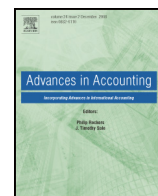




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A critical assessment of the time-series literature in accounting pertaining to quarterly accounting numbers

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ABSTRACT

This paper summarizes, critiques, and synthesizes the time-series literature in accounting pertaining to quarterly accounting numbers. It reviews work on quarterly earnings, quarterly balance sheet and income statement subcomponents, and quarterly cash-flows from operations (CFOs). Several salient findings emerge. First, the premier ARIMA models attributed to Foster (1977), Griffin (1977) and Brown and Rozeff (1979) were identified on relatively small samples dominated by “old economy” firms. It appears that the descriptive validity of these ARIMA structures must be called into question when analyzing more current databases replete with high-technology, regulated, and financial-service firms (Lorek & Willinger, 2007). Second, the use of ARIMA-based analytical review procedures in audit settings is not cost effective. Third, recent evidence (Lorek & Willinger, 2008, 2011) supports the univariate Brown & Rozeff (100) × (011) ARIMA model as the best statistically-based prediction model for quarterly CFO, a finding of considerable import to analysts, investors, and researchers.

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Considerable research activity has been directed toward the specification of the time-series properties of a diverse set of quarterly accounting data since the late 1970s [see Foster (1977), Brown and Rozeff (1979), Lorek (1979), and Brown (1993), among others]. This paper summarizes research findings pertaining to several quarterly accounting series which time-series researchers have examined extensively; namely, quarterly earnings, quarterly balance sheet and income statement subcomponents, and quarterly cash-flow from operations (CFOs).² The output of such research has contributed to advancements in several areas including: (1) identifying the stochastic process by which quarterly earnings are generated, (2) specifying the structural form(s) and parameter(s) of quarterly earnings time-series models, (3) employing statistically-based quarterly earnings expectation models to proxy for the market's expectation of quarterly earnings in capital-market association testing, (4) developing and refining analytical review procedures, and (5) specifying the structural form(s) and parameter(s) of statistically-based quarterly CFO

prediction models. While the potentially burdensome notational structure of the autoregressive-integrated-moving-average (ARIMA) family of models has contributed to the esoteric statistical nature of this research stream, contributions continue to be made in the aforementioned research areas (see Lorek & Willinger, 2007, 2011) that have important implications for analysts, investors, and researchers in empirical financial accounting.

The purpose of this article is to summarize extant knowledge pertaining to the time-series properties of quarterly earnings, quarterly balance sheet and income statement subcomponents, and quarterly CFO with the objective of synthesizing extant research findings and suggesting avenues for future research strategies. It begins with a discussion of the time-series properties of quarterly earnings data addressing model identification issues, structural ARIMA model forms and parameters. Next, it explains the firm-size effect and its impact on model structure, parameter values, and predictive ability. It then assesses the impact that a growing number of nonseasonal firms has had on the identification of quarterly earnings prediction models. Interestingly, these nonseasonal firms have time-series properties of quarterly earnings at variance with the premier, seasonal ARIMA models and require unique ARIMA models tailored to them. Next, it summarizes work identifying statistically-based models of potential use as analytical review procedures. Then, it synthesizes recent findings with respect to the stochastic properties and predictive ability of quarterly CFO, an area of increased importance to analysts, investors, and researchers interested in firm valuation. Finally, suggested avenues for future time-series research strategies are discussed.

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² Other areas in which time-series research has been applied in accounting include the development of earnings persistence proxies (See Baginski, Lorek, Willinger, & Branson, 1999), human information processing of the parameters of time-series models (See Maines & Hand, 1996), the examination of the post-earnings announcement drift phenomenon (See Brown & Han, 2000) as well as work assessing the time-series properties of annual earnings data (See Ball & Watts, 1972).

1. Descriptive evidence

The “golden age” of time-series research in accounting occurred more than three decades ago in the late 1970s when researchers initially specified ARIMA models descriptive of quarterly earnings. These descriptive findings supported a dual-process characterization of quarterly earnings comprised of quarter-to-quarter (adjacent) as well as quarter-by-quarter (seasonal) components. Early works by Foster (1977), Griffin (1977), and Brown and Rozeff (1979) provided the support for this generalization. More recent works [i. e., see Bathke, Lorek, & Willinger, 2006; Lorek & Willinger, 2007; Lorek, Willinger, & Bathke, 2008], have extended these findings using more current databases. While seasonality is not present in annual net earnings numbers, disaggregating annual net earnings into quarterly earnings allows researchers to identify potential seasonal characteristics in the data that are masked at the annual level. In fact, Lorek (1979) demonstrated that ARIMA models conditioned upon a quarterly earnings database can be used to generate one-thru-four step ahead quarterly earnings predictions which, when aggregated, yield more accurate annual earnings forecasts than those derived from random-walk models conditioned upon an annual earnings database. Thus, the disaggregation of the annual earnings series enhances predictive ability.

