THE IMPACT OF INVENTORY VALUATION TECHNIQUES ON TIME SERIES BEHAVIOR OF FIRMS EARNINGS AND CASH FLOWS

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CHAPTER I

INTRODUCTION

Accountants are faced with a variety of alternative measurement and reporting methods. Debate exists on whether such alternatives result in significantly different accounting signals and, if so, whether reduction or elimination of alternatives ought to be sought. At the present time there appears to be no unanimously agreed-upon set of standards for making a choice between such competing alternatives. The usefulness of alternative methods in predicting events of interest to decision makers is one standard that has been suggested by some authoritative bodies as well as researchers in accounting.

Inventory valuation is an area of accounting for which alternative measurement bases exist. The impact of alternative inventory valuation methods on different aspects of the economy (both at the micro and macro levels) is of major concern to many interested groups including econimists, financial analysts, accountants, and others who may use financial statements. Two extreme historical inventory cost methods [First-in First-out (FIFO) versus Last-in First-out (LIFO)] have been the subject of many research efforts.

Within the predictive-ability context, it can be speculated that LIFO would produce under certain circumstances (increasing prices and well-maintained inventory quantities) incomes and cash flows series better than those produced by the FIFO method. "Better" in this context means that the LIFO series could be modeled in such a way that prediction errors would be smaller than for the FIFO series. Results from the average cost method might be between the LIFO and FIFO results.

Assuming that investors are interested in predicting income and cash flow, it is interesting to empirically examine how inventory valuation techniques influence firms' earnings and cash flow series. This can be achieved from descriptive as well as predictive standpoints. In this study, firms that have been applying a single method of inventory valuation; LIFO, FIFO, or average cost, for a considerable number of years were identified. A robust modeling technique, namely Box-Jenkins, was applied to the income and cash flows for a portion of the time series of each firm to identify the most appropriate model. The model was then used to predict values of the same series for the remaining years of the series. Measures of the prediction errors for firms using different inventory methods were computed and compared.

Justification for the Study

The lack of unanimity on the appropriate method of inventory valuation is evidenced by considerable debate among accountants on the existing alternative methods. McAnly (1966), who is known for his advocacy of the LIFO inventory cost flow method, has spoken and written on many occasions about its desirable attributes. On one occasion he stated that LIFO

> . . .tends to eliminate one of the greatest speculative features in business. As a result, it reduces substantially the peaks and valleys of reflected earnings to which business has long been subjected [emphasis added]. It is a notable fact that such concerns as have used Last-in, First-out or its parent idea, the base stock method, have reflected earnings on a more dependable basis.(p. 63)

The 1953 American Accounting Association (AAA) Committee on Concepts and Standards Underlying Corporate Financial Statements evaluated alternative inventory methods in light of effect of changes in price level on inventory pricing. In its evaluation of the FIFO method, the Committee stated the following attractive characteristics:

> First, in the great majority of cases it so nearly approximates the physical movement of goods that the actual differences in flow can be ignored; second, it eliminates all possibility of influencing profits through selection of individual items from a homogeneous inventory or through the mere expansion or contraction of inventory quanities; third, the method produces a balance-sheet quantum which is, in general, a reasonable reflection of the current market. (p. 38)

Despite these attractive features of the method, its failure to compensate for changes in the price level is a major objection to FIFO. The Committee pointed out that:

> . . . low costs may be matched against relatively high selling prices and vice versa. The effect produced during periods of steeply rising prices is often described as one of 'fictitious inventory profits'. (p. 38)

The problem of creating fictitious inventory profits by matching the oldest inventory costs with current revenues can be mitigated through the use of the LIFO method. This method became acceptable for tax purposes in the Revenue Act of 1939 so long as it is also used for financial accounting purposes. In its evaluation of the LIFO method, the 1953 AAA Committee stated: ". . . LIFO has appealed to some during periods of markedly changing price levels as a means of approaching a matching of current cost with current revenues." (p. 37) The Committee, however, expressed "grave doubt" as to whether the accuracy of such artificial matching is sufficient to justify the resultant departure from realism. Such a departure from realism has, to some extent, been ignored in practice because of the tax benefits available through the use of the LIFO method. Moonitz (1953) observed:

> . . . despite all the marshalling of facts, arguments, logic, and analysis, the popularity of LIFO increases. Given permission as seems more than possible at this moment, to use 'LIFO Cost or Market', many more taxpayers will adopt LIFO. This popularity rests solely on the unique provision of the Internal Revenue Code requiring the use of LIFO in all published reports if a taxpayer wishes to use LIFO for tax purposes. (p. 69)

However, Moonitz's anticipation of an increase in LIFO's popularity was not until some time later matched by world reality. It was not until the 1970's that the LIFO method was adopted by a substantial number of firms. FIFO, on the other hand was used more than LIFO until that time.

Though the current research is not concerned with motivations for selecting one method over the other, some points of interest can be listed in terms of this preference. First, during the period of rising prices experienced in recent time there is a trade-off between an improved cash position when LIFO is adopted and higher reported profits when FIFO is adopted. The implication of the Efficient Market's research may have played a significant role in the decision by some firms to switch to LIFO. An adverse reaction in the stock market to low reported income is unlikely according to the Efficient Market Hypothesis, if the cash position of the firm has actually been improved. Second, the inflationary rate might be mild for firms preferring FIFO, or the start-up costs of adopting LIFO may outweigh the tax benefits generated by switching.

In spite of these and other environmental incentives to change, there are some firms which applied a single method of inventory valuation for a substantial number of years. This as well as the theoretical debate outlined above indicates that the controversy of which inventory valuation alternatives to adopt is far from resolved on the basis of mere theoretical argumentation. Something more than theoretical appeals to consistency and logic seems necessary. The usefulness of alternative accounting measures in making predictions is a step in this direction that was emphasized by authoritative as well as research bodies in accounting. For example, the American Accounting Association's Committee to prepare a Statement of Basic Accounting Theory (1966) took the position that accountants ought to provide information to external users which is useful in predicting earnings with a minimum of uncertainty. Additionally, Beaver, Kennelly and Voss (1968) expressed that alternative accounting measures should be evaluated on the basis of their ability to predict events of interest to decision makers. Their argument is based upon the idea that this evaluation is proper as long as the alternatives under consideration meet the tests of logical propriety and selection cannot be made on a priori grounds. The American Institute of Certified Public Accountants' Study

Group on the Objectives of Financial Statements (1973) took the position that accounting reports should not only be useful in predicting earnings but should also be useful in predicting cash flows. The Financial Accounting Standards Board (1973) took similar stands on the matter.

In light of these considerations, this research was conducted to evaluate the effect of different inventory valuation alternatives on the predictability of the future values of firms' earnings and cash flows. The objective is to throw more light on the controversy about the appropriateness of the accounting alternatives. The generating process of earnings and cash flows of each firm was identified and examined for the purpose of determining whether or not there is any tendency of time series models within groups of firms using a particular inventory valuation method. In addition, the supremacy in terms of predictive ability of models associated with each method of inventory valuations was examined.

Scope of the Study

The alternative methods of inventory valuation examined in this study included the following:

1. First-in First-out (FIFO)
2. Last-in First-out (LIFO)
3. Average Cost.

These valuation alternatives were chosen for the following three reasons: (1) each can be defended on the basis of internal consistency and logical validity; (2) each has received substantial support in the literature; and (3) each has been widely applied by firms which makes it possible to obtain a reasonable sample size of firms.

Actual earnings and cash flows are the criteria chosen to determine which of these three methods of inventory valuation was most useful in prediction performance. Two earnings series and cash flow series for each firm are investigated. The earnings series are gross profit and net income.

Firms that applied a single method of inventory valuation throughout the investigation period were identified and their earnings and cash flow series were examined. The investigation period is the thirty years between 1950 and 1979. The COMPUSTAT file is the primary source of information for this study. Other sources included Moody's industrial manual as well as direct contact with firms.

Organization of the Study

The next chapter contains review of literature on inventory valuation methods as well as time-series of accounting numbers. Data definition and description of the methodology are presented in Chapter III. The fourth chapter provides an analysis of the research results. Research conclusions, limitations and suggestions for further study are given in the fifth and final chapter.

CHAPTER II

REVIEW OF THE LITERATURE

Previous efforts to analyze time series behavior of some accounting numbers can be divided into two groups: (1) the classical approach and (2) the new approach. This chapter will review these two groups of time series studies and conclude with an overall summary.

The Classical Approach of Time-Series Analysis in Accounting

Research on the time-series behavior of accounting numbers, particularly corporate earnings, has increased in the last two decades. The purpose of such research is to gain some knowledge about the process generating the observed series. An identified process or model can, among other things, be utilized as an input to various schemes of decision-making. Income smoothing, security valuation, and relative forecasting ability of alternative accounting methods are just a few examples of such utilization.

The early work on the subject was conducted in the United Kingdom. Little (1962) investigated changes in British Corporate incomes and concluded that such changes are independent. Later, Little and Rayner (1966) examined the same question but in a larger study (more firms and longer period) and arrived at the same conclusion, i.e., British Corporate growth rates are random.

