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Time-Series Properties of Quarterly Accounting Numbers

Dr. Abdullah A. Abdulkader
Assistant Professor, Accounting Department, College of Administrative Sciences, University of Riyadh, Riyadh, Saudi Arabia.

Time-series research is the investigation of the quantitative measures of a variable collected over equally spaced intervals of time. The investigation involves the specification of statistical models that represent and/or predict values of the variable, and the estimation of the parameters of the models.

This paper is an attempt to present and evaluate that type of empirical research in accounting, and to shed some light on the conclusions presented.

The models evaluated herein are; (Watts 1975, Griffin 1977 and Larek 1979 Multiplicate first order moving average model), (Foster 1975 first order autoregressive model adjusted seasonally) and (Brown and Rozeff 1977 first order autoregressive seasonal moving average model, adjusted seasonally with a drift.

The paper also, introduces the theoretical frame-work utilized in the time-series research of accounting numbers, and some suggestional topics for future research in this area of the empirical research in accounting.

SECTION I

Introduction

Accounting numbers, unlike Picasso's paintings or chamber music, are not a phenomenon to be appreciated for their own sake; rather, they are utilitarian. Their survival is dependent on the utility derived from them, and this utility is a function of their contribution to and facilitation of decision making. A necessary prerequisite to the optimal utilization of accounting numbers is the understanding of their time-series properties and their generating mechanism.(1)

Increasing attention has been given to the time-series properties of accounting numbers in recent years. This attention is justified for several reasons. Firse, a major objective of generating accounting numbers is to provide information useful in valuing a firm's common equity. The finance literature is rich with different valuation models that assess a firm's future cash flows to investors on the basis of the probability distribution associated with various levels of performance (earnings). These valuation models recognize the interrelationship between the key variables affecting a firm's future cash flows to investors and the probability distribution of price changes. In relation to this, the assessment of the probability distribution of price changes is dependent upon available messages about these future cash flows. If these messages (that is, accounting numbers) alter the assessed probability distributions, then they can be inferred to have informational content. Thus, there is a primary justification for trying to demonstrate that these messages can be represented as a product of a stochastic information generating process. The search for such relationships is the objective of research into the time-series properties of accounting numbers.

A second reason for investigating the time-series properties of accounting numbers is related to the "income smoothing hypothesis." This hypothesis suggests that firm uses discretionary accounting policies in an effort to moderate observed fluctuations about some level of earnings assumed to be normal for the firm. Although it is unclear what managers perceive to be normal, it is reasonable to view the expected value of the (stochastic) earning process at a given point in time as the normal level of earnings. Thus, the importance to management of knowing the stochastic process generating the reported earnings series when making "smoothing" decisions is self-evident, as Gonedes (1972) has documented.

Another reason for studying the time-series properties of accounting numbers is to determine their predictive ability, since this is a necessary condition for their proper utilization in decision making. Time-series research aids in identifying the most appropriate prediction models of accounting numbers.

Thus, research into the time-series properties of accounting numbers has direct implications for the assessment of their information content and their predictive ability. All of these issues provide a strong justification for this type of research.

Studies investigating the time-series properties of accounting numbers typically use either annual or quarterly data. Annual accounting numbers have been the focus of considerable research, such as: Little and Rayner (1966), Brealey (1969), Beaver (1970), Ball and Brown (1971), Dopuch and Watts (1972), Ball and Watts (1972), Lookabill (1976), and Albrecht *et al.* (1977). Also, recently, several studies have examined the time-series properties of quarterly accounting numbers. These include: Lorek (1975, 1979), Watts (1975), Griffin (1977), Foster (1977), and Brown and Rozeff (1977). Several issues have been investigated using quarterly data. Some of these issues are descriptive model specification and the evaluation of the predictive ability of these models. Although there is some level of agreement among the studies on particular issues, there is sufficient disagreement to warrant further research.

Theoretical Framework

Research into the statistical properties of accounting numbers and their model specification has utilized various strategies to find the most appropriate models to represent the underlying processes. These stretegies, or methodologies, can be grouped into three distinct categories: econometric models, predefined models, and BoxJenkins (BJ) models. This section presents a brief explanation and evaluation of these three methodologies.

Econometric Models Methodology

Studies based on econometric models employ an extraneous variable to explain and/or predict a time-series of accounting numbers. In other words, this methodology regards an accounting number as a dependent variable that is determined by the value of another variable(s). Econometric models methodology has been used by several researchers, including Ball and Brown (1968), Benston (1967), and Gonedes (1972, 1973).

For example, in his 1973 study of the properties of accounting numbers, Gonedes proposed two market (economy-wide) index models to represent the time series of accounting numbers. These models are presented as follows:

$$\tilde{V}K_{it} = \gamma K_i + \delta K_i \tilde{V}\overset{m}{K}_t + \tilde{\epsilon}K_{it} \qquad (1)$$

$$\Delta V K_{it} = \omega K_i + \pi K_i \Delta \tilde{V}\overset{m}{K}_t + \tilde{\tau}K_{it} \qquad (2)$$

where:

$\tilde{V}K_{it}$ = Kth accounting number series for firm i in period t (t = 1,2, . . ., n)

$\tilde{V}\overset{m}{K}_t$ = Kth accounting number series for "market-wide" index in period t (t = 1, 2, ..., n).

