ability of historical cost and constant dollar accounting methods in predicting future cash flow.

Method:

(a) Forecasts:
- one-year-ahead, 1980, using the base 1951-1979
- two-year-ahead, 1981, using the base 1951-1979
- one-year-ahead, 1981, using the updated base 1951-1980.

(b) Error measures (metrics):
- absolute percentage error
- squared percentage error

(c) Tests:
- parametric - analysis of variance
- non-parametric - Wilcoxon signed rank test

RWD - Random walk with a drift. This model is used as low cost alternative to compare with the accuracy of other models.

Table 6.2

Summary of Results

Historical Cost	Constant Dollar
1. Cash flow appear to be autoregressive or white noise process.	Cash flow appear to be autoregressive or white noise process.
2. There is no evidence that income is a leading indicator of cash flow	There is no evidence that income is a leading indicator of cash flow
3. For one-year-ahead forecasts, F(80/51-79)	For one-year-ahead forecasts, F(80/51-79)
BJU outperformed RWD	BJU outperformed RWD
For two-year-ahead forecasts, F(81/51-79)	For two-year-ahead forecasts, F(80/51-79)
No difference	BJU outperformed RWD
For one-year-ahead forecasts, F(81/51-80)	For one-year-ahead forecasts, F(80/51-79)
No difference	No difference

4. For one-year-ahead forecasts, F(80/51-79)

Hc (BJU and RWD)	outperformed	Cda (RWD)
Hc (BJU and RWD)	same as	Cda (BJU)

For two-year-ahead forecasts, F(81/51-79)

Hc (BJU and RWD)	same as	Cda (RWD)
Hc (BJU and RWD)	outperformed by	Cda (BJU)

For one-year-ahead forecasts, F(81/51-80)

Hc (BJU and RWD)	same as	Cda (BJU and RWD)

BJU : Box-Jenkins univariate models
RWD : Random walk with a drift models
Hc : Historical cost series
Cda : Constant dollar series

The predictive ability results are statistically significant at .10 level evidence that income was the leading indicator of cash flow for either the historical cost or constant dollar measurement method. Due to the lack of relationship between income and cash flow, it was not possible to develop Box-Jenkins multivariate forecasting models.

The third objective of this research was to test the predictive ability of the Box-Jenkins univariate model with the random walk with a drift model within each accounting method. The naive model that had been used in prior studies was used as a minimum cost base against which to compare the accuracy of the more sophisticated models.

To test the predictive accuracy, two error metrics were employed. The error metrics were absolute percentage error and squared percentage error. The non-parametric test, the Wilcoxon signed-rank test, and the parametric test, the analysis of variance test, were performed on the absolute percentage error and squared percentage error metrics to test the null hypothesis of no difference in the predictive ability of the forecasting models within and across accounting methods. Since the homogeneity of the covariance matrix was highly critical due to the use of repeated correlated data, the degrees of freedom of the F-statistic were adjusted by using a theta factor adjustment. This procedure has been suggested by Box (1954). New corrected probability significance levels were also obtained.

The results of the predictive ability tests were somewhat mixed for one-year-ahead forecasts. For the historical cost accounting method, it can be concluded that (1) for one-year-ahead forecasts, F(80/51-79), the Box-Jenkins model outperformed the random walk with a drift, at the 0.05 level of significance; (2) for the two-year-ahead forecasts, F(81/51-79), there was no difference in the predictive ability of the forecasting models and (3) for another one-year-ahead forecasts, F(81/51-80), there was no difference in the predictive ability of the forecasting models.

For the constant dollar accounting, it can be concluded that (1) for the one-year-ahead forecasts, F(80/51-79), the Box-Jenkins model outperformed the random walk with a drift model, (2) for the two-year-ahead forecasts, F(81/51-79) the Box-Jenkins model outperformed the random walk with a dift model at .05 level of significance, and (3) for another one-year-ahead forecasts, F(81/51-80), there was no difference in the predictive accurcy of the forecasting models.

The last objective of this study was to test the predictive ability of forecasting models across accounting methods. These tests were also discussed in Chapter 5.