The question was shifted to a new environment and tackled from another standpoint. Lintner and Glauber (1967) examined the association between growth rates in successive periods for U. S. Corporate earnings. They utilized a larger sample and longer period than those of Little and Little and Rayner. Association is defined as the slope coefficient in the regression of six income variables on two sets of time periods, namely five and ten years.[1] Although the degree of association in a cross-sectional sense is very small, the authors state that it is too early to accept the hypothesis of independent growth rates.

Instead of examining growth rates in incomes, Brealey (1967) examined changes in incomes. He concluded, based upon a variety of techniques, that income changes follow a martingale process.[2] In a later study, Brealey (1969) reviewed his previous investigation as well as that of Lintner and Glauber and maintained his earlier conclusions.

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[1]These income variables are sales, operating income, earnings before interest and taxes, aggregate dollar earnings, earnings per share and dividends per share.

[2]The martingale as well as random walk processes are special cases of the submartingale. If Z_t is the observed value of a series, then a submartingale process can be described as having the following properties:

$$Z_t = Z_{t-1} + \delta + U_t$$

where $\delta > 0$ is a constant growth component, and U_t is the error component which has no distributional assumptions. The martingale is defined as

$$Z_t = Z_{t-1} + U_t$$

which could be interpreted as a random walk model if the U_t component is assumed to be independently distributed. A random walk with trend model is a random walk model which contains a trend component: $\delta \gtrless 0$.

All of these processes are special cases of the general first-order autoregressive model which is defined later.

In a later study, Brealey (1969) reviewed his previous investigation as well as that of Lintner and Glauber and maintained his earlier conclusions.

Ball and Watts (1972) investigated time series properties of accounting income applying different methods from those of previous studies. Average changes, runs tests, serial correlations, and mean squared successive differences were applied to firms data from Standard and Poor's COMPUSTAT file for the twenty years 1947-1966. They concluded that measured annual accounting incomes follow either a submartingale or some very similar process. The authors showed what implications such a process has for forecasters and researchers in accounting and finance (e.g., income smoothing and the interpretation of the growth and declines of firms).

Ball and Watts, however, acknowledged that their findings are somewhat limited because of an ex post sample selection bias against decreases in income (e.g., survivorship bias). They stated that the importance of this bias cannot be determined within their own selected sample of firms.

In an attempt to provide some evidence of the above mentioned bias, Salamon and Smith (1977) applied the partial adjustments procedures of Ball and Watts to samples of firms which they claimed to be free of such bias. They investigated the Earnings per share (EPS) data on two groups of firms (used by Smith (1974) in his Ph.D. dissertation) that were randomly selected from the firms listed in the U. S. Senate Staff Report, (Factors Affecting the Stock Market). They found that the bias caused Ball and Watts to over-estimate the time instability of the EPS time-series. They also challenged Ball and Watts' conclusion of a submartingale process based upon "mean" or "median" results. Salamon and Smith suggested that there is more diversity than similarity in some individual firms' earnings processes.

In their reply, Ball and Watts (1977) maintained that Salamon and Smith are also unable to provide an evidence on the two issues of survivorship bias and diverse generating processes. First, their sampling period extends over the 13-year period 1950-1962. However, their criterion that a firm be listed on NYSE in 1954 means that the firm survives the first five years which is a selection bias. Second, their test of diverse generating processes cannot be directly interpreted for such purpose. Ball and Watts cited unpublished research by them in which they could avoid the survivorship bias and works by Watts (1975) and Watts and Leftwich (1977) in defense for their conclusion of a representative process.

The research methodology as well as the conclusions of the research on time series of firms earnings are, for the most part, conflicting. There is, however, a pattern which is common to the method of investigation followed in time-series studies prior to 1970: an investigator selects the forecasting process without the preliminary investigation needed for additional knowledge of the underlying generating process of the data.

Beaver (1970) suggested that some assumptions have to be made about the underlying nature of the process rather than reliance upon a knowledge of such process. He cites the Granger and Hatanaka's three stages of time-series analysis:

1. investigation
2. model selection and fitting, and
3. application.

The first stage, which is crucial for the other stages, is concerned with examining statistical properties, i.e., mean, variance, and serial correlation of the data. The last stage deals with applying a particular model(s) to a set of data as in the case of the previous studies of accounting time series. Beaver confines the major part of his analysis to the investigation stage. His conclusion based upon simulated as well as empirical data (deflated and undeflated) is that accounting earnings follow a mean reverting (MR) process, which is a special case of the general moving average (MA) model, i.e., a MR process is a MA(0) process.[3] Ball and Watts (1972) found that annual accounting incomes follow either a submartingale or some very similar process. The submartingale, as shown above, is a special case of the general autoregressive (AR) model, symbolically represented as AR(1) with unity coefficient, positive constant, and unrestricted error term.

Because such findings and their implications on firms are conflicting, Lookabill (1976) attempted to resolve the controversy of

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[3]The pure MR process is defined as follows:

$$Z_t = \mu + U_t$$

in which

$$E(U_t) = 0$$

$$\sigma^2(Z_t) = \sigma^2$$

$$\sigma(Z_t, Z_s) = 0 \text{ for } t \neq s$$

and first-order serial correlation of original series is zero, but first-order serial correlation of first differences is $-\frac{1}{2}$. The MA is defined in a later chapter.

Ball and Watts' (1972) conclusions and that of Beaver (1970). His argument is that while both conclusions are inconsistent with a pure MR Process, Beaver's is inconsistent with an AR(1) process. A MA process, however, was found to be an appropriate representation for both studies. Lookabill's major concern was to distinguish between two competing explanations for such a finding, i.e., an observed time series of accounting signals being well described by a MA process. First, the underlying generating process may be a MR in which the error term each period is smoothed by the historical cost accounting system or deliberate managerial manipulation (selection of accounting alternatives). Second, the process may be an AR(1) for a firm within a given risk class, but because firms change risk classes over time the observed series can be described best by a MA process. His methodology which involves risk analysis is a modification of Beaver's High-Low test. Lookabill concluded that changes in risk as an explanation for Beaver's results is ruled out. This leaves him with the other explanation, i.e., income smoothing which is induced by the historical cost system or possibly managerial manipulation in the selection of accounting alternatives.

The New Approach

Instead of arbitrarily applying a model to the series under investigation, a well-structured technique has emerged into the research arena of accounting generating processes. The technique, which is called Box-Jenkins (B-J) extracts a model from the series itself rather than imposing any model on it. It is composed of three integral stages: (1) identification, (2) estimation, (3) diagnostic checking.

Dopuch and Watts (1972) utilized the technique to test the significance of depreciation policies changes. Significance was defined as a change in model parameters. The study, however, suffered from a number of limitations. The sample contained only eleven firms selected from a single industry (steel) for periods far below the optimum number of observations. The authors justified the study, despite the existence of such limitations, by indicating that their objective was to point out a possible area of application for B-J technique to accounting.

Generating processes of quarterly data were investigated via the B-J methodology by Watts (1975), Foster (1977), and Griffin (1977). While they all concluded that quarterly earnings do not belong to the martingale family (a process which was in the classical analysis appropriate for annual earnings), their proposed models were different. Watts (1975) and Griffin (1977) (hereafter W G) suggested (in B-J terminology) a (0,1,1) x (0,1,1) model while Foster (1977) preferred a (1,0,0) x (0,1,0) model.[4]

Brown and Rozeff (1979) (hereafter BR) proposed a (1,0,0) x (0,1,1) model and compared it against individually identified B-J models on one hand and against W G and Foster's on the other hand. They found that their model forecasted equally well as individual B-J models for one period ahead forecasts and outperformed them for longer forecasting periods. They found also that their model is superior to both W G and

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[4]These are representations of ARIMA modesl (p,d,q) x (P,D,Q) in which p, d, and q are the regular (nonseasonal) parameters for autoregressive, level of differencing, and moving average parts, respectively. The P, D, and Q are the corresponding parameters for the seasonal parts of a model.

Foster's models. BR offered the model as a replacement to subjectively identified B-J models and a benchmark for evaluating security analysts' or time series models' quality earnings forecasts.

Benston and Watts (1978) based on a seventy-three firms sample with results across twenty-four quarters found that Foster's model is superior in terms of forecasting ability while BR's model forecasting performance is among the four worse models tested. The authors, however, refrained from advocating any specific model per se stating that it is difficult to choose between the better models.

The only published works on the annual generating processes up till now are Albrecht, Lookabill, and McKeown (1977) and Watts and Leftwich (1977). The sample of the first study consisted of the forty-nine firms of Lookabill (1976) study that were selected from three industries. The authors concluded that a random walk model with drift performed as well for undeflated income in all three industries as the more complicated firm-specific model. Deflating earnings resulted in removing the trend parameter. Hence, deflated earnings are sufficiently described by a simple random walk model. Both conclusions, however, are subject to the condition that the B-J models were not misspecified due to small sample properties.

After warning against misspecification of the estimated Box-Jenkins models in their study of annual earnings, Watts and Leftwich (1977, p. 269) concluded that "the ability of random walk models to 'outpredict' the identified Box-Jenkins models suggests that the random walk is still a good description of the process generating annual earnings in general, and for individual firm."