K = accounting number series
(1 = net sales/common equity;
2 = net income/common equity)

Δ = first differences operator

$\gamma, \delta, \tilde{\epsilon}, \omega, \pi, \tilde{\tau}$ = parameters to be estimated

The market index models represent an attempt to use the implications of some current market variables to describe the operation and resulting accounting numbers of a given firm. In defense of this methodology, Gonedes states:

> One reason for capitalizing on cross-sectional dependence with respect to firm's accounting numbers is to provide a basis for specifying statistical models for such numbers. If the resultant models exhibit stationary relationships over time and a market-wide factor *can be predicted* with sufficient small prediction errors, *then* models may serve as useful forecasting devices. (p. 213) (Emphasis added.)

There are some drawbacks to using econometric models to explain or predict the item of interest. First, the model itself may be subject to specification error. That is, the form of the model may be deficient in some respects in accurately representing the underlying process. A second drawback is that future values of the independent variables will undoubtedly differ from whatever values are assumed when the model is constructed. Thus, the econometric models methodology does not actually solve the forecasting problem, but rather transforms it. This transformation dilemma lies in the fact that, in order to forecast the future values of the dependent variable, one needs to know the future values of the independent variables. However, these independent variables are not always available. When they are available, it is likely that the future values have been estimated by similar econometric techniques. (Refer to emphasis added in Gonedes quote.) Nelson (1975) summarizes the problems associated with using econometric models:

> The fact that econometric models have as yet failed to demonstrate that they can forecast with greater accuracy than extrapolative models—for example, Box-Jenkins models—is perhaps more troublesome. Of course, . . . econometric models may be subject to substantial error of specification and parameter estimation. We can only speculate that these errors are great enough at the present state of the art to prevent structural models from attaining their potential as tools of prediction. (p. 343).

Predefined Models Methodology

In the predefined models methodology the search for a model to represent the generating process of accounting numbers is confined to a limited set of predefined models assumed to be representative of the behavior of accounting numbers. This methodology has been used by several researchers, including Brealey (1969), Ball and Watts (1972), and Beaver (1970). The models tested include the mean reversion, random walk, and moving average models. Validation of the models is based on empirical evidence.

In general, the predefined models methodology treats the specification and the forecasting problems of a time-series observation as functions of only the past observations of the series itself. These models can be represented in general terms (using Gonedes's notation) as:

$$E(VK_{it} / VK_{it-1}, VK_{it-2};\ldots) = bK_{i(t)} VK_{it-1} + gK_{i(t)} \qquad (3)$$

where:

E = the expectation operator for a given K and i

$bK_{i(t)}$ and $gK_{i(t)}$ = function of time

This general model (3) can be modified to represent several naive models by choosing different values for the parameters of the function. For example:

If $bK_{i(t)} = 0$ and $gK_{i(t)}$ = some constant, then (3) becomes a first-order stationary process, or a pure mean reversion process.

If $bK_{i(t)} = 1$ and $gK_{i(t)} = 0$, then (3) becomes a random walk process.

If $bK_{i(t)} \geqslant 1$ and $gK_{i(t)} = 0$, then (3) becomes a semimartingale process.

The disadvantages of using the predefined models methodology arise from its reliance on a small family of naive models and from its requirement that the researcher select values of the functions $bK_{i(t)}$ and $gK_{i(t)}$. Therefore, this methodology is restrictive in its scope since it is unable to incorporate a wide range of models that might be more appropriate in representing the underlying generating process.

Box-Jenkins Methodology

The Box-Jenkins (BJ) approach to time-series analysis has been called the "Rich Models" methodology because it offers a wider range of models from which to select the most appropriate model to describe or predict the time series under consideration. The strength of this methodology lies in its capitalization of dependencies in the observations of any time-series data. The distinguishing feature of BJ is the assumption that the sequence of observations of a given variable is determined by jointly distributed random variables. Thus, if the density function of these jointly distributed random variables can be determined, then the probable outcome of a future observation can be predicted. This is a stochastic model, since the sequence of observations evolves through time according to the laws of probability.

The BJ methodology has been used in several studies of the statistical properties of accounting numbers. These studies include Dopuch and Watts (1972), Mabert and Radcliffe (1974), Lorek *et al.* (1976), Griffin (1977), Foster (1977), and Brown and Rozeff (1977). This methodology was selected by these researchers as the most appropriate statistical tool for analyzing accounting numbers. Lorek (1979) outlined the advantages and disadvantages of this methodology as follows:

Advantages

1. Incorporates a very powerful family of models to select from, using statistical goodness-of-fit criteria.

2. Contains a structure inherent in the modeling process.

3. Includes certain simplistic (naive) models as possible models for eventual selection.

4. Alleviates the necessity of specifying a complete economic theory of the firm in order to generate expectation models.

Disadvantages

1. Relies totally upon past data without consideration of macroeconomic variables.

2. Is relatively time consuming when applied on a sample firm basis.

3. Has a data requirement of around 50 observations.(2)

Because the advantages seem to far outweigh the disadvantages of using the BJ methodology to investigate the time-series properties of accounting numbers, a full description of its process is presented in the next section.