The results of the predictive ability tests across accounting methods were also mixed, but it can be concluded that (1) for the one-year-ahead forecasts, F(80/51-79), both random walk with a drift model and Box-Jenkins univariate model utilizing historical cost cash flow series outperformed the random walk with a drift model utilizing the constant dollar cash flow series but there was no difference when compared to

Box-Jenkins model utilizing constant dollar, (2) For the two-year-ahead forecasts, F(81/51-79), both the random walk with a drift and Box-Jenkins model utilizing historical cash flow were unable to outperform the random walk with a drift model utilizing constant dollar and were outperformed by the Box-Jenkins model utilizing constant dollar at .05 level of significance and (3) for another one-year-ahead forecasts, F(81/51-80), there were no differences in the predictive accuracy of the models utilizing cash flow from different accounting methods.

In summary, the results were mixed. Since for one-year-ahead forecasts models utilizing the constant dollar cash flow series can not outperform the random walk with a drift model utilizing historical cost cash flow, it would appear that the constant dollar accounting's usefulness is limited for one-year-ahead forecasts. However, the other results are inconclusive.

Limitations

The conclusions of this study are subject to several limitations. Firstly, only the firms on the COMPUSTAT tapes were considered for inclusion in the sample. This introduced the 'survivorship' bias in the sample. Failed firms and recently organised firms were also excluded due to unavailability of data. Moreover, the sample design excluded firms that did not meet the selection criteria. Therefore, the results of this study will not be universally applicable.

Secondly, it was necessary to use a proxy for the cash flow due to the unavailability of the unremmitted earnings of unconsolidated subsidiaries and some non-cash items in the income before extraordinary items and discontinued operations. To the extent the variable is misspecified, the results of this study would be inappropriate. However, the proxy for cash flow repesents the most appropriate estimate for the actual cash flow that could be made from publicly available information.

Thirdly, the constant dollar financial statements were obtained by a restatement algorithm. It is not known to what extent the restatement data differ from the actual constant dollar data.

Fourthly, the results of the predictive ability results are dependent upon the models employed. The results of this study are limited to Box-Jenkins models used and can not be generalised to other models. The Box-Jenkins models do, however, represent a broad class of stochastic linear time series models.

Fifthly, the results of the study may be limited by the number of observations and the period over which the models were built and forecasts made. If the period is not a 'typical' period, then the results may be different if a new period is selected. Similarly, and more importantly, the tests of the predictive accuracy were for only points in time (1980, 1981). The actual cash flow of these two years may be unrepresentative of the general cash flow generating process.

Sixthly, the Box-Cox transformations used in this study were selected from a small subset of transformations available. If these transformations were not the optimal ones bias may result. Since the series requiring the transformations were few, the effect may be minimal.

Lastly, The forecasting models were evaluated based on two error metrics. These error metrics should ideally have been selected based on the investors' specific decision models.

<u>Extensions</u>

Given the importance of predicting cash flow there are several logical extension to this study. Firstly, the "smoothing" phenomenon reported in the accounting literature may have contributed to the unusual results. Managements appear to smooth income to keep it at a constant level (perhaps a drift). This suggests that the behaviour of income would follow a random walk with a drift. However, in the 1980's the cash flow number was receiving considerable attention and focus was shifting from the income to cash flow number. Management may have immediately started manipulating the cash flow as it allegedly did income to make it more predictable. Since cash flow is easily manipulated by management the cash flow may have started showing random walk with a drift characteristics. Since 1980 cash flow may not have been manipulated, Box-Jenkins outperformed the random walk with a drift. In 1981, the cash flow may have been manipulated and Box-Jenkins performed as well as random walk with a drift. This phenomenon could be examined by using the methodology of this study over the years prior to and subsequent to 1981.

Secondly, samples that are industry specific may be used to examine whether there are any industry effects.

Thirdly, the constant dollar numbers utilized in this study were estimated by an algorithm. Since the constant dollar numbers are now published this methodology could be applied to the published numbers.

Fourthly, the information content of the published accounting cash flow could be tested to see whether stock prices react to the "unexpected cash flow".

Finally, a natural extension would be to consider the market index of cash flow of all firms and/or other variables, such as total assets, as the leading indicators in the Box-Jenkins multivariate (transfer function) setting.

This study has provided descriptive evidence on the time-series behaviour of historical cost and constant dollar annual cash flow. It found no conclusive evidence for the Financial Accounting Standards Board's assertion that past series of income can be used to predict cash flow.