Lorek (1979) tested the ability of quarterly models to predict annual earnings. He compared the predictive - ability of five naive models, firm specific B-J models, and three parsimonious models, namely W G, Foster, and BR. Four hypotheses were tested for each model; each hypothesis relates to a specific quarter from the first to the fourth. Because of the conflicting results, Lorek did not give a specific conclusion. Instead, he indicated that it may be premature to choose a representative quarterly model, or that such a representative model may not exist.

Investigating accounting numbers' generating processes constitutes an interesting area of research for accountants. However, the search for a generating process per se appears to be a vague and unpromising direction if inquiry. Any realized series of accounting data is influenced by alternative standards of measurement and reporting. Lev (1974, p. 253) as a way of dealing with this problem, suggested that research efforts for areas where adequate theories do not exist (e.g., corporate bankruptcy, the process generating corporate earnings, etc.) should be concentrated on theory construction. Before a solid theory can be constructed, theorists should have some knowledge of the effects of the presently available alternatives on the predictive ability of the earnings and cash flow of the firm.

The objective of the current study is to determine the effect of alternative methods of accounting for inventory on the time-series model of earnings and cash flow. Firms are grouped according to their method of accounting for inventories. The earnings and cash flow series are modeled using the B-J technique and compared for the groups of firms.

Summary

Most of the studies of time-series properties of accounting numbers lack a solid and clear objective. Attempts to analyze these series in order to identify a model applicable to all firms without taking into consideration firms' differences are fruitless. In this research effort a clear objective is established. The objective is to identify time series models for cash flow and income series of different firms and to attempt to determine the impact of alternative inventory valuation techniques on such models.

CHAPTER III

RESEARCH DESIGN

The purpose of this chapter is to state the research hypotheses, define the sample selection and describe the research methodology.

The Research Hypotheses

It is the conviction of some accounting scholars (Hoffman and Gunders, 1970; Jaedieke and Sprouse, 1965; Sundar, 1973, 1976b) and practitioners (successive issues of the AICPA's Accounting Trends and Techniques since 1950) that the LIFO method of inventory valuation is a more desirable method than the FIFO or average cost methods during periods of rising prices because the LIFO method matches the most current costs against revenues thereby eliminating fictional profits and because the LIFO method results in smaller taxes which increases the value of the firm. There are, however, some constraints that need to be carefully considered when the LIFO technique is adopted; maintaining a rational inventory policy (ending inventory level is at least equal to the beginning level) and general trend of inflation are the principal ones. Since the environment in which companies operate may not provide a guarantee for the fulfillment of such constraints (i.e., prices of some specific inventory items may go down in times of high inflation rates, and managers may liquidate inventory holdings in times of need for it), the long-run impact of LIFO on firm's earnings and cash flows (versus that of FIFO) may turn out to be minimal. Hence, it was anticipated that the three alternative methods of inventory valuation under current investigation would perform the same. The research hypothesis, therefore, is:

> HO_1: There is no significant difference between the FIFO, LIFO and average cost methods of inventory valuation in predicting future values of the accounting number series under investigation.

Three prediction models were applied to the empirical data. The models are B-J firm specific models as well as two naive ones; random walk (RW) and random walk with trend (RWWT). These models are evaluated and compared against each other to see if the sophisticated model building process of Box and Jenkins would be more efficient in prediction than the naive models. The hypothesis here is:

> HO_2: There is no significant difference between the B-J, RW and RWWT models in forecasting future values of the accounting numbers series under investigation.

The COMPUSTAT tape was used to identify three groups of firms. Each group consisted of firms which consistently adhered to one of the inventory valuation techniques considered over the period of study. DATA (59) of the tape contains codes referring to a variety of inventory valuation alternatives. For some firms, data from the tape were insufficient or lacking, other sources were used such as successive editions of Moody's Industrial Manual and direct contact with firms.

The optimal length of the series is one of the central issues of the B-J technique. A structural change, which is more likely in accounting due to merger, management changes, etc., may change the process generating the series.

Watts and Leftwich (1977, p. 255) examined the issue in terms of ". . . tradeoff between sampling error and the likelihood of structural change." Three prediction models (B-J identified models, random walk, and random walk with trend) were applied to four sets of observations (38, 50, 55, and 60 years). The overall findings based upon three error metrics is that the relative performance of models improves as the number of observations (length of the series) increases.

Lorek and McKeown (1977, p. 205) examined the issue in terms of "the optimal trade-off between sample size and predictive ability." One of their conclusions is:

> Although there was no clear-cut minimum number of observations below which the Box-Jenkins methodology was inappropriate, predictive results were quite poor for data bases $\leq$ 24 observations. (p. 213)

The above studies used actual data while Nelson (1972), and Gonedes and Roberts (1976) used simulation to examine the same question. In the two sets of data (30 and 100 length), Nelson preferred the 100 observations case for his model of a MA Process. In their three sets of data length 20, 30, and 60, Gonedes and Roberts found that model estimation was superior to ordinary least squares (OLS) for sample sizes ranging from 20 to 60.

Quarterly data, instead of annual data, could have been used for the sake of the current research. This would make more observations (quarterly data) available for investigation. There is, however, a strong reason for not using such data; most of the LIFO method firms, particularly before APB Opinion No. 28 on interim reporting in 1973, apply the technique only to the annual financial statements, but not to the quarterly statements. This will place more restrictions on the number of firms consistently applying the LIFO method.

With these constraints and shortcomings in mind, a minimum period of 27 years for model identification and estimation and three years as a hold-out were maintained. Because of the massive trend in changing inventory valuation methods in times of changing prices (particularly to LIFO in the early 50's, to FIFO in the mid 60's and back to LIFO in 1974 . . .) and because of a minimum of 30 observations needed for this study, the number of pure LIFO firms is smaller than that of either the FIFO or the average cost firms.

Earnings and Cash Flows Series Defined

Conventional measures of earnings may not be useful in analyzing the impact of different inventory methods because these measures are affected by the firms' choices of many other accounting alternatives such as depreciation and amortization methods. Therefore, it was felt that the use of such series in this study could produce misleading results. They are examined for (any) indirect impact of the valuation techniques.

To examine the direct impact of inventory valuation techniques, a different series is defined. Gross profit (defined as sales minus cost of goods sold) was used as a measure of earnings for the purpose of this study. Hence, three series are considered for investigation, two conventional ones (net income and cash flow) and an operationally defined one (gross profit as a measure of earnings). They are as follows:

Conventional Series	Operational Series
1a. Earnings:	1b. Earnings (Gross Profit):
Net Income	Net Sales
of the COMPUSTAT	Less: Cost of Sales
2a. Cash Flows:	
Net Income	
Add: Depreciation and Amortization	

The Box-Jenkins Technique

In addition to the issue of sample size discussed earlier, three other statistical aspects of the B-J methodology must be kept in mind: invertibility, stationarity, and parsimony. Invertibility refers to a set of conditions which ensure that, in any MA or AR model, the fitted value of the current observations does not depend overwhelmingly on observations in the remote past. Stationarity refers to some level of differencing (including zero) which ensures a constant mean and variance of the process. Parsimony simply refers to the ability to represent the data adequately with the minimum number of parameters.

The principal tools of the B-J technique are the backshift operator, B, where

$$BZ_t = Z_{t-1}$$

and Z_t is the ith observation of the times series process, and the difference operator, ∇, where

$$\nabla Z_t = W_t = Z_t - Z_{t-1}$$

and the autocorrelation function (ACF) and the partial autocorrelation function (PACF).

To compute the ACF the mean of the process, its variance, and its covariance at any lag, say k, are first computed. For example, the ACF at lag k = $r_k = \frac{c_k}{c}$ where c_k is the covariance of the process at lag k and c_o is the variance of the process. Now

$$c_k = \frac{1}{n} \sum_{t=1}^{n-k} (Z_t - \bar{Z})(Z_{t+k} - \bar{Z}) \text{ for } t = 0,1,2, \ldots, k \tag{1}$$

where $\bar{Z}$ = the mean of the process, Z_t = the ith realization of the process and n is the number of observations in the original series (27 in this study). The mean of the process, $\bar{Z}$, is defined in the usual way as

$$\bar{Z} = \frac{1}{n} \sum_{t=1}^{n} Z_t \tag{2}$$

The variance of the process, c_o, is defined as

$$c_o = \frac{1}{n} \sum_{t=1}^{n} (Z_t - \bar{Z})^2 \tag{3}$$

r_k then becomes

$$r_k = \frac{\sum_{t=1}^{n-k} (Z_t - \bar{Z})(Z_{t+k} - \bar{Z})}{\sum_{t=1}^{N} (Z_t - \bar{Z})^2} \tag{4}$$

and the PACF = $r_{kk} = \frac{|P_k^*|}{|P_k|}$

where the denominator is the determinant of the k x k autocorrelation matrix, P_k, and the numerator is the determinant of the same matrix, P_k, with the last column replaced by

$$\begin{matrix} r_1 \\ r_2 \\ \cdot \\ \cdot \\ \cdot \\ r_k \end{matrix}$$

The technique builds upon the argument of Box and Jenkins that many economic time series belong to the general class of linear stochastic processes of AR, MA, or a mixed form of the two. This general calss may be defined as

$$\phi_p(B)W_t = \theta_q(B)U_t \tag{6}$$

where ϕ_p and θ_q are the parameters of the AR and MA processes respectively and U_t is the error component. The model can be written in terms of the original series which then includes d to represent the degree of regular differencing to achieve stationarity

$$\phi_p(B)(1-B)^d Z_t = \theta_q(B)U_t.$$

Equation (6) and its variation are representations of the (regular) autoregressive-integrated-moving-average (ARIMA) process.[1] The left-hand side of the equation represents an AR process and the right-hand side a MA process.[2] The following is an outline of the three steps of B-J methodology which were applied to the observed series, defined above, at the univariate level.