SECTION 2

Box-Jenkins Methodology

The purpose of this section is to describe the BJ time series analysis methodology. This methodology is aimed at determining the most appropriate time-series model to represent the empirical data under consideration. The technical process of this methodology comprises three structural stages: identification, estimation, and diagnostic checking. The interested reader is referred to Box and Jenkins (1970) for an in-depth description of the technique; for a less technical presentation, see Nelson (1973). A brief description of the three stages is presented here.

Identification

This first stage of the Box-Jenkins methodology is directed at selecting the model that "best" describes the sample data. The technique involves the computing and plotting of the sample data autocorrelation (ACF) and partial autocorrelation (PACF) functions. The shapes of these functions and their statistical properties are then compared to known shapes and properties of theoretical functions. For example, the most important characteristics of a sample autocorrelation function for a stationary time series is that the function tends to decay after a relatively small number of lags. The sample autocorrelation function is defined in the following manner:

$$r_k = \frac{\sum_{t=1}^{n-k} (z_t - \bar{z})(z_{t+k} - \bar{z})}{\sum_{t=1}^{n} (z_t - \bar{z})^2}$$

where:

r_k = the autocorrelation coefficient for a lag of k time units

n = the number of observations of time-series data

$\bar{z}$ = the sample mean of the series

z_t = the sample observation at period t

Thus, the concurrent examination of both the sample autocorrelation and partial autocorrelation functions, in conjunction with visual inspection of data plots, provides the analyst with valuable information at this stage of indentification.

Estimation

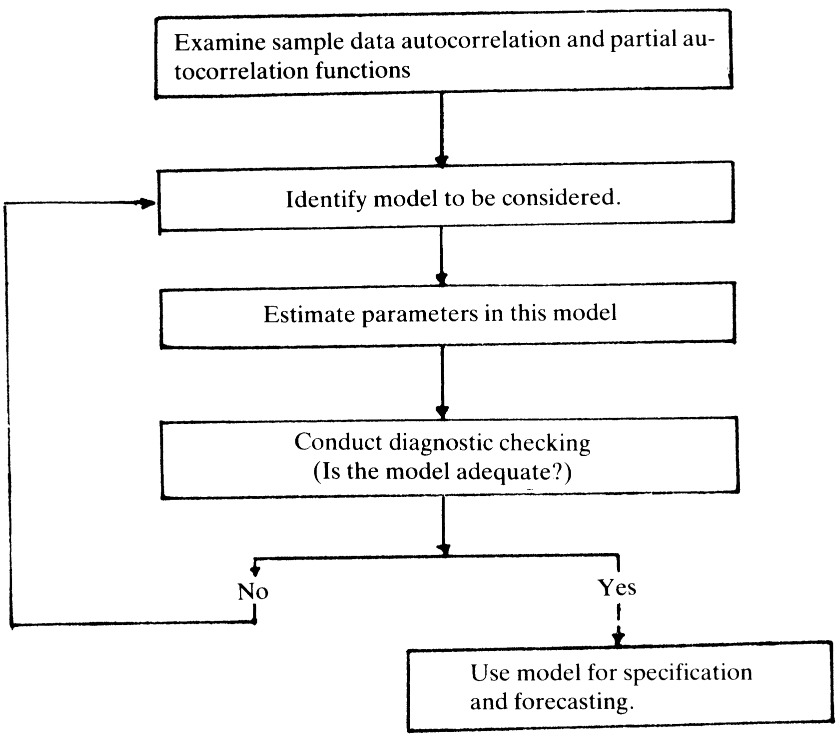
After identifying the best models, preliminary estimates for the parameters of the model (or set of models) are determined. These estimates are useful in providing an indication of how the final model is likely to look, as well as in suggesting starting values for iterative procedures used in computing maximum likelihood estimates of parameters.

Diagnostic Checking

At the third stage the adequacy of the proposed model is determined through statistical testing. This is done by using the proposed model to generate a time series of the data under examination. Then the differences between the actual data and the generated data are calculated. The model is accepted if the residuals (differences) are random, indicating that the model captures the particular characteristics of the sample data. Otherwise, the model is modified.

The diagram in figure 1 summarizes and illustrates the iterative approach to Box-Jenkins time-series methodology.

For an in-depth description of the iterative approach of this methodology and for illustrative examples, see Mabert and Radcliff (1974), Lorek (1975), and Griffin (1977).



SECTION 3

Review of the Literature

Only a few studies have examined the time-series properties of quarterly accounting numbers in a rigorous manner. The literature upon which this study is based may be classified into two groups: (1) predictive studies, which examine the predictive ability of certain models that suggest alternative generating processes for quarterly accounting numbers, and (2) descriptive studies, which examine the time-series behavior of quarterly accounting numbers. Summaries of the methodologies and conclusions of the major studies in these two groups are presented chronologically in this section[(3)].

Watts (1975) investigated the process generating quarterly accounting earnings per share (EPS). His purpose was to develop a forecasting model for quarterly earnings that could serve as a surrogate for the market's expectations of earnings. The sample consisted of quarterly EPS data for 175 New York Stock Exchange (NYSE) firms for the period 1958-69. Fifteen different forecasting models were used to estimate the market's expectation of earnings. The selection among these models was determined on the basis of which forecasts best approximated the market's expectations.