APPENDICES

Table A.1

Historical Cost Cash Flow ARIMA Models : 1951-1979

Cash Flow Series	Model (p,d,q)	AR Parameters AR1	AR2	MA parameters MA1	MA2	Constant	Transform
Firm 1	(100)	0.577				40.712	
Firm 2	(000)					16.732	
Firm 3	(110)	-0.518					
Firm 4	(011)			0.641			
Firm 5	(010)						
Firm 6	(000)					8.225	
Firm 7	(010)						
Firm 8	(000)					2.444	Log
Firm 9	(000)					10.399	
Firm 10	(000)					1.862	
Firm 11	(000)					2.310	
Firm 12	(000)					2.586	
Firm 13	(110)	-0.570				12.509	
Firm 14	(200)	-0.681	-0.509				
Firm 15	(110)	-0.602				5.697	
Firm 16	(012)			0.731	-0.865		
Firm 17	(100)	0.812					
Firm 18	(010)						
Firm 19	(110)	-0.713				6.987	
Firm 20	(010)						
Firm 21	(110)	-0.612				54.953	
Firm 22	(200)	*	0.533				
Firm 23	(100)	0.555					
Firm 24	(010)						
Firm 25	(110)	-0.597					
Firm 26	(110)	-0.661					
Firm 27	(110)	-0.401					
Firm 28	(000)					5.062	Log
Firm 29	(000)					0.102	Ricf
Firm 30	(000)					530.567	
Firm 31	(110)	-0.693					
Firm 32	(001)			-0.554			

(Continued)

* : Parameter not significant
Log : Log transformation
Ricf : Square root inverse transformation

Table A.1 (Continued)

Historical Cost Cash Flow ARIMA Models : 1951-1979

Cash Flow Series	Model (p,d,q)	AR Parameters		MA parameters		Constant	Trans-form
		AR1	AR2	MA1	MA2		
Firm 33	(200)	0.951	-0.648				
Firm 34	(210)	*	0.536				
Firm 35	(210)	-0.838	-0.383				
Firm 36	(010)						
Firm 37	(010)						
Firm 38	(210)	-0.384	-0.588				
Firm 39	(012)			*	0.531	0.875	
Firm 40	(110)	-0.640					
Firm 41	(000)					9.611	
Firm 42	(011)			0.774			
Firm 43	(012)			*	-0.652		
Firm 44	(100)	0.613					
Firm 45	(000)					5.923	
Firm 46	(110)	-0.785					
Firm 47	(011)			0.746			
Firm 48	(010)					0.373	Log
Firm 49	(110)	-0.595					
Firm 50	(110)	-0.678					
Firm 51	(100)	0.964					Log
Firm 52	(110)	-0.673					
Firm 53	(210)	*	-0.347				
Firm 54	(010)						
Firm 55	(011)			0.664			
Firm 56	(110)	-0.583					
Firm 57	(110)	-0.425					
Firm 58	(010)						
Firm 59	(100)	-0.415				2.714	
Firm 60	(100)	0.479					
Firm 61	(000)						
Firm 62	(000)						
Firm 63	(100)	0.526				17.854	
Firm 64	(110)	-0.745				0.226	Log

* : Parameter not significant
Log : Log transformation
Ricf : Square root inverse transformation

Table A.2

Historical Cost Cash Flow ARIMA Models : 1951-1980

Cash Flow Series	Model (p,d,q)	AR Parameters AR1	AR2	MA Parameters MA 1	MA 2	Constant	Trans-form
Firm 1	(001)			-0.868			
Firm 2	(000)					14.782	
Firm 3	(110)	-0.618				11.515	
Firm 4	(011)			0.623			
Firm 5	(010)						
Firm 6	(000)					8.397	
Firm 7	(011)			0.565			
Firm 8	(000)					2.449	Log
Firm 9	(000)					10.595	
Firm 10	(000)					1.606	
Firm 11	(000)					2.394	
Firm 12	(000)					2.355	
Firm 13	(110)	-0.570				12.536	
Firm 14	(200)	-0.678	-0.508				
Firm 15	(110)	-0.775				5.689	
Firm 16	(012)			0.784	-0.884		
Firm 17	(100)	0.795					
Firm 18	(010)						
Firm 19	(110)	-0.697				6.694	
Firm 20	(210)	*	0.927				
Firm 21	(110)	-0.712					
Firm 22	(200)	*	0.489			3.115	
Firm 23	(110)	0.623					
Firm 24	(210)	-0.606	-0.785			13.493	
Firm 25	(110)	-0.580					
Firm 26	(110)	-0.599					
Firm 27	(110)	-0.342					
Firm 28	(000)					5.088	Log
Firm 29	(000)					0.102	Ricf
Firm 30	(000)					551.168	
Firm 31	(110)	-0.980				4.807	
Firm 32	(000)						