Identification

The objective of this stage of the Box-Jenkins methodology is to determine the model that "best" describes the sample data. Plotting the data is a useful step for several purposes: checking for possible errors or outliers in the series, checking for evidence of structural change in the data being examined, and checking for evidence of possible nonstationarity in the series.

The statistical analysis involves a comparison of the shapes and properties of the sample ACF and sample PACF against their theoretical counterparts. Stationarity of the process is the first thing to examine via these functions. Nonstationarity can be detected either at the plotting step when no affinity for a mean value of the series is exhibited or through ACF and PACF examination. Nonstationarity can be detected at the second level when the ACF takes a relatively

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[1]The seasonal counterpart can be expressed as

$$\phi_p(B)\phi_P(B^s)\nabla^d\nabla_s^d Z_t = \theta_q(B)\Theta_Q(B^s)U_t$$

which is no concern to this study.

[2]Some expanded forms of the euqation are given in the following chapter.

long number of lags to die-down. If nonstationarity is evidenced, a stationary series has to be derived. This is achieved by taking the first difference of the original series or transforming it to its natural logarithms.

The comparison between empirical and theoretical ACF and PACF of a stationary series will enable the analyst to identify a tentative model for further consideration. This identification is reached on the basis of the known patterns of the autoregressive-moving average classes of models.

Thus, visual inspection as well as formal examination of the sample ACF and PACF are the principal tools in this stage. The analyst now is ready for the second stage; estimating parameters of his preliminary model.

Estimation

Preliminary estimates for the parameters (constants as well as coefficients) of the preliminary model (or set of models) identified in the first stage are obtained in this stage. The objective is to find a vector of parameter estimates which minimizes the shock sum of squares. Estimates obtained serve two purposes. First, they provide the analyst with an idea of how the final model would look. Second, they provide useful starting values for iterative procedures used in computing maximum likelihood estimates of parameters.

Diagnostic Checking

Statistical tests are conducted on the estimated model(s) in this final stage of analysis to check the model's adequacy. One class of checks is concerned with testing for significance of coefficients of model parameters. Another class is concerned with examining the residuals of the estimated models for randomness. This is achieved by generating a time series for the data under consideration using the proposed models. The residuals, then, are computed by finding the difference between the original data and the generated data. If tests showed randomness is lacking, this indicates that the generated series is serially correlated which implies that there is additional information in the past sequence of the series that can be utilized in the forecasting stage. The model(s) is accepted if checks fail to detect any inadequacy. Otherwise, it is either modified or abandoned and new one(s) is identified and subjected to the same process of analysis.

Specifically, the Box-Pierce Chi-Square (BPQ) Statistic was used to determine whether the first 10 autocorrelations of the residuals, considered together, indicate model adequacy. BPQ is computed as

$$BPQ = (n-d) \sum_{i=1}^{k} r_i^2(U).$$

A model was accepted if the calculated value of BPQ is less than $X_5^2(k-n_p)$ where n_p is the number of parameters that must be estimated in the model under investigation. The residual mean square (RMS), which measures the overall fit of the model, was applied to choose between two or more models that passed the BPQ adequacy test. The model is chosen if its RMS, defined as

$$RMS = \sqrt{\frac{SSE}{n-n_p}} = \sqrt{\frac{\sum_{i=1}^{n} (Z_i - \hat{Z}_i)^2}{n-n_p}}$$

is the smallest, and the SSE is the sum squares of the errors component.

The flowchart below shows the procedures followed in the Bcx-Jenkins time-series methodology.

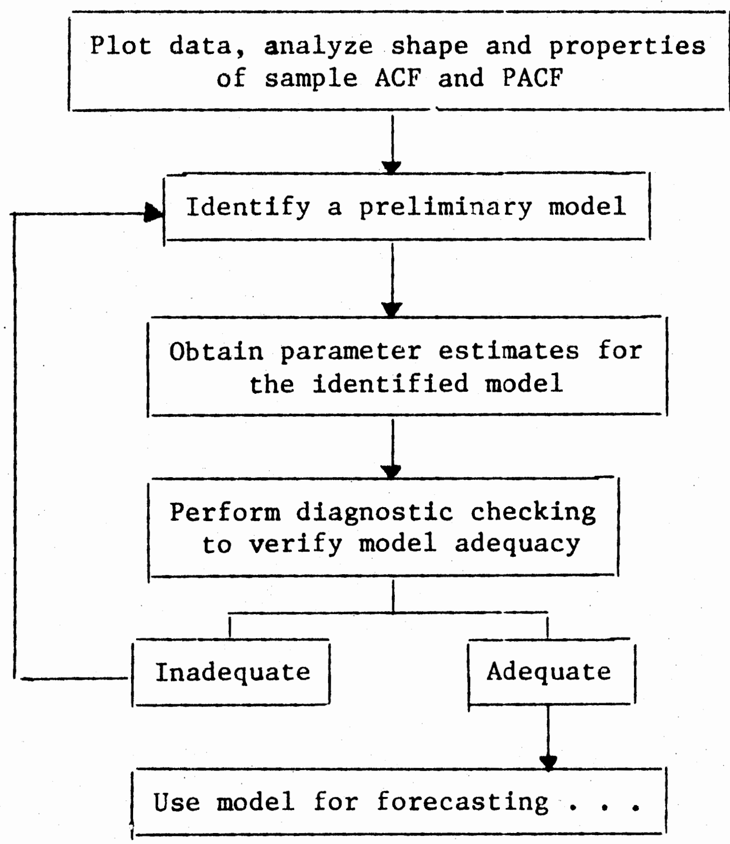

Figure 1. Procedures for the B-J Methodology

Criteria for Predictive Efficiency

Models obtained through the above stages are utilized to generate future values of the series from which the models were identified.

Three sets of data were forecasted for each measure, those for 1977, 1978 and 1979. These data have not been used for model identification and estimation. In order to validate the proposed Box-Jenkins models, two additional models were applied to the series under consideration:

a) Pure random walk model defined as:

$$E(Z_t) = Z_{t-1}$$

b) Random walk model with trend defined as:

$$E(Z_t) = Z_{t-1} + \delta$$

where:

Z_t = the realization of the series in period t,

E = the expectation operator, and

δ = the trend, which can be computed in the same way as that of Albrecht et al. (1977, p. 238):

$$\delta = \frac{Z_{t-1} - Z_1}{t - 2}$$

The measure of forecasting error used was the absolute percentage deviation (APD) defined as

$$APD_{it} = \frac{|\hat{Z}_{it} - Z_{it}|}{Z_{it}}$$

where Z_{it} = the actual accounting number for firm i in year t and $\hat{Z}_{it}$ = the predicted accounting number for firm i in year t.

The APD was chosen because a percentage error was considered to be a more meaningful measure of accuracy since the predicted numbers varied widely among series.

The multivariate analysis of variance (MANOVA) was used to evaluate the predictive efficiency of the forecasts. The APD calculated for each of the forecasted years represented the response variables while the valuation methods and forecasting models represented the rows effects and columns effects respectively. There was a separate MANOVA test conducted for each of the three accounting series used in this study. Figure 2 shows the research design for the MANOVA test. A separate MANOVA test was conducted on the forecasting errors for the gross profit, net income and cash flows series.

The Data

The names as well as the industry classes of the firms used in the research are shown in Table I. The table is composed of three firm groups. The first group contained the FIFO method firms, the second is the LIFO and the thrid is the average cost method group.

Over the entire period 1950-1979, the COMPUSTAT file classified 34 firms in the FIFO group, 22 firms in each of the LIFO group and average cost group. However, some of these firms were excluded because they did not meet the following necessary criteria:

1. The major portion of inventory must be consistently accounted for by only one of the alternative methods of inventory valuation for the entire period.[13]

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[3]Some firms were contacted directly when the COMPUSTAT file showed that the inventory valuation method is not available.