The fifteen candidate models were selected on the basis of their use in previous studies. These models were grouped into five categories. A through E. Group A represented a constant change model; groups B and C represented earnings changes as random walk and random walk with trend, respectively. Group D represented earnings as an autoregressive process. Group E also represented them as an autoregressive process, but with parameters differing according to the quarter.

After a lengthy analysis of the serial correlation of these simplistic models. Watts rejected them as not representative of quarterly accounting numbers. A BJ model was then introduced as a modification to one of the early models. This BJ model was specified as a multiplicative moving average of the form 011 x 011, in BJ notation,[(4)] which the author concluded to be the best representative of the quarterly data analyzed.

In evaluating this study it is important to recognize two shortcomings. First, it is only a partial analysis of the problem of determining the time--series properties of accounting numbers; second, the investigation is only descriptive. However, since the conclusions are in agreement with Griffin (1977) and Lorek (1979), it can be accepted as supportive evidence that the 011 x 011 model is representative of quarterly accounting numbers.

Foster (1977) suggested models to describe the behavior of quarterly earnings, sales, and expense series, and measured the predictive ability of these models. The time-series and predictive ability analyses were performed via BJ methodology on quarterly data for 69 NYSE firms over the period 1946-74.

Foster examined six different models as representative of the accounting numbers series. (Actually there were five models examined, since the sixth was a family of models selected individually to represent the data under consideration.) Using his notation, the models examined are:

Model 1

$$E(Q_t) = Q_{t-4}$$

Model 2

$$E(Q_t) = Q_{t-4} + \delta$$

Model 3

$$E(Q_t) = Q_{t-1}$$

Model 4

$$E(Q_t) = Q_{t-1} + \delta$$

Model 5

$$E(Q_t) = Q_{t-4} + \phi_1(Q_{t-1} - Q_{t-5}) + \delta$$

Where:

Q_t = earnings in quarter t

δ = a drift term

E = an expectation operator

Models 1 and 2 are random walk and random walk with drift, respectively, for quarter-by-quarter series. Models 3 and 4 are the same as 1 and 2, but for quarter-to-quarter series. Model 5 is an autoregressive process of degree 1 adjusted for seasonal differences or, in BJ notation, a 1000 x 010 model. Model 6 is a collection of models fitted to each firm's series using BJ methodology. This fitting uses an extensive analysis of each firm's sample data autocorrelation and partial autocorrelation functions.

The time-series analysis was undertaken in two parts. First, there was a cross-sectional autocorrelation analysis for the aggregated sample data of the three combinations of regular (d) and seasonal (D) differences, up to twelve lags. The tests implied in this analysis are: (1) If the time-series process implicit in model 1 was an adequate description for each firm, the sample autocorrelation for the d = 0, D = 1 combination would not be significantly different from zero; (2) If the time-series process implicit in model 3 was an adequate description for each firm, the sample autocorrelation for the d = 1, D = 0 combination would not be significantly different from zero. (Models 2 and 4 resemble models 1 and 3, respectively, with the addition of a drift term). The analysis showed that there is strong evidence of seasonality in quarterly data. In addition, it indicated that quarterly data are related to quarterly numbers in time t - 4, but also are related to the quarterly numbers reported between time t - 1 and t - 5. This evidence suggests that models 1 through 4 may be improperly specified for many firms. In essence, the analysis showed that sales , expenses, and earnings series have both (1) an adjacent quarter-to-quarter component and (2) a seasonal component.

The second step in Foster's analysis was a test of the predictive ability of the six proposed models. For every quarter/firm combination in the 1962-74 period, the forecast errors from the six models were ranked in terms of accuracy, measured by the mean absolute percentage error. The model yielding the most accurate forecast for a particular quarter/firm was given a rank of one; the model yielding the least accurate forecast was given a rank of six. Then, the average rank was computed for each model over all firms and all quarters. Friedman ANOVA was used to examine the null hypothesis that there was no difference in the average ranks of all models. This analysis indicated that: (1) for all three series, there was a statistically significant difference in average ranks of the six models; and (2) for all three series, model 5 ranked the lowest in each fiscal year quarter.

From the predictive ability and cross-sectional autocorrelation analysis, Foster concluded the following:

1. Quarterly earnings, sales, and expense series do not follow the submartingale process that appears to adequately describe the annual earnings. Each quarterly series appears to have (a) an adjacent quarter-to-quarter component, and (b) a seasonal component.

2. A BJ 100 x 010 with drift model provided more accurate forecast of one-step-ahead sales than any other model tested.

3. Cross-sectionally, there is strong evidence of seasonality in the quarterly series examined.

Griffin (1977) also presented preliminary evidence on the time-series behavior of quarterly earnings. Employing BJ time-series analysis, he examined 94 NYSE firms' quarterly earnings for the period 1958-71. The author proposed that the quarterly earnings generating process is a multiplicative combination of two processes. One reflects the quarter-by-quarter movement, which is defined as the sequence of quarterly earnings for the same quarter in successive years. The other process reflects the movement between adjacent quarters, or quarter-to-quarter movement, and is describ by the number of regular differences of the general model. Specifically, using BJ notation, Griffin tested five models:

1. First-order autoregressive process, adjusted seasonally—100 x 010

$$(1 - \phi_1 B)(1 - B^4) Z_t = a_t$$

2. Nonstationary multiplicative random walk process—010 x 010

$$(1 - B)(1 - B^4) Z_t = a_t$$

3. Multiplicative first-order moving average process—011 x 011

$$(1 - B)(1 - B^4) Z_t = a_t (1 - \theta_1 B)(1 - \bar{\theta}_4 B^4)$$

4. Stationary multiplicative first-order autoregressive process—

100 x 100

$$(1-\phi_1 B)(1-\phi 4B^4)(Z_t^* - u) = a_t$$

5. Multiplicative mean-reverting first-order moving average process—001 x 001

$$(Z_t^* - u) = a_t (1-\bar{\theta}_1 B)(1-\bar{\theta}_4 B^4)$$

These models were examined employing the BJ process of identification, estimation, and diagnostic checking. The examination was based on cross-sectional analysis of the autocorrelation function (ACF) and of the partial autocorrelation function (PACF) of the aggregated quarterly earnings series. The aim was to determine model adequacy in terms of the agreement between the estimated functions and the theoretically defined functions. Griffin defended his aggregation procedure on the grounds that he desired "to identify a representative process which is sufficiently robust to diagnostic testing to allow meaningful firm-specific parameter estimation" (p. 74).

The findings suggested "that there are two components to the quarterly process: (1) a four-period seasonal component and (2) an adjacent quarter component which describes the seasonally adjusted series" (p. 71). Both processes may be characterized as either a multiplicative first-order autoregressive process, or a multiplicative firstorder moving average process in first differences of the four-period differences. However, a first-order autoregressive model applied to the four-period differences in quarterly earnings did not appear to account fully for seasonality in the series. Therefore, the conclusion of this study is that quarterly earnings series are best described by a multiplicative first-order moving average process or, in BJ notation, a 011 x 011 process.

In evaluating this study, one is forced to question the author's decision to aggregate cross-sectional data. The aggregated ACF and PACF came from firms in different industries that may have unique characteristics. Thus, the aggregation of these functions may result in an unrelated, heterogeneous collection of data that does not represent a particular firm or an industry. In addition, the aggregation process may mask highly variant time-series behavior across firms by simply averaging it out.

Brown and Rozeff (1977), in search of a premier "Parsimonious" model as the most representative of the generating process, reviewed previous studies on the subject to develop a new model. Their research combined descriptive and predictive evidence supporting their proposed model. They examined previously suggested models that were claimed to represent quarterly earnings data, including the Griffin-Watts (GW) 011 x 011 model and the Foster (F) 100 x 010 model. From these studies and others they derived a new model (BR) in the form of 100 x 011.

The research was conducted using the quarterly EPS of 50 firms for the period 1951-76. This sample was reduced to 23 firms to eliminate and bias resulting from the inclusion of firms whose firm-specific models were identical to one of the examined models. The study was designed to perform two tests to validate its conclusions: a fitting test and a test of predictive ability. The test of fit compared the actual and theoretical autocorrelation and partial autocorrelation functions of the three models (GW, F, and BR). In this test the BR model was favored over GW, and GW over F.

The second test measured the predictive ability of the three models as well as BJ firm-specific models for the selected firms' data. In this test forecasts for one, five, and nine periods ahead were generated for each model, with a two-year holdout period. The error measure used was the mean absolute percentage error; the Wilcoxon test statistic was used to determine significance. The results of this testing showed that for longer forecast horizons, the BR, F, and individual BJ models outperformed the GW model. For shorter forecasts the GW model performed no better than the individual BJ models or the BR model. Also, the BR model outperformed the F model for all horizons. From these two tests (fittings and forecasting), Brown and Rozeff concluded that "the 100 x 011 model is the best single model form candidate underlying quarterly earnings per share proposed to date" (p. 23).

Lorek (1979) evaluated several quarterly time-series models in an effort to provide evidence regarding their ability to predict annual net earnings. The study was designed to utilize the quarterly earnings of thirty NYSE firms for the period 1958-73 in a comparative analysis of the predictive ability of nine different models. The models analyzed included five simplistic models, consisting of three random walk models with and without drift for the annual data, one random walk model for quarterly data, and one moving average model. Three parsimonious BJ models were also examined:

1. An autoregressive model of degree 1 with a seasonal differencing span of 4, plus a drift term. (In BJ notation this model is 100 x 010, s = 4, with drift.) This model was suggested by Foster (1977) as one of the "best" representations of quarterly earnings data.

2. A multiplicative first-order moving average in first differences and seasonal differences. (In BJ notation this model is 011 x 011, s = 4.) This model was suggested by Watts (1975) and Griffin (1977) to represent the underlying process of quarterly data.

3. A first-order autoregressive seasonal moving average, adjusted seasonally. (In BJ notation, 100 x 011.) This model was introduced by Brown and Rozeff (1977).

Finally, firm-specific BJ models (where each firm's time-series data may dictate a unique BJ model) were derived from each sample firm's data. In other words, these models fit each firm's particular situation.