(Continued)

* : Parameter not significant
Log : Log transformation
Ricf : Square root inverse transformation

Table A.2 (Continued)

Historical Cost Cash Flow ARIMA Models : 1951-1980

Cash Flow Series	Model (p,d,q)	AR Parameters AR1	AR2	MA Parameters MA1	MA2	Constant	Trans-form
Firm 33	(200)	0.693	-0.381				
Firm 34	(210)	*	0.494			15.469	
Firm 35	(210)	-0.839	-0.385				
Firm 36	(010)						
Firm 37	(010)						
Firm 38	(210)	-0.396	-0.386				
Firm 39	(012)			*	0.533	0.949	
Firm 40	(110)	-0.787					
Firm 41	(000)					9.750	
Firm 42	(000)						
Firm 43	(010)						
Firm 44	(100)	0.617					
Firm 45	(100)	0.885					
Firm 46	(110)	-0.700					
Firm 47	(011)			0.706			
Firm 48	(010)					0.357	Log
Firm 49	(110)	-0.600					
Firm 50	(110)	-0.393					
Firm 51	(110)	-0.471					
Firm 52	(110)	-0.570					
Firm 53	(010)						
Firm 54	(010)						
Firm 55	(011)			0.939		14.380	
Firm 56	(010)						
Firm 57	(110)	-0.491					
Firm 58	(110)	-0.802					
Firm 59	(100)	-0.464				3.165	
Firm 60	(100)	0.493					
Firm 61	(000)						
Firm 62	(100)	-0.635				2.182	
Firm 63	(100)	0.427				17.028	
Firm 64	(110)	-0.743				0.225	Log

* : Parameter not significant
Log : Log transformation
Ricf : Square root inverse transformation

Table A.3

Diagnostic Test
Historical Cost Cash Flow ARIMA Models : 1951-1979

Model	Degrees of Freedom	Box-Pierce Q-Statistic	Probability ≥
Firm 1	11	8.6	.25
Firm 2	12	8.1	.25
Firm 3	11	9.3	.25
Firm 4	11	5.6	.25
Firm 5	12	15.2	.10
Firm 6	12	9.1	.25
Firm 7	12	9.5	.25
Firm 8	12	6.8	.25
Firm 9	12	4.6	.25
Firm 10	12	15.1	.10
Firm 11	12	9.4	.25
Firm 12	12	12.1	.25
Firm 13	11	9.0	.25
Firm 14	10	3.4	.25
Firm 15	11	6.6	.25
Firm 16	10	2.4	.25
Firm 17	11	11.6	.25
Firm 18	12	10.4	.25
Firm 19	11	14.4	.10
Firm 20	12	7.6	.25
Firm 21	11	5.7	.25
Firm 22	11	9.4	.25
Firm 23	11	7.4	.25
Firm 24	12	5.7	.25
Firm 25	11	1.8	.25
Firm 26	11	4.5	.25
Firm 27	11	8.8	.25
Firm 28	12	4.3	.25
Firm 29	12	1.1	.25
Firm 30	12	11.5	.25
Firm 31	11	7.8	.25
Firm 32	11	5.6	.25

(continued)

Table A.3 (Continued)