Valuation Methods \ Forecasting Models	Firms*	Box-Jenkins (a)			Random Walk (b)			Random Walk with Trend (c)		
		X_{77}	X_{78}	X_{79}	X_{77}	X_{78}	X_{79}	X_{77}	X_{78}	X_{79}
FIFO I	1	$(X_{1,I,a,77})$,	$(X_{1,I,a,78})$,	$(X_{1,I,a,79})$	.	.	.	$(X_{1,I,c,77})$,	$(X_{1,I,c,78})$,	$(X_{1,I,c,79})$
	2	.	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.
	18	.	.	.	.	.	.	.	.	.
LIFO II	1	$(X_{1,II,a,77})$,	$(X_{1,II,a,78})$,	$(X_{1,II,a,79})$	$(X_{1,II,b,77})$,	$(X_{1,II,b,78})$	$(X_{1,II,b,79})$	.	.	.
	2	.	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.
	18	.	.	.	.	.	.	.	.	.
AC III	1	$(X_{1,III,a,77})$,	$(X_{1,III,a,78})$,	$(X_{1,III,a,79})$	.	.	.	.	.	.
	2	.	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.
	18	$(X_{18,III,a,77})$,	$(X_{18,III,a,78})$,	$(X_{18,III,a,79})$	.	.	.	$(X_{18,III,c,77})$,	$(X_{18,III,c,78})$,	$(X_{18,III,c,79})$

*Response Variables

Figure 2. Conceptual Framework for MANOVA Tests

2. Gross profit, net income and cash flow data must be available in each period examined in the study.[4]

Some firms were therefore excluded, and the minimum number in the three groups, 18, was selected as the common sample size.

Summary

The present study utilizes the Box-Jenkins time-series technique to generate linear stochastic models for firms which have consistently applied one of three inventory valuation methods (FIFO, LIFO and average cost) over the 30 years period of study. The identified models are compared on both the descriptive and predictive bases across firm groups in order to determine the effect of alternative inventory costing methods on earnings and cash flow series.

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[4]Moody Industrial Manual was used for part of the period when the file indicated missing values for some firms.

TABLE I

LIST OF INDUSTRIES AND FIRMS IN SAMPLE

Method Firm	Industry	SIC 4-Digit Code	Firms	Inventory Valuation Method Code
1.1	Oth Constr	1600	*Elgin National Industries	1
1.2	Food Prods	2000	*Consolidated Foods Corp	1
1.3	Bakery Pds	2050	*American Bakeries Co.	1
1.4	Hshld Furn	2510	*Kroehler Mfg. Co.	1
1.5	Books	2731	*Grolier, Inc.	1
1.6	Drugs	2830	*Abbott Laboratories	1
1.7	Drugs	2830	*Merck and Co.	1
1.8	Drugs	2830	*Searle (G.D.) & Co.	1
1.9	Petro. Ref.	2911	*Imperial Oil Ltd-CLA	1
1.10	Fab. Met. Prod.	3499	*Diebold, Inc.	1
1.11	General Mch.	3560	*Stewart-Warner Corp.	1
1.12	General Mch.	3560	Rexnord, Inc.	1
1.13	Off-Comp. Eq.	3570	*Burroughs Corp.	1
1.14	Motor Vehcl.	3711	*American Motors Corp.	1
1.15	Surg. Inst.	3841	*American Hospital Supply	1
1.16	Photographic	3861	*Bell & Howell Co.	1
1.17	Photographic	3861	*Minnesota Mining & Mfg. Co.	1
1.18	Ret-Lumber	5211	*Evans Products Co.	1
2.1	Paper	2600	Mead Corp.	2
2.2	Chemicals	2800	Union Carbide Corp.	2
2.3	Petrol. Ref.	2911	Cities Service Co.	2
2.4	Petrol. Ref.	2911	Phillips Petroleum Co.	2
2.5	Petrol. Ref.	2911	Standard Oil Co. (Ohio)	2
2.6	Petrol. Ref.	2911	*Union Oil Co. of California	2
2.7	Mis. Min. Pd.	3290	*Johns-Manville Corp	2
2.8	Blast Furnc.	3310	Armco Inc.	2
2.9	Blast Furnc.	3310	Inland Steel Co.	2
2.10	Blast Furnc.	3310	*National Steel Corp.	2
2.11	Blast Furnc.	3310	*Republic Steel Corp	2
2.12	Blast Furnc.	3310	*U. S. Steel Corp.	2
2.13	Blast Furnc.	3310	*Carpenter Technology	2
2.14	Blast Furnc.	3310	Interlake, Inc.	2
2.15	Nonfer Mtl.	3330	Aluminum Co. of America	2

TABLE I (Continued)

Method Firm	Industry	SIC 4-Digit Code	Firms	Inventory Valuation Method Code
2.16	Constr. Mach.	3531	*Caterpillar Tractor Co.	2
2.17	Special Mch.	3550	Joy Mfg. Co.	2
2.18	Indl. Contrl.	3622	Square D Co.	2
3.1	Misc. Minerl	1499	*Freeport Minerals Co.	3
3.2	Food Prods	2000	*Standard Brands, Inc.	3
3.3	Dairy Prods.	2020	*Kraft, Inc.	3
3.4	Malt Beverage	2082	*Pabst Brewing Co.	3
3.5	Cigars	2121	J.S. Tobacco Co.	3
3.6	Text Ml Pds	2200	*Belding Heminway	3
3.7	Lumber-Wood	2400	Champion International Corp	3
3.8	Books	2731	*Macmillan, Inc.	3
3.9	Chemicals	2800	*Sterling Drug, Inc.	3
3.10	Drugs	2830	*Smithkline Corp.	3
3.11	Cement Hydr.	3241	General Portland, Inc.	3
3.12	Nonfer Mtl.	3330	Brush Wellman, Inc.	3
3.13	General Mch.	3560	Curtiss-Wright Corp	3
3.14	Off-Comp Eq.	3570	*Intl. Business Machines Corp	3
3.15	Air Trans.	4511	*American Airlines, Inc.	3
3.16	Air Trans.	4511	*Delta Air Lines, Inc.	3
3.17	Air Trans.	4511	*Eastern Air Lines	3
3.18	Air Trans.	4511	*Northwest Airlines, Inc.	3

*Pure or nearly-pure single-method firm.

CHAPTER IV

RESULTS OF STUDY

Empirical data obtained from the COMPUSTAT for the period 1950-1976 inclusive were used to determine the time series properties of firms' gross profit, net income and cash flow. Three time-series models were identified for each of 54 firms using the Box-Jenkins technique.

Data from three years, 1977-1979, were used to test the forecasting performance of the B-J, RW and RWWT time-series models. In order to determine model superiority, the APD was calculated for each series. The same measure was used to examine if differences between (FIFO, LIFO, and average cost) methods of inventory valuation exist. MANOVA was conducted to analyze the values of APD. This chapter describes the types of processes identified for firms in the different accounting series and the results of the tests of prediction significance.

Model Specification

The time-series models obtained from the application of the B-J technique are shown in Table II. They are grouped at three main classes: mixed, autoregressive and moving average processes at both the stationary and nonstationary levels. The numbers in the body of the table represent the frequency of the B-J class of models for the corresponding accounting series and valuation method. All models are special forms of the general regular ARIMA model shown by equation (6)

TABLE II

FREQUENCY TABLE OF B-J MODELS IDENTIFIED FOR FIRMS ASSOCIATED WITH INVENTORY VALUATION ALTERATIVES

Accounting Series	Inventory Valuation Methods	B-J Time Series Models		
		ARMA/ARIMA	AR/ARI	MA/IMA
A. Gross Profit	FIFO	8	8	2
	LIFO	4	5	9
	Average Cost	5	7	6
B. Net Income	FIFO	4	8	6
	LIFO	0	9	9
	Average Cost	4	9	5
C. Cash Flow	FIFO	5	7	6
	LIFO	0	8	10
	Average Cost	4	7	7

in the previous chapter. The following is an expanded form of the equation for the major models found in the study.

ARMA (1,0,1) $$Z_t = \phi_1 Z_{t-1} - \theta_1 U_{t-1} + U_t \qquad (1)$$

ARIMA (1,1,1) $$(1-\phi_1 B)W_t = (1-\theta_1 B)U_t \qquad (2)$$

or $$Z_t = (1+\phi_1)Z_{t-1} - \phi_1 Z_{t-2} - \theta_1 U_{t-1} + U_t$$

AR (1,0,0) $$Z_t = \phi_1 Z_{t-1} + U_t \qquad (3)$$

ARI (1,1,0) $$W_t = \phi_1 (Z_{t-1} - Z_{t-2}) + U_t \qquad (4)$$

or $$Z_t = Z_{t-1} + \phi_1 (Z_{t-1} - Z_{t-2}) + U_t$$

MA (0,0,1) $$Z_t = U_t - \theta_1 U_{t-1} \qquad (5)$$

IMA (0,1,1) $$W_t = U_t - \theta_1 U_{t-1} \qquad (6)$$

or $$Z_t = Z_{t-1} + U_t - \theta_1 U_{t-1}$$

Gross Profit

With respect to the gross profit time series, it is apparent from the table that grouping firms by the method of inventory valuation results in model differences. The FIFO group, for example, seems to have fewer of the moving average models than the two other processes of time series. The LIFO group, on the other hand, tends to have more of the moving average models than either of the mixed or autoregressive types; actually, half of the firms in this group were found to be of the MA class. The average cost group is in a position between the

FIFO and the LIFO groups with respect to the frequencies of the MA model. Models in this group are almost equally distributed among the three main classes. This may suggest that, all other things being equal, average cost inventory does not influence the behavior of the gross profit series. This is due to the almost equal probability of occurrence for the three classes of time series processes. On the other hand, the FIFO or LIFO method would result, in the long run, in a low probability of an MA process for FIFO and a moderately high probability of an MA process for LIFO.