Using these various models, the study tested four different predictive hypotheses. The first hypothesis compared the forecasting error between the models utilizing a quarterly earnings data base ending with the fourth quarter earnings of the preceding year. The second hypothesis added to the analysis the first quarter earnings of the forecasted year, while the third hypothesis included the dirst and second quarter earnings of the forecasted year. The fourth hypothesis included the first and second quarter earnings of the forecasted year. The fourth hypothesis included the first three quarters' earnings. The quarterly forecasts were summed to determine the predicted annual earnings for the three previous years (1971-73) and then compared to the actual earnings. The accuracy of the prediction was measured by the absolute percentage error (which is equal to the actual values minus the predictive values, divided by the actual values). Using this measure, the models were ranked according to predictive ability with the model yielding the smallest absolute percentage error for a particular firm receiving a rank of one; the largest, nine. These ranks were averaged for each model across firm for each forecasted year. Friedman ANOVA was used to test statistically the four prediction hypotheses.

The results of the study were as follows:

1. There is a statistically significant difference in the predictive ability of the nine models.

2. The Griffin-Watts model and the firm-specific BJ model had higher predictive ability of the nine models.

3. The Brown-Rozeff model performed poorly in predicting annual earnings, but improved significantly when the forecast horizon decreased.

4. The firm-specific and parsimonious BJ model outperformed all of the simplistic models except for the Foster and Brown-Rozeff models over forecast horizons of three to four quarters.

Lorek's conclusions support the Griffin-Watts parsimonious model (011 x 011, in BJ notation) as the best representative model of quarterly earnings. However, his conclusions are in conflict with the Foster and Brown-Rozeff research. He explained that:

> The diverse predictive ability results reported above suggest that it may be premature to single out a particular parsimonious time series model for quarterly earnings. Results are apparently specific to the sample of firms analyzed. Perhaps this phenomenon is simply a reflection of the diversity exhibited by underlying time series, so the search for an optimal parsimonious model for quarterly earnings may prove futile. (p. 20)

In summary, the studies reviewed here demonstrate that there are conflicting conclusions in regard to the time-series properties of accounting numbers. The disagreement centers on the question of what constitutes a representative model of quarterly data. Watts (1975), Griffin (1977), and Lorek (1979) support the 011 x 011 model, whereas Foster (1977) and Brown and Rozeff (1977) advocate the 100 x 010 and 100 x 011 models, respectively. In the next section the apparently conflicting conclusion will be explained and synthesized.

SECTION 3

Synthesis and Conclusions

The main problems addressed in this study were the time-series properties of equarterly accounting numbers. Model specification of these series and the determination of the predictive ability of the models were of primary concern. Model specification is the process of deciding which statistical model best represents the underlying process. The decision is based on the statistical goodness of fit of the suggested models.

The set of models from which the most appropriate model can be selected exhibits a wide range of characteristics and applicability. A simplified typology of the models most frequently selected to represent an accounting number series includes three categories:

(1) *Simplistic Models*

These are intended to be naive, machanical predictors. Examples are the random walk, mean reverting, and moving average models. For example, accordin to the random walk model, the next observation in the series under consideration—e.g., earnings in period t—1 plus a random error term. In mathematical terms, a random walk model would be:

$$z_t = z_{t-1} + e$$

where:

z_t = time-series observation in period t

e = random error term with expected value of zero and a constant variance

Simplistic models are usually selected on an arbitrary basis; therefore, their predictive performance tends to be erratic (Lorek 1979). These models can also be selected as representative of an accounting number series when a more sophisticated methodology (i.e., BJ) is employed. Thus, even if the underlying process generating quarterly earnings and sales data is a simplistic one, the use of the BJ methodology is still appropriate.

(2) *BJ Autoregressive Integrated Moving Average (ARIMA) model*

This model represents a wide range of different models. It allows for seasonality as well as adjacent autocorrelation. The ARIMA model is usually represented in the following manner:

$$(1 - \phi_1 B - \ldots - \phi_p B^p)\ (1 - \bar{\phi}_1 B^s - \ldots - \bar{\phi}_p B^{sP})\ (1 - B^s)^D$$

$$(1 - B)^d \; z_t = \theta_o + (1 - \theta_1 B - \ldots - \theta_q B^q)$$

$$(1 - \bar{\theta}_1 B^s - \ldots - \bar{\theta}_q B^{sQ}) \; a_t$$

where:

B = backshift operator; $BZ_t = z_{t-1}$

$\phi 1 - \phi_p$ = regular autoregressive parameters

$\bar{\phi}_1 - \bar{\phi}_p$ = seasonal autoregressive parameters

s = seasonal span

d = order of regular (consecutive) differences

D = order of seasonal differences

θ_o = deterministic trend constant

$\theta_1 - \theta_q$ = regular moving average parameters

$\bar{\theta}_1 - \bar{\theta}_q$ = seasonal moving average parameters

a_t = current disturbance term.

The model is said to be of the order p, d, q x P, D, Q. Autoregressive parameters are denoted by p and P, and moving average parameters by q and Q, while d and D stand for the degrees of regular and seasonal differences that are required to achieve stationarity. If the original data, represented by z_t, are non-stationary, a transformation is necessary. First and second differencing are normally employed to remove linear and/or quadratic trends from the series being analyzed.

(3) *Parsimonious BJ models*

These are simplified BJ time-series models with fewer parameters and a simpler structure. These models are used as alternatives to the full BJ ARIMA models for several reasons. Any BJ ARIMA model can be classified as a parsimonious model if it contains fewer parameters and/or differences, yet predicts as well as a full BJ ARIMA model. This conclusion was supported by Foster (1977) and Griffin (1977). Use of the parsimonious BJ models can be defended on a cost/benefit basis. However, these models may not correctly describe the underlying time series even though they may predict better than the full models. This last characteristic could be deemed an advantage from the viewpoint of positive economics.