Diagnostic Test
Historical Cost Cash Flow ARIMA Models : 1951-1979

Model	Degrees of Freedom	Box-Pierce Q-Statistic	Probability ≥
Firm 33	10	4.4	.25
Firm 34	11	9.4	.25
Firm 35	10	5.8	.25
Firm 36	12	8.1	.25
Firm 37	12	20.2	.05
Firm 38	10	16.7	.10
Firm 39	11	8.4	.25
Firm 40	11	14.6	.10
Firm 41	12	10.0	.25
Firm 42	11	9.4	.25
Firm 43	11	5.6	.25
Firm 44	11	14.2	.10
Firm 45	12	9.3	.25
Firm 46	11	9.4	.25
Firm 47	11	6.4	.25
Firm 48	12	4.7	.25
Firm 49	11	13.7	.25
Firm 50	11	14.4	.10
Firm 51	11	10.8	.25
Firm 52	11	4.9	.25
Firm 53	11	12.7	.25
Firm 54	12	11.2	.25
Firm 55	11	12.4	.25
Firm 56	11	3.1	.25
Firm 57	11	4.0	.25
Firm 58	12	6.4	.25
Firm 59	11	10.0	.25
Firm 60	11	7.0	.25
Firm 61	12	8.8	.25
Firm 62	12	10.7	.25
Firm 63	11	7.0	.25
Firm 64	11	11.3	.25

Interpretation : If the residuals are white noise with mean zero and constant variance then the probability of observing a Q-statistic that large is as given.

Table A.4

Diagnostic Test
Historical Cost Cash Flow ARIMA Models : 1951-1980

Model	Degrees of Freedom	Box-Pierce Q-Statistic	Probability ≥
Firm 1	11	6.4	.25
Firm 2	12	11.0	.25
Firm 3	11	9.0	.25
Firm 4	11	6.7	.25
Firm 5	12	20.8	.05
Firm 6	12	7.6	.25
Firm 7	11	15.0	.10
Firm 8	12	7.1	.25
Firm 9	12	4.8	.25
Firm 10	12	18.1	.10
Firm 11	12	9.6	.25
Firm 12	12	17.5	.10
Firm 13	11	9.1	.25
Firm 14	10	4.3	.25
Firm 15	11	3.6	.25
Firm 16	10	8.7	.25
Firm 17	11	13.7	.25
Firm 18	12	3.7	.25
Firm 19	11	14.5	.10
Firm 20	11	5.8	.25
Firm 21	11	10.6	.25
Firm 22	11	8.6	.25
Firm 23	11	8.0	.25
Firm 24	10	3.0	.25
Firm 25	11	1.6	.25
Firm 26	11	3.4	.25
Firm 27	11	8.9	.25
Firm 28	12	3.1	.25
Firm 29	12	1.2	.25
Firm 30	12	6.9	.25
Firm 31	11	6.3	.25
Firm 32	12		

(continued)

Table A.4 (Continued)

Diagnostic Test
Historical Cost Cash Flow ARIMA Models : 1951-1980

Model	Degrees of Freedom	Box-Pierce Q-Statistic	Probability ≥
Firm 33	10	7.0	.25
Firm 34	11	9.4	.25
Firm 35	10	5.8	.25
Firm 36	12	14.5	.25
Firm 37	12	20.0	.05
Firm 38	10	12.4	.25
Firm 39	11	7.7	.25
Firm 40	11	11.5	.25
Firm 41	12	10.3	.25
Firm 42	12	4.3	.25
Firm 43	12	10.1	.25
Firm 44	11	14.3	.25
Firm 45	11	12.2	.25
Firm 46	11	12.8	.25
Firm 47	11	4.2	.25
Firm 48	12	4.8	.25
Firm 49	11	13.9	.10
Firm 50	11	7.3	.25
Firm 51	11	5.4	.25
Firm 52	11	7.0	.25
Firm 53	12	14.2	.25
Firm 54	12	12.9	.25
Firm 55	11	11.8	.25
Firm 56	12	7.5	.25
Firm 57	11	8.3	.25
Firm 58	11	9.8	.25
Firm 59	11	10.4	.25
Firm 60	11	7.5	.25
Firm 61	12	10.6	.25
Firm 62	11	6.6	.25
Firm 63	11	6.2	.25
Firm 64	11	11.7	.25

Interpretation : If the residuals are white noise with mean zero and constant variance then the probability of observing a Q-statistic that large is as given.