A X^2 test of significance was conducted to determine if the frequency of time series models was different for firms using different inventory methods. The test revealed that the differences in the distribution of different time series models for firms using different inventory models is not statistically significant at the .05 probability level (the X^2 value is 6.27 which has $P \approx .15$).

Another way of looking at the results reported in Table II is to relate them to the more detailed breakdown of the same models in Table III. Table III shows for every firm the type of model, the model's parameter estimate when applicable, and the criteria for selecting that particular model, i.e. Box-Pierce-Q Statistics (BPQ) and the residual mean square (RMS). Notice in the table that among the AR/ARI class of processes there are several firms for which the mere differencing of the Z_t series was sufficient for model identification, i.e., parameter value was not statistically significant. This is an indication of the random nature of the series. There are three firms of this kind in the FIFO group, three in the LIFO group and two in the average cost

TABLE III

MODELS IDENTIFIED AND ESTIMATED FOR GROSS PROFIT SERIES FOR FIRMS IN THE THREE GROUPS

Inventory Method and Firm*	Pdq**	Estimated Parameters***						Statistics****	
		ϕ_1	ϕ_2	ϕ_t	θ_1	θ_2	θ_t	BPQ	RMS
				Gross Profit/FIFO Firms					
1.1	(1,0,0)	.84						11.5	4.45
1.2	(1,1,1)	.99			.69			6.12	34.62
1.3	(0,1,0)								
1.4	(1,1,1)	.55			.91			5.09	3.06
1.5	(0,1,0)								
1.6	(2,1,1)		.54		-.51			2.07	17.55
1.7	(1,2,0)	-.63						4.91	16.46
1.8	(1,1,3)	.87					.62	1.59	13.94
1.9	(0,1,3)						.79	4.49	79.4
1.10	(2,1,1)		-.69					15.2	3.29
1.11	(0,1,0)								
1.12	(1,1,0)	.72						1.89	7.37
1.13	(2,2,0)		-.5					7.32	27.38
1.14	(1,1,1)	-.66			-.93			5.91	36.13
1.15	(0,2,4)						.61	3.67	7.57
1.16	(5,1,0)	.76						7.14	8.05
1.17	(1,1,1)	.99			.68			7.02	48.61
1.18	(1,1,1)	.55			.94			3.43	19.39
				Gross Profit/LIFO Firms					
2.1	(1,1,0)	-.62						2.38	29.91
2.2	(0,1,0)								
2.3	(2,1,4)		.58				-.87	2.78	40.31
2.4	(0,1,0)								
2.5	(0,1,2)				-.41	-.69		2.03	25.00
2.6	(0,1,0)								
2.7	(0,1,3)						-.81	3.51	17.39

TABLE III (Continued)

Inventory Method and Firm*	Pdq**	Estimated Parameters*** ϕ_1	ϕ_2	ϕ_t	θ_1	θ_2	θ_t	Statistics**** BPQ	RMS
2.8	(1,1,1)	.60			.93			2.93	53.08
2.9	(0,1,1)				.55			2.89	38.66
2.10	(0,1,1)				.93			3.25	58.42
2.11	(0,0,1)				.96			11.19	62.34
2.12	(1,1,1)	.54			.94			3.52	206.32
2.13	(0,1,2)					.89		3.47	6.82
2.14	(0,1.4)							.79	11.56
2.15	(1,1,0)	-.65						3.08	58.43
2.16	(3,1,1)			.82	-.42			6.57	72.70
2,17	(0,1,1)				-.62			4.96	10.71
2.18	(0,1,4)						-.49	1.42	7.45
		Gross Profit/Average Cost Firms							
3.1	(0,1,5)						.73	10.23	6.83
3.2	(1,1,1)	.97			.75			4.21	17.92
3.3	(0,2,1)				.71			4.00	20.55
3.4	(0,1,1)				-.38			4.36	8.85
3.5	(1,1,0)	.63						2.34	3.23
3.6	(1,1,0)	.45						2.93	1.66
3.7	(5,1,0)			.72				5.75	39.63
3.8	(0,1,0)								
3.9	(0,2,1)				.90			5.37	15.89
3.10	(1,1,0)	.77						5.12	8.77
3.11	(0,1,3)						.62	4.23	5.03
3.12	(0,1,0)								
3.13	(0,1,5)						.80	5.82	17.68
3.14	(1,1,0)	.75						3.99	369.33

TABLE III (Continued)

Inventory Method and Firm*	Pdq**	Estimated Parameters*** ϕ_1	ϕ_2	ϕ_t	θ_1	θ_2	θ_t	Statistics**** BPQ	RMS
3.15	(1,1,3)	-.43					.66	4.09	40.62
3.16	(1,1,1)	.99			.80			12.36	27.23
3.17	(1,1,1)	.59			.95			6.95	.33
3.18	(6,1,5)			-.98			-.75	2.17	21.41

* The following numbers are used to represent the three methods of inventory valuations:
1 = First-in First-out
2 = Last-in First-out
3 = Average Cost.

** The following notations are used to describe the identified Box-Jenkins models:
P = maximum order of any autoregressive parameter
d = maximum level of consecutive differncing
q = maximum order of any moving average parameter

*** The following symbols are used to represent the estimated parameters:
ϕ_t = P^{th} order regular autoregressive parameter
θ_t = q^{th} order regular moving average parameter

**** The following symbols represent the diagnostic checks statistics as defined in the previous chapter.

BPQ = Box-Pierce-Q statistics.
RMS = residual mean square

group. BPQ and RMS were not computed for the models of these firms because AR and MA parameters were zero in these models. Therefore estimation and diagnostic checking cannot be performed.

Differencing of the Z_t series is an additional area of comparison between models across the three groups of firms. A series is transformed via differencing so that stationarity is restored and model identification and estimation procedures are applied. Examination of Table III shows that first differencing was performed on 14 of the gross profit series in the FIFO group, 17 in the LIFO and 16 in the average cost. Additionally, second differencing was applied to three more firms in the FIFO group and two firms in the average cost groups. When firms were ordered in terms of instability of their series as indicated by differencing it appeared that almost all firms had their series differenced.

Finally, the order of the model is another aspect that was examined. Literature suggests that the majority of identified B-J-models have a maximum order of two.[1] Table III again shows that there are four firms in the FIFO group, five in the LIFO group, and six in the average cost group that have models of an order higher than the second-order.

Net Income

Net income is the most conventional measure of performance in accounting. As it was stated previously in this study this measure

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[1]Higher order models were encountered for a number of firms in this study. This finding may be attributed to a number of reasons which include the length of the time series, overfitting for better descriptive results and the nature of the firm's data.

is not as relevent to the current research question as the measure discussed above, i.e. gross profit.

Part B of Table II shows model frequencies for the net income series for firms in the three different inventory groups. No particular class of model seems to predominate in the FIFO group; however, the frequency of the AR model is twice that for the mixed (ARMA/ARIMA) model. For the LIFO firms, the AR and MA processes occurred with equal frequency and the mixed model did not occur at all. For four of the firms with an AR process, however, the model had only a first differencing of the time series. The most pronounced pattern of model clustering was found in the average cost group. The AR process occurs twice as often as those for the mixed and MA models. A X^2 test showed that the differences in the distribution of different time series models between inventory methods are not significant at the .05 level (the X^2 value was 5.38 which has $P \approx .20$).

The data in Table IV show that in the AR/ARI class there are two models of first differences in the FIFO group, one in the LIFO group and four in the average cost group. Differencing was required for 14 series in the FIFO groups. Three of them were second differenced. For the LIFO group there are twelve first differenced series, while in the average cost there are fourteen series which are first differenced and two second differenced.

The order of the model is one or two. Higher order was found for two firms in the FIFO group, four firms in the LIFO group and one firm in the average cost group.