As discussed in section 2, several independent studies have suggested that parsimonious models are better than firm-specific models in representing the underlying process that generates quarterly accounting numbers. Watts (1975), Griffin (1977), and Lorek (1979) advocated a parsimonious model in the form of 011 x 011, in BJ notation. Foster (1977) suggested a 100 x 010 model, and Brown and Rozeff (1977), a 100 x 011 model as the best single candidate for the model underlying quarterly numbers. The models presented in these studies are discussed below.

(a) *Griffin, Watts, and Lorek model (GWL)*

The GWL model states that the current series (z_t) under consideration (for example, earnings) equals the earnings four quarters ago (z_{t-4}) plus the most recent quarter's growth in earnings ($z_{t-1} - z_{t-5}$), plus a current disturbance term (a_t) and several past disturbance terms:

$$z_t = z_{t-4} + (z_{t-1} - z_{t-5}) + a_t - \theta_1 a_{t-1} - \theta_4 a_{t-4} + \theta_1 \theta_4 a_{t-5}$$

(b) *Foster model (F)*

The F model shows the current series as equal to the same series four quarters ago (z_{t-4}) plus a fraction (ϕ_1) of the most recent quarter's change in earnings ($z_{t-1} - z_{t-5}$), plus a current disturbance term and a drift:

$$z_t = z_{t-4} + \phi_1 (z_{t-1} - z_{t-5}) + a_t + \theta_o$$

(c) *Brown and Rozeff model (BR)*

The BR model is the same as the F model without drift, except for the inclusion of a seasonal moving average parameter (ϕ_4):

$$z_t = z_{t-4} + \phi_1 (z_{t-1} - z_{t-5}) + a_t - \phi_4 a_{t-4}$$

Examination of these three models shows that the F model has only one parameter (ϕ_1, a regular autoregressive parameter), plus a drift term. The GWL model has two parameters (θ_1 and θ_4, a regular and a seasonal moving average), whereas the BR has both a regular autoregressive parameter and a seasonal moving average parameter. The apparent conflicting results and conclusions of these models may be explained by the following circumstances. First, sampling variation may introduce bias into the data. All of the studies reviewed employed different samples drawn from widely ranging subpopulations. This diversity in the samples and population selected and the numbers reached. Second, the aggregation approach used in some of the studies, whereby the ACF and PACF from different firms are summed together and analyzed as one function, may average out some of the particular characteristics picked up by other studies. Third, most of the sample data used in the studies are collected from different industries, thus, several industry factors that may have characterized the data are ignored. These industry factors may be responsible for the varying performance of the models when applied to different samples of quarterly data.

Suggestions for Future Research

The results of this study suggest various topics for further investigation:

1. The efficiency of industry-specific models in describing and predicting the quarterly accounting numbers of individual firms in the industry can be tested by comparing firm-specific models to the models identified for each industry. This type of research may provide further evidence of the validity of the industry conclusions, and would provide evidence on the efficiency of the cross-sectional methodology relative to the firm-specific approach.

2. Accounting numbers other than sales and earnings, or a combination of them, can be examined at the industry and/or firm level. This extension has the potential for exploring the wide range of the time-series characteristics of the accounting numbers.

3. The introduction of some exogenous variables in the analysis of the time-series properties investigated in this study is still another possibility for extending the research reported here. Because BJ time-series analysis predicts future values on the basis of historic observations of the series analyzed, it is possible that the prediction of future values may be

strengthened by the addition of exogenous variables in the model specification stage.

4. A firm's financial input factors, such as its Product supply and demand characteristics, and other related environmental variables underlying its accounting numbers generating process might be investigated. This type of research will contribute to the selection of future input data for time-series research, and will increase the suitability of the data to the analysis.

Footnotes

1. Time-series research is the investigation of the quantitative measures of a variable collected over equally spaced intervals of time. The investigation involves the specification of statistical models that represent and/or predict values of the variable, and the estimation of the parameters of the models.

2. Lorek and McKeown (1978) provided evidence on the robustness of BJ methodology when the 50 observations "rule of thumb" is violated.

3. The intention in this section is to review some of the studies that addressed the time-series properties of quarterly data. There are several studies that have investigated the time-series properties of annual accounting data, but these are outside the scope of this study. They include Beaver (1970), Ball and Watts (1972), and Albrecht *et al.* (1977).

4. Box-Jenkins notation, which is used in this and subsequent sections, is explained in conjunction with the ARIMA model, page 31.

References

Albrecht, W.S., Lookabill, L.L. and McKeown, J.C. (1977) The time series properties of annual earnings: An analysis of individual firms, *Journal of Accounting Research.* Autumn, pp. 226-244.

Ball, R. and Brown, P. (1968) An empirical evaluation of accounting income numbers, *Journal of Accounting Research,* Autumn, pp. 159-178.

Ball, R. and Brown, P. *(1971) Stock price elasticity.* Unpublished manuscript, University of Chicago.

Ball, R. and Watts, R. (1972) Some time-series properties of accounting income, *The Journal of Finance,* June, pp. 662-681.