The research methodology typically employed in time-series research is to generate firm-specific sample autocorrelation functions (SACFs) across one-thru-twelve lags for sample firms for which a lengthy time-series database of quarterly earnings has been obtained. Firm-specific SACFs are then aggregated across lags and the resulting mean SACFs are analyzed for clues with respect to model structure (i.e., stationarity, appropriate level of differencing, the presence of autoregressive and/or moving-average parameters, etc.). The advantage of this approach vis-à-vis analyzing SACFs on a firm-specific basis is that sampling variation, noise, and measurement error are mitigated. Using this approach, Griffin (1977) conducted a purely descriptive exercise in which he demonstrated that the consecutively and seasonally-differenced quarterly earnings series exhibits spikes at both the first and fourth lags of the SACF. Such time-series behavior is consistent with the presence of both regular and seasonal moving-average parameters. Using Box–Jenkins notation, Griffin then identified the (011) X (011) ARIMA model for quarterly earnings. His descriptive evidence is consistent with the notion that adjacent and seasonal autocorrelations are present in quarterly earnings data and was instrumental in specifying the aforementioned dual-process characterization. Surprisingly, however, Griffin did not provide any predictive evidence in support of the (011) X (011) ARIMA model.

In his seminal work, Foster (1977) used a similar methodology but concentrated upon the seasonally-differenced quarterly earnings series where he detected exponential decline in autocorrelation across multiple lags of the SACF. Rather than using a series of moving-average parameters like Griffin, Foster employed a singular autoregressive parameter enabling him to identify a more parsimonious ARIMA model structure. Foster identified the (100) X (010) with drift ARIMA model for quarterly earnings. Unlike Griffin, he provides predictive support in favor of the (100) X (010) with drift model versus a set of relatively naïve alternative models and then employs it to derive good/bad news earnings signals in a capital market association test. Foster also explored whether model structure might be firm-specific providing empirical evidence that common-structure ARIMA models outperformed firm-specific ARIMA models in both predictive ability and capital market association tests.³

Brown and Rozeff (1979) extended Foster's analysis by detecting a spike at the fourth (seasonal) lag of the SACF of the seasonally-differenced quarterly earnings series in addition to the exponential decline identified by Foster. This behavior is consistent with the

presence of a seasonal moving-average parameter and resulted in the identification of the (100) X (011) ARIMA model, a refinement of Foster's ARIMA model. They provided predictive evidence suggestive of the dominance of the (100) X (011) ARIMA structure versus several alternative ARIMA models. In general, all of these efforts provide empirical support for the dual-process characterization of quarterly earnings at variance with more simplistic random-walk models that had been championed for annual earnings data.

2. Premier ARIMA model structures for quarterly earnings

Despite general consensus pertaining to the time-series properties of quarterly earnings, alternative statistically-based quarterly earnings ARIMA prediction models proliferated during the “golden-age” of time-series. These relatively parsimonious premier ARIMA models have been developed as candidate quarterly earnings expectation models. The structures of the three dominant statistically-based, quarterly earnings ARIMA forecast models discussed above are:

1) Foster's (1977) model	(100) X (010) with drift
2) Griffin (1977) & Watts (1975) model	(011) X (011)
3) Brown and Rozeff's (1979) model	(100) X (011)

Although the (pdq) X (PDQ) terminology is fairly standard in the time-series literature, the use of this notation served to be a stumbling block to widespread understanding of the premier ARIMA models cited above. To facilitate a more thorough understanding of the aforementioned ARIMA model structures, the specific equations for each of the premier ARIMA models are presented below:

Model 1) Foster's ARIMA model (100) X (010) with drift

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

where:

Q_t = quarterly earnings at time t

ϕ_1 = autoregressive parameter

Q_{t-n} = quarterly earnings at time $t - n$.

Foster's premier ARIMA model is a simple autoregressive process superimposed upon the seasonally-differenced series with an appended drift term. Due to the ease with which its parameters may be estimated, it quickly became the most popular of the premier ARIMA models because its parameters may be readily estimated using OLS regression.

Model 2) Brown and Rozeff's ARIMA model (100) X (011)

$$E(Q_t) = Q_{t-4} + \phi_1(Q_{t-1} - Q_{t-5}) - \theta_1 a_{t-4} \quad (2)$$

where:

Q_t = quarterly earnings at time t

ϕ_1 = autoregressive parameter

θ_1 = seasonal moving average parameter

a_{t-4} = disturbance term at time $t - 4$.