Models can be grouped across the three classes of firms for an overall assessment of time series properties of firms' earnings. The

TABLE IV

MODELS IDENTIFIED AND ESTIMATED FOR NET INCOME SERIES FOR FIRMS IN THE THREE GROUPS

Method and Firm	Pdq	ϕ_1	ϕ_2	ϕ_t	θ_1	θ_2	θ_t	BPQ	RMS
				Net Income/FIFO Firms					
1.1	(0,1,1)				.71			11.41	3.06
1.2	(0,1,0)								
1.3	(1,0,0)	.59						1.82	1.93
1.4	(0,0,1)				-.70			2.99	1.14
1.5	(0,0,2)					-.86		9.60	12.8
1.6	(1,1,1)	.99			.61			3.03	7.26
1.7	(1,2,0)	.41						7.98	6.29
1.8	(1,1,3)	.42					.77	.90	4.82
1.9	(1,1,1)	-.59			-.98			1.2	20.42
1.10	(0,1,1)				-.96			4.97	.86
1.11	(5,1,2)			-.72		.56		6.42	1.52
1.12	(1,1,0)	.97						6.83	2.05
1.13	(2,2,0)		-.46					10.14	4.72
1.14	(1,0,0)	.48						6.54	28.29
1.15	(0,2,2)					.66		6.78	1.23
1.16	(2,1,0)	.46	-.46					4.18	1.44
1.17	(0,1,0)								
1.18	(0,1,1)				.97			2.22	13.7
				Net Income/LIFO Firms					
2.1	(1,1,0)	-.50						1.71	11.54
2.2	(0,1,0)								
2.3	(0,1,1)				.44			2.69	24.44
2.4	(0,1,0)								
2.5	(0,1,5)						.72	2.81	9.29
2.6	(0,1,0)								
2.7	(0,1,2)					.86		11.21	4.74

TABLE IV (Continued)

Method and Firm	Pdq	ϕ_1	ϕ_2	ϕ_t	θ_1	θ_2	θ_t	BPQ	RMS
2.8	(1,0,0)	.66						2.98	27.47
2.9	(0,0,2)				-.38	-.81		1.53	17.87
2.10	(1,0,0)	.41						2.12	26.6
2.11	(0,0,3)						.81	6.78	25.18
2.12	(1,0,0)	.69						4.34	91.27
2.13	(0,1,2)					.90		6.29	2.66
2.14	(0,1,4)						.79	8.64	4.62
2.15	(2,0,0)		.65					4.57	27.86
2.16	(0,1,3)						-.82	3.94	33.85
2.17	(0,1,1)				-.56			4.39	4.25
2.18	(0,1,0)								
				Net Income/Average Cost Firms					
3.1	(1,0,0)	.63						3.00	13.12
3.2	(1,1,1)	.99			.69			3.90	2.16
3.3	(0,1,1)				.41			.77	8.73
3.4	(0,1,0)								
3.5	(0,2,0)								
3.6	(2,1,0)		.42					8.81	.34
3.7	(0,1,1)				.58			4.01	13.48
3.8	(1,1,2)	-.67				.73		1.91	3.13
3.9	(0,2,0)								
3.10	(1,1,0)	.44						4.17	2.35
3.11	(1,1,1)	-.46			-.94			2.02	1.97
3.12	(0,1,2)					.84		4.23	1.19
3.13	(1,1,0)	.59						8.29	4.96
3.14	(1,1,0)	.83						9.66	80.27

TABLE IV (Continued)

Method and Firm	Pdq	ϕ_1	ϕ_2	ϕ_t	θ_1	θ_2	θ_t	BPQ	RMS
3.15	(0,1,2)				.67	-.87		4.45	20.49
3.16	(0,1,1)				.60			3.20	11.56
3.17	(3,0,0)		.48	-.57				6.35	15.67
3.18	(2,1,1)		-.61		-.58			6.80	8.98

bulk of models are in the autoregressive category. This finding confirms the conclusion of some researchers in accounting that earnings generating processes can be represented by a submartingale or very similar process. Such a pattern was not found in the gross profit series where models were approximately equally distributed among the three main classes of processes.

Cash Flow

Models identified for the cash flow series in both the FIFO group and average cost group of firms did not show any tendency to cluster into one class. This was not the case for the FIFO group in the gross profit series and the average cost in the net income. Adjustments were made on the net income figure to obtain a measure of cash flow. The removal of the impact of the depreciation and amortization policies of the firms resulted in restoring some normality in model distribution between the three processes in these two groups. The LIFO group, on the other hand, seemed to have more of the moving average kind. Ten firms had MA processes. The other eight firms had an autoregressive process. A X^2 test showed, however, that the differences in the frequency of the occurrence of models across methods of inventory valuation are not statistically significant at the .05 level X^2 value was 4.84, $P \approx .30$).

The total number of models which required that the Z_t series be differenced were 14 in the FIFO group. Three series in this group required second differencing. The LIFO group contained 17 models with only first differencing; and for the average cost group, 16 models required first differencing and two models required second differencing.

TABLE V

MODELS IDENTIFIED AND ESTIMATED FOR CASH FLOW SERIES FOR FIRMS IN THE THREE GROUPS

Method and Firm	Pdq	ϕ_1	ϕ_2	ϕ_t	θ_1	θ_2	θ_t	BPQ	RMS
				Cash Flow/FIFO Firms					
1.1	(0,1,1)				.71			11.41	3.06
1.2	(1,1,0)	.46						6.18	4.55
1.3	(1,0,0)	.55						2.72	2.03
1.4	(0,0,1)				-.63			2.42	1.12
1.5	(0,0,2)		-.86					5.74	12.37
1.6	(1,1,1)	.99			.68			3.12	6.79
1.7	(1,2,1)	.54			.93			4.36	5.53
1.8	(1,1,3)	.54					.72	.76	5.21
1.9	(3,1,1)			.65	-.50			1.43	19.99
1.10	(0,1,1)				-.82			4.35	.89
1.11	(1,1,2)	-.46				.51		5.97	1.58
1.12	(1,1,0)	.99						5.12	2.64
1.13	(2,2,0)		-.80					7.31	6.19
1.14	(0,1,2)					.87		9.69	26.1
1.15	(6,2,0)			-.58				3.76	1.56
1.16	(3,1,0)			-.48				5.18	1.5
1.17	(3,1,0)			.94				5.15	18.68
1.18	(0,0,3)						-.75	.87	13.72
				Cash Flow/LIFO Firms					
2.1	(1,1,0)	-.48						2.25	12.08
2.2	(0,1,0)								
2.3	(0,1,0)								
2.4	(0,1,0)								
2.5	(0,1,4)						-.74	3.80	10.47
2.6	(0,1,0)								
2.7	(0,1,2)					-.84		6.65	5.35

TABLE V (Continued)

Method and Firm	Pdq	ϕ_1	ϕ_2	ϕ_t	θ_1	θ_2	θ_t	BPQ	RMS
2.8	(0,1,1)				.96			11.00	27.30
2.9	(1,1,0)	-.41						6.54	19.56
2.10	(0,1,1)				.95			10.18	28.33
2.11	(0,0,3)						.81	4.24	25.91
2.12	(0,1,3)						.51	3.51	108.48
2.13	(0,1,4)						.82	5.29	2.65
2.14	(0,1,4)						.79	8.64	4.62
2.15	(0,1,1)				.70			4.59	29.99
2.16	(3,1,0)	.95						4.28	37.76
2.17	(0,1,1)				-.56			4.81	4.51
2.18	(0,1,0)								
<u>Cash Flow/Average Cost Firms</u>									
3.1	(1,1,0)	-.41						4.88	13.34
3.2	(1,1,1)	.99			.70			1.81	2.46
3.3	(0,1,0)								
3.4	(0,1,1)				-.49			4.79	3.52
3.5	(0,2,1)				.44			1.84	.56
3.6	(0,1,0)								
3.7	(6,1,0)			-.75				5.26	13.03
3.8	(0,1,2)					.41		2.23	3.54
3.9	(1,2,1)	.65			.94			4.83	1.47
3.10	(1,1,0)	.47						4.90	2.68
3.11	(0,1,2)					.69		4.83	2.00
3.12	(0,1,2)					.56		4.16	1.40
3.13	(0,1,0)								
3.14	(1,1,0)	.66						8.10	125.06

TABLE V (Continued)

Method and Firm	Pdq	ϕ_1	ϕ_2	ϕ_t	θ_1	θ_2	θ_t	BPQ	RMS
3.15	(0,1,2)				.77	-.88		5.87	19.97
3.16	(0,1,4)						-.76	4.97	10.14
3.17	(1,1,0)	-.69						10.18	.35
3.18	(2,1,1)		-.57		-.68			2.95	9.54

Six models of an order higher than second were found in each of the FIFO and LIFO groups. The average cost groups contained only two models of an order higher than second order.

Prediction Testing and Statistical Analysis

Prediction testing involved the forecasting of future values using the B-J models selected for each firm as well as the two naive models, namely, the random walk and the random walk with trend models. The use of these latter models was useful in validating the results of the analysis.

For each series, predicted values obtained from each model comprised the basis for evaluating the predictive ability of that model. The evaluation consisted of the comparison of each model's predicted values for each year with the actual values of that year's accounting numbers. A 3x3 MANOVA analysis was conducted in which the forecasting errors (expressed as absolute percentages) for the three years served as response variables. The valuation methods and forecasting models were representative of row effects and column effects, respectively. There were 18 firms in each of the three valuation method groups and three forecast periods for each firm for each forecasting model which resulted in 162 observations per valuation method.

In order to test for forecasting model differences as well as valuation method differences for the firms' accounting numbers series, it is customary to first determine whether or not there is interaction between forecasting model and valuation method.

The next step of analysis depends on whether or not there is interaction between forecasting model and valuation method. If there is interacting, forecasting models must be compared on a valuation method-by-method basis in order to determine the effect on predictive ability of the different inventory valuation methods. The hypothesis here is:

HO_1: There is no significant difference between the FIFO, LIFO and average cost methods of inventory valuation in predicting future values of the accounting numbers series under investigation.