Table A.5

Tail Areas of Chi-Square Distribution

Degrees of Freedom	Values at Significant Level		
	.05	.10	.25
9	16.9	14.7	11.4
10	18.3	16.0	12.5
11	19.7	17.3	13.7
12	21.0	18.5	14.8

Table A.6

Constant Dollar Cash Flow ARIMA Models : 1951-1979

Cash Flow Series	Model (p,d,q)	AR Parameters AR1	AR2	MA parameters MA1	MA2	Constant	Trans-form
Firm 1	(000)					75.208	
Firm 2	(200)	*	0.637				
Firm 3	(210)	-0.870	-0.438				
Firm 4	(000)					90.270	
Firm 5	(100)	0.658				68.370	
Firm 6	(000)					19.826	
Firm 7	(100)	0.640				46.816	
Firm 8	(000)					4.647	
Firm 9	(000)					28.830	
Firm 10	(000)					4.751	
Firm 11	(000)					6.969	
Firm 12	(000)					0.203	Ricf
Firm 13	(110)	-0.636					
Firm 14	(2 00)	-0.597	-0.461				
Firm 15	(110)	-0.706					
Firm 16	(110)	-0.549					
Firm 17	(000)					4.615	Log
Firm 18	(100)	0.454				96.993	
Firm 19	(210)	-0.897	-0.445				Log
Firm 20	(110)	-0.448					
Firm 21	(110)	-0.720				65.277	
Firm 22	(000)					4.461	
Firm 23	(100)	0.538					
Firm 24	(100)	0.839				132.454	
Firm 25	(200)	*	0.590			35.300	
Firm 26	(110)	-0.719					
Firm 27	(110)	0.686				64.270	
Firm 28	(000)					287.136	
Firm 29	(000)					297.299	
Firm 30	(000)					6.908	
Firm 31	(100)	0.485				14.901	
Firm 32	(000)					5.567	

(Continued)

* : Parameter not significant
Log : Log transformation
Ricf : Square root inverse transformation

Table A.6(Continued)

Constant Dollar Cash Flow ARIMA Models : 1951-1979

Cash Flow Series	Model (p,d,q)	AR Parameters AR1	AR2	MA parameters MA1	MA2	Constant	Trans-form
Firm 33	(200)	0.729	-0.489				
Firm 34	(110)	-0.533					
Firm 35	(000)					22.311	
Firm 36	(011)			0.373			
Firm 37	(011)			0.524		203.340	
Firm 38	(210)	-0.675	-0.361				Log
Firm 39	(100)	0.741				14.316	
Firm 40	(011)			0.671			
Firm 41	(000)					22.221	
Firm 42	(000)						
Firm 43	(001)			-0.483			
Firm 44	(000)					0.071	Ricf
Firm 45	(000)					14.468	
Firm 46	(110)	-0.737					
Firm 47	(300)	0.443	0.463(+)				
Firm 48	(010)						Log
Firm 49	(210)	-0.853	-0.451				
Firm 50	(200)	*	0.574			63.450	
Firm 51	(100)	0.729				54.765	
Firm 52	(002)			*	-0.797		
Firm 53	(010)						
Firm 54	(100)	0.655				204.134	
Firm 55	(100)	0.488				278.118	
Firm 56	(110)	-0.706					
Firm 57	(000)					0.712	
Firm 58	(100)	0.728				151.007	
Firm 59	(000)						
Firm 60	(000)					22.048	
Firm 61	(000)						
Firm 62	(000)						
Firm 63	(000)					37.675	
Firm 64	(110)	-0.725				0.167	Log

* : Parameter not significant
(+) : Estimates relates to AR3. AR2 parameter not significant
Log : Log transformation
Ricf: Square root inverse transformation

Table A.7

Constant Dollar Cash Flow ARIMA Models : 1951-1980

Cash Flow Series	Model (p,d,q)	AR Parameters AR1	AR2	MA parameters MA1	MA2	Constant	Trans-form
Firm 1	(100)	0.694				89.699	
Firm 2	(100)	-0.432				33.548	
Firm 3	(210)	-0.976	-0.543			18.769	
Firm 4	(000)					91.531	
Firm 5	(100)	0.707				73.565	
Firm 6	(000)					19.612	
Firm 7	(100)	0.606				49.248	
Firm 8	(000)					4.700	
Firm 9	(000)					28.822	
Firm 10	(000)					4.410	
Firm 11	(000)					6.926	
Firm 12	(000)					0.205	Ricf
Firm 13	(110)	-0.631					
Firm 14	(200)	-0.591	-0.457				
Firm 15	(110)	-0.765					
Firm 16	(110)	-0.546					
Firm 17	(000)					4.648	Log
Firm 18	(110)	0.750				112.291	
Firm 19	(210)	-0.890	-0.447				Log
Firm 20	(110)	-0.472					
Firm 21	(110)	-0.806				77.315	
Firm 22	(000)					4.939	
Firm 23	(100)	0.549					
Firm 24	(100)	0.667				122.681	
Firm 25	(200)	*	0.564			35.171	
Firm 26	(200)	*	0.584			137.376	
Firm 27	(100)	0.704				67.514	
Firm 28	(000)					286.625	
Firm 29	(000)					288.424	
Firm 30	(000)					6.912	Log
Firm 31	(110)	-0.833					
Firm 32	(000)					6.375	