Beaver, W.H. (1970) The time series behavior of earnings. *Empirical research in accounting: Selected studies*, Supplement to vol. 8, *Journal of Accounting Research*, pp. 62-99.

Benston, G.J. (1967) Published corporate accounting data and stock prices. *Empirical research in accounting: Selected studies*, Supplement to vol. 5, *Journal of Accounting Research*, pp. 1-14.

Box, G.E.P. and Jenkins, G.M. (1970) *Time series analysis: Forecasting and control.* San Francisco: Holden-Day.

Brealey, R.A. (1969) *An introduction to risk and return from common stocks.* Cambridge: M.I.T. Press.

Brown, L.D. and Rozeff, M.S. (1977) Univariate time series models of quarterly earnings per share: A proposed premier model. *The University of Iowa, Working Paper Series* No. 77-27, October.

Dopuch, N. and Watts, R. (1972) Using time series models to assess the significance of accounting changes, *Journal of Accounting Research*, Spring pp. 180-194.

Foster, G. (1977) Quarterly accounting data: Time series properties and predictive ability results, *The Accounting Review*, January, pp. 1-21.

Gonedes, N.J. (1972) Income-smoothing behavior under selected stochastic processes, *Journal of Business*, October, pp. 570-584.

Gonedes, N.J. (1973) Properties of accounting numbers: Models and tests, *Journal of Accounting Research*, Autumn, pp. 212-237.

Griffin, P.A. (1977) The time series behavior of quarterly earnings: Preliminary evidence, *Journal of Accounting Research*, Spring, pp. 71-83.

Little, I.M.D. and Rayner, A.C. (1966) *Higgledy piggledy growth again*, Oxford: Blackwell.

Lookabill, L.L. (1976) Some additional evidence on the time series properties of accounting earnings. *The Accounting Review*, October, pp. 724-738.

Lorek, K.S. (1975) An empirical examination of the time-series behavior of quarterly earnings, *Ph.D. thesis, University of Illinois.*

Lorek, K.S. (1979) Predicting annual net earnings with quarterly earnings time series models. *Journal of Accounting Research.* Forthcoming, Spring.

Lorek, K.S., McDonald, C.L. and Patz, D.M. (1976) A comparative examination of management forecasts and Box-Jenkins forecasts of income. *The Accounting Review*, April, pp. 321-330.

Lorek, K.S. and McKeown, J.C. (1978) The effect on predictive ability of reducing the number of observations on a time series analysis of quarterly earnings data. *Journal of Accounting Research*, Spring, pp. 204-214.

Mabert, V.A. and Radcliff, R.C. (1974) A forecasting methodology as applied to financial time-series. *The Accounting Review*, January, pp. 61-75.

Nelson, C.R. (1973) *Applied time-series analysis for managerial forecasting.* San Francisco: Holden-Day.

Nelson, C.R. (1975) Rational expectation and the predictive efficiency of economic models. *Journal of Business*, July, pp. 331-343.

Watts, R. (1975) The time series behavior of quarterly earnings. *Unpublished manuscript. The University of New Castle.*

خصائص السلاسل الزمنية للأرقام المحاسبية الفصلية

الدكتور عبدالله عبدالعزيز العبدالقادر

الاستاذ المساعد بقسم المحاسبة ، كلية العلوم الإدارية ، جامعة الرياض، الرياض، المملكة العربية السعودية .

السلسلة الزمنية هي مقياس كمي لظاهرة معينة مجمعة عن مدى زمني متساوي الفترات والأرقام المحاسبية الفصلية تدخل ضمن هذا التعريف .

لذلك ، فإن بحوث خصائص السلاسل الزمنية للأرقام المحاسبية هي محاولة تحديد الخصائص الإحصائية لهذه الارقام بنماذج رياضية تساعد على تفسيرها رياضياً والتنبوء المستقبلي باتجاهاتها .

البحث التالي هو محاولة تقديم تقييم هذا الاتجاه التجريبي في بحوث المحاسبة ، وكذلك محاولة إلقاء الضوء على النتائج التي تدخل إليها من حيث أنواع النماذج الرياضية المقترحة لتفسير أرقام المبيعات وصافي الأرباح الفصلية ومدى قدرة هذه النماذج على التنبوء بهذه الأرقام مستقبلاً .

من هذه النماذج التي شملها التحليل والتقييم : نموذج واتز ١٩٧٥م ، وجرفن ١٩٧٧م ، ولورك ١٩٧٩م ، ذو المتوسط المتحرك من الدرجة الأولى المتطابق ، نموذج فوستر ١٩٧٧م ، ذو الانحدار الذاتي من الدرجة الأولى المعدل فصليا ، وأخيرا نموذج براون وروذف ١٩٧٧م

ذو الانحدار الذاتي من الدرجة الأولى المرتبط فصلياً بالمتوسط المتحرك والمعدل فصلياً أيضاً بالتغيرات الفصلية .

كذلك يتطرق البحث إلى مناقشة الإطار النظري لمناهج البحث المستعملة في بحوث خصائص السلاسل الزمنية للأرقام المحاسبية .

وفي خاتمة البحث هناك عدة اقتراحات لمواضيع بحوث جديدة لتطوير وتعميق النتائج المتوصل إليها في هذا المجال في بحوث المحاسبة التجريبية .