If there is no interaction, the indication is that the valuation method has no affect on predictive ability. The line of inquiry then moves to determine the overall forecasting model effect. The null hypothesis for this analysis is:

HO_2: There is no significant difference between the B-J, RW and RWWT models in forecasting future values of the accounting numbers series under investigation.

The following is an examination of results for these hypotheses for each of the accounting series chosen for this study.

Gross Profit

With respect to the gross profit time series, the MANOVA test showed that interaction between forecasting model and valuation method is not significant ($P \approx .40$). This means that model differences are consistent from one valuation method to another. Such a finding makes it possible to examine forecasting models across valuation methods. The results of such an examination indicated that the hypothesis of no overall model effect is rejected at the .05 level ($P \approx .02$).

In order to evaluate the performance of the forecasting models some form of a posteriori analysis is desirable. Duncan's multiple range test was conducted to determine which model(s) was (were) responsible for such model differences. The analysis was undertaken for each of the three-year ahead forecasts (all tests are at .05 probability):[2]

a) 1-Year Ahead Forecast: The performance of all forecasting models were not significantly different from each other for this time horizon.

b) 2-Year Ahead Forecast: The performance of the RW and RWWT models were not significantly different from each other. The RWWT model was not significantly different from the B-J models. The trend in the RWWT was just enough to make this model perform as good as the B-J type but not large enough to outperform the RW type.

c) 3-Year Ahead Forecast: The conclusions here are identical to those in (b) above.

With respect to the differences between inventory valuation methods, the results indicated that there is a significant difference in predictive ability ($P \approx .0001$) which permits rejection of the hypothesis of no overall inventory method effect on prediction. When Duncan's multiple range test was conducted, the following conclusions were obtained:

a) 1-Year Ahead Forecast: Every method was significantly different from the others, with LIFO performance being the worst, average cost being the best.

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[2]There was no attempt to compute a new error rate per comparison in this study. The error rate is the same (.05) throughout the tests. For a detailed discussion on the subject see Kirk (1968).

b) 2-Year Ahead Forecast: LIFO, performing the worst, was significantly different from both the FIFO and average cost methods which were not significantly different from each other in prediction efficiency.

c) 3-Year Ahead Forecast: The conclusions here are identical to those in (a) above.

As the test showed, the LIFO performed the worst in all three horizons followed by the FIFO in two of the three horizons; one-year horizon and three-year horizon.

Given the above results, the conclusion of the impact of valuation method on predicting future values seems to be reasonable. There are, however, many other factors that must be considered before any firm conclusion can be drawn, e.g., firm specifics, industry class, and other accounting alternatives.

Net Income

With respect to the net income time series, the hypothesis of no interaction between prediction model and valuation method was supportable at a probability level of about .05 by the MANOVA test. This value makes the decision to reject or not-reject a matter of personal judgment. The choice made in this study was to not-reject so that conclusions drawn from the model comparison would be more conservative; therefore, a method by method analysis for model effect was conducted. The results indicated that there was no model effect for the FIFO method firms ($P \approx .10$) and the average cost firms ($P \approx .30$) All time series models for the two inventory groups performed about the same for all time horizons. There was no clearly determinable single best model for the LIFO method firms (P $\approx$.05). Duncan's test revealed that all models in the LIFO method performed similarly for one and two periods ahead. For three years ahead, B-J performed worse than both the RW and the RWWT models.

The hypothesis of no over all method effect was strongly rejected (P $\approx$.0001). Further multiple comparison tests were carried out to detect specific method differences. Duncan's test showed that average cost was not significantly different from the LIFO method which, in turn, was not different from the FIFO method; while the average cost and the FIFO methods were found to be significantly different at the one-year horizon. For two years ahead all methods performed differently, with LIFO doing the worst and FIFO the best. For three years ahead, LIFO again performed worse than both the average cost and FIFO methods.

Cash Flow

With respect to the cash flow series the hypothesis of no overall interaction between forecasting model and valuation method had a very high associated probability (P $\approx$ .83). Unlike the case of net income, forecasting models for this series can be compared across methods because the level of predictive performance was consistent.

Based upon the no interaction conclusion, the hypothesis of no overall model effect was examined. With the high probability of no model effect (P $\approx$ .66), it can be concluded that forecasting models performed about the same for all three time horizons.

The hypothesis of no overall valuation method effect was rejected to be very significant ($P \approx .0001$). This required further investigation in the form of multiple comparisons between the three valuation methods for the three years forecast. Duncan's test showed that all three methods performed equally well for one year ahead forecast. All methods performed differently for two year ahead forecast with LIFO performing the worst and the FIFO the best. The three year ahead forecast showed that LIFO and average cost performing at about the same level of predictive efficiency. Average cost and FIFO performed about the same, but the performance of the LIFO and FIFO groups are significantly different from each other.

Summary

This chapter contained the results of the study. In terms of the types of generating processes identified through the B-J methodology, there was no particular process that seemed predominant for any method of inventory valuation or accounting number series. There was some tendency, though not strong, for a class of forecasting model to be more frequently associated with one valuation method than another.

Identified B-J models and two naive models, random walk and random walk with trend, were used to predict future values of these different accounting series in order to test for prediction superiority of forecasting models and inventory valuation methods. For the gross profit series, the level of performance of the valuation methods and forecasting models was consistent for each of the three forecast periods.

The cash flow series was second to the gross profit series with respect to consistency of performance, followed by the net income series. This finding supports the a priori expectations that the gross profit time series would be the most representative measure of the impact of the inventory valuation methods.

The overall conclusion of this chapter is that while the LIFO method group was found to perform at the lowest level of efficiency, the average cost and FIFO methods performed at about the same level. In addition, the forecasting models performed about the same for all time horizons.

CHAPTER V

SUMMARY AND CONCLUSIONS

This final chapter consists of three sections. The first summarizes the findings of the study. The second points out several limitations of the research methodology which affect the generalizability of the reported results. The third describes the implications of the study's findings on future research.

Summary of Research

Measurement of periodic performance of firms is influenced by the many alternatives which are available to accountants. The controversy of which alternative to choose as the best measure cannot be resolved on the sole basis of appeals to reason and logical propriety. However, the usefulness of a measure to produce efficient predictions of events of interest to users is one important aspect of selection among such competing alternatives.

This study deals with one segment of this measurement dilemma in accounting. Inventory valuation was chosen as an area of application of the predictive-ability criterion. The most popular inventory valuation alternatives (FIFO, LIFO and average cost) were evaluated in light of their ability to predict earnings and cash flows.

Three groups of firms each of which used only one of these methods consistently over a period of 30 years were investigated. The underlying generating processes of firms' gross profit, net income and cash flow series were identified through the Box-Jenkins ARIMA technique. There was no strong pattern of a single process that can be attributed to one of the valuation methods. There was, however, a noticeable tendency toward a predominance of a single class of model in some of the analysed series. The LIFO group for example, had 50% of its firms' processes in the MA class for the gross profit series and 56% in the same class for the cash flow series. The processes were equally divided between the AR and MA classes for the net income series. The average cost group, on the other hand, had 50% of its firms' processes in the AR class for the net income series.

The identified models were subjected to further parameter estimation and diagnostic checking. The three accounting numbers series were forecasted for three-periods ahead using the Box-Jenkins models as well as random walk and random walk with trend models. The absolute percentage deviations for each series were computed and analyzed through multivariate analysis of variance.

Results showed that LIFO data were the least efficient in making predictions, and the average cost and FIFO data were about the same with respect to efficiency. This equal performance of average cost and FIFO may justify the tendency of some researchers in accounting to treat the two measures, as for all practical purposes, a single measure (Sunder, 1976b).

Limitations

The use of 27 observations only for model identification and parameter estimation may make the results somewhat biased, particularly with respect to parameter estimates. The 50-observations rule of thumb for the Box-Jenkins technique could not, however, be met. This limitation was imposed by the lack of availability of the data for 50-consecutive years. The lack of data for 50 years may not have a significant affect on the results of this study because annual data is being used. For a 50-year time horizon it is quite likely that structural shifts would have occurred which would reduce the influence of early observations on the time series model.

A second limitation is that the study was restricted to the COMPUSTAT firms. These firms are among the oldest and largest in the economy. This limitation may not permit generalized conclusions applicable to all firms in the economy. Adherence to a single method of inventory valuation for long periods may not be representative of most firms in the market.

A third limitation is the small number of firms in each group, namely 18. This limitation may result in a small sampling bias.

Implications and Suggestions

The need to define the appropriate accounting measure of interest when conducting time-series research is apparent. Results become more meaningful when the influence of the many accounting alternatives is minimized.

Simulation can be used to overcome the problem of sample size on both firms and time periods. Additionally, quarterly data generated through simulation can be investigated for time-series properties associated with inventory valuation methods or other aspects of the accounting alternatives measurement process. Such quarterly simulated data will make more observations available to the analyst and significantly reduce the problem of the length of time interval. Moreover, the analyst can include in his analysis as many simulated firms as needed and have some control over the many factors that cannot be eliminated in actual data. Finally, cross-sectional analysis can be used to identify a process that is an overall representative for each group of firms. The performance of this process can be evaluated against the performance of the uniquely identified processes.

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