(Continued)

* : Parameter not significant
Log : Log transformation
Ricf : Square root inverse transformation

Table A.7 (Continued)

Constant Dollar Cash Flow ARIMA Models : 1951-1980

Cash Flow Series	Model (p,d,q)	AR Parameters AR1	AR2	MA parameters MA1	MA2	Constant	Trans-form
Firm 33	(200)	0.594	-0.395				
Firm 34	(011)			0.471			
Firm 35	(000)					23.398	
Firm 36	(011)			0.459			
Firm 37	(011)			0.493		193.569	
Firm 38	(210)	-0.678	-0.350				Log
Firm 39	(100)	0.812				13.321	
Firm 40	(011)			0.637			
Firm 41	(000)					21.963	
Firm 42	(000)						
Firm 43	(001)			-0.503			
Firm 44	(000)					0.071	Ricf
Firm 45	(000)					15.053	
Firm 46	(013)			0.883	-0.544 (+)		
Firm 47	(300)	0.468	0.472 (++)				
Firm 48	(010)						Log
Firm 49	(210)	-0.850	-0.452				
Firm 50	(200)	*	0.731				
Firm 51	(011)			0.468			
Firm 52	(000)						
Firm 53	(010)						
Firm 54	(100)	0.652				203.646	
Firm 55	(011)			0.714			
Firm 56	(110)	-0.581					
Firm 57	(100)	0.674					
Firm 58	(100)	0.491				132.768	
Firm 59	(000)						
Firm 60	(000)					22.619	
Firm 61	(000)						
Firm 62	(000)						
Firm 63	(000)					37.278	
Firm 64	(110)	-0.710				0.161	Log

* : Parameter not significant
(+) : Estimates relates to MA3. MA2 parameter not significant
(++): Estimates relates to AR3. AR2 parameter not significant
Log : Log transformation
Ricf: Square root inverse transformation

Table A.8

Diagnostic Test
Constant Dollar Cash Flow ARIMA Models : 1951-1979

Model	Degrees of Freedom	Box-Pierce Q-Statistic	Probability ≥
Firm 1	12	11.8	.25
Firm 2	11	16.8	.10
Firm 3	10	9.3	.25
Firm 4	12	5.7	.25
Firm 5	11	11.0	.25
Firm 6	12	4.4	.25
Firm 7	11	9.0	.25
Firm 8	12	10.5	.25
Firm 9	12	6.4	.25
Firm 10	12	16.7	.10
Firm 11	12	10.5	.25
Firm 12	12	7.1	.25
Firm 13	11	8.7	.25
Firm 14	10	4.7	.25
Firm 15	11	7.9	.25
Firm 16	11	7.9	.25
Firm 17	12	7.3	.25
Firm 18	11	8.3	.25
Firm 19	10	8.9	.25
Firm 20	11	8.1	.25
Firm 21	11	8.1	.25
Firm 22	12	20.6	.05
Firm 23	11	7.5	.25
Firm 24	11	8.3	.25
Firm 25	10	7.6	.25
Firm 26	11	5.1	.25
Firm 27	11	15.0	.10
Firm 28	12	12.7	.25
Firm 29	12	5.5	.25
Firm 30	12	4.1	.25
Firm 31	11	7.9	.25
Firm 32	12	10.3	.25

(continued)

Table A8 (Continued)

Diagnostic Test
Constant Dollar Cash Flow ARIMA Models : 1951-1979

Model	Degrees of Freedom	Box-Pierce Q-Statistic	Probability ≥
Firm 33	10	6.0	.25
Firm 34	11	13.2	.25
Firm 35	12	8.9	.25
Firm 36	11	5.5	.25
Firm 37	11	17.0	.10
Firm 38	10	7.7	.25
Firm 39	11	11.1	.25
Firm 40	11	17.3	.10
Firm 41	12	8.0	.25
Firm 42	12	6.2	.25
Firm 43	11	10.7	.25
Firm 44	12	5.1	.25
Firm 45	12	8.9	.25
Firm 46	11	12.1	.25
Firm 47	10	3.6	.25
Firm 48	12	5.8	.25
Firm 49	10	7.3	.25
Firm 50	11	6.8	.25
Firm 51	11	15.4	.10
Firm 52	11	7.8	.25
Firm 53	12	20.6	.05
Firm 54	11	8.4	.25
Firm 55	11	15.8	.10
Firm 56	11	7.4	.25
Firm 57	11	11.8	.25
Firm 58	11	13.4	.25
Firm 59	12	10.5	.25
Firm 60	12	6.3	.25
Firm 61	12	4.2	.25
Firm 62	12	13.4	.25
Firm 63	12	7.2	.25
Firm 64	11	9.8	.25

Interpretation : If the residuals are white noise with mean zero and constant variance then the probability of observing a Q-statistic that large is as given.

Table A.9

Diagnostic Test
Constant Dollar Cash Flow ARIMA Models : 1951-1980

Model	Degrees of Freedom	Box-Pierce Q-Statistic	Probability ≥
Firm 1	11	7.1	.25
Firm 2	11	17.7	.05
Firm 3	10	9.4	.25
Firm 4	12	7.1	.25
Firm 5	11	16.9	.10
Firm 6	12	4.7	.25
Firm 7	11	9.9	.25
Firm 8	12	10.9	.25
Firm 9	12	6.5	.25
Firm 10	12	15.8	.10
Firm 11	12	10.7	.25
Firm 12	12	6.2	.25
Firm 13	11	9.0	.25
Firm 14	10	5.0	.25
Firm 15	11	5.4	.25
Firm 16	11	9.4	.25
Firm 17	12	4.4	.25
Firm 18	11	6.6	.25
Firm 19	10	7.5	.25
Firm 20	11	8.4	.25
Firm 21	11	9.0	.25
Firm 22	12	16.2	.10
Firm 23	11	8.2	.25
Firm 24	11	7.3	.25
Firm 25	11	6.9	.25
Firm 26	11	3.9	.25
Firm 27	11	15.3	.10
Firm 28	12	13.2	.25
Firm 29	12	7.4	.25
Firm 30	12	4.2	.25
Firm 31	11	7.8	.25
Firm 32	12	10.5	.25

(continued)

Table A.9(Continued)

Diagnostic Test
Constant Dollar Cash Flow ARIMA Models : 1951-1980

Model	Degrees of Freedom	Box-Pierce Q-Statistic	Probability ≥
Firm 33	10	7.9	.25
Firm 34	11	11.4	.25
Firm 35	12	11.9	.25
Firm 36	11	7.5	.25
Firm 37	11	15.5	.10
Firm 38	10	7.7	.25
Firm 39	11	11.8	.25
Firm 40	11	19.0	.05
Firm 41	12	8.4	.25
Firm 42	12	5.7	.25
Firm 43	11	10.1	.25
Firm 44	12	5.3	.25
Firm 45	12	8.7	.25
Firm 46	11	11.5	.25
Firm 47	10	3.9	.25
Firm 48	12	18.1	.10
Firm 49	10	6.6	.25
Firm 50	11	9.3	.25
Firm 51	11	14.0	.10
Firm 52	12	9.2	.25
Firm 53	12	20.4	.05
Firm 54	11	9.0	.25
Firm 55	11	17.1	.10
Firm 56	11	10.6	.25
Firm 57	11	10.7	.25
Firm 58	11	9.8	.25
Firm 59	12	9.7	.25
Firm 60	12	7.1	.25
Firm 61	12	4.9	.25
Firm 62	12	12.2	.25
Firm 63	12	6.1	.25
Firm 64	11	10.6	.25

Interpretation : If the residuals are white noise with mean zero and constant variance then the probability of observing a Q-statistic that large is as given.

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