Brown and Rozeff (1979) provided descriptive evidence that Foster's premier ARIMA model did not fully account for residual autocorrelation at lag 4 of the SACF, and, as a result, was potentially misspecified. In fact, they added a seasonal moving-average parameter (θ_1) to remedy this potential deficiency and presented empirical evidence consistent with the notion that their model exhibits better descriptive fit and predictive performance than that of Foster [see Bathke and Lorek (1984) for corroborating evidence].

³ Foster attributes this finding to data over-fitting, parameter redundancy, and lack of parsimony.

Model 3) Griffin & Watts ARIMA model (011) X (011)

$$E(Q_t) = Q_{t-4} + (Q_{t-1} - Q_{t-5}) - \hat{\phi}_1 a_{t-1} - \hat{\phi}_1 a_{t-4} - \hat{\phi}_1 \hat{\phi}_1 a_{t-5} \quad (3)$$

where:

Q_t = quarterly earnings at time t

$\hat{\phi}_1$ = regular moving-average parameter

= seasonal moving average parameter

a_{t-n} = disturbance term at time n .

Watts (1975) and Griffin (1977) independently identified this relatively complex ARIMA process that contains both consecutive and seasonal differences as well as regular ($\hat{\phi}_1$) and seasonal ($\hat{\phi}_1$) moving-average parameters combined with a series of distributed-lag, disturbance terms (i.e., a_{t-1} , a_{t-4} , a_{t-5}). The similarities in model structure across the three premier ARIMA models are readily apparent upon inspection of Eqs. (1)–(3) above. For example, all of these models relate current levels of quarterly earnings (Q_t) to quarterly earnings four periods ago (Q_{t-4}) and the most recent quarter's growth in earnings ($Q_{t-1} - Q_{t-5}$). However, the Foster and Brown–Rozeff ARIMA models multiply this growth term by an autoregressive parameter (ϕ_1) while the Griffin–Watts ARIMA model does not.

The Brown & Rozeff ARIMA model is virtually identical to the Foster ARIMA model except for the addition of a disturbance term four periods ago (a_{t-4}) multiplied by a seasonal moving-average parameter ($\hat{\phi}_1$). This disturbance term represents the error that was made in predicting quarterly earnings four periods ago. When one considers the similarities in structure shared by the premier ARIMA models, it is not surprising that predictive findings have varied across studies. Nevertheless, it appears that the Brown–Rozeff ARIMA model captures the unobservable market expectation of quarterly earnings with the greatest precision. Brown and Rozeff (1979) and Bathke and Lorek (1984) attribute its superior performance to the seasonal moving-average parameter included in the Brown & Rozeff model but not in Foster's. In any case, these so-called “premier” ARIMA models have consistently outperformed simplistic random walk and seasonal random walk models in predictive-ability tests on holdout samples from the 1970s – 1980s in all previously cited work.

Foster (1977), Lorek (1979), and Bathke, Lorek, and Willinger (1989), among others, also provide empirical evidence that the common-model structures of the premier ARIMA models outperform firm-specific ARIMA models. It appears that common-model ARIMA structures are less sensitive to structural changes and sampling variation than firm-specific alternatives. Despite imposing a common-model structure on all sample firms, each of the premier ARIMA models estimates its parameters on a contextual, firm-specific basis. Thus, overall model structure is held constant, but parameters are allowed to vary. While these premier ARIMA models are relatively parsimonious, they are univariate in nature relying entirely upon past quarterly earnings to predict future quarterly earnings.

3. Second phase of time-series research on quarterly accounting variables

While Bao, Lewis, Lin, and Manegold (1983) and Brown (1993) provide detailed reviews of the numerous research papers devoted to advancing applications of the premier ARIMA models, several unique aspects of this voluminous literature are discussed here by partitioning studies into four categories; namely, research on: (1) identification of ARIMA models for purely nonseasonal firms, (2) the construction of multivariate prediction models for quarterly earnings, (3) the assessment of the impact of firm size on the time-series properties and predictive ability of quarterly earnings, and (4) the utilization of ARIMA modeling techniques to facilitate auditor judgments when employing analytical review procedures.

3.1. Nonseasonal firms

Although the premier, common-structure ARIMA models have demonstrated superior predictive ability versus firm-specific ARIMA models, the cross-sectional methodology that has been used to identify the premiers may be subject to potential misspecification bias. This approach assumes implicitly that the behavior of a hypothetical average firm is necessarily representative of every firm. It is true that, on average, cross-sectional results indicate that seasonality is an important determinant in the specification of the time-series properties of quarterly earnings. Therefore, it is not surprising that all three premier ARIMA models contain either seasonal differencing and/or seasonal moving-average parameters to capture this effect. Yet, this cross-sectional approach may attribute seasonal characteristics to nonseasonal firms via the averaging process described above. By doing so, model specification for nonseasonal firms is needlessly complex adversely affecting predictive ability.

Lorek and Bathke (1984) detected the presence of 29 nonseasonal firms from a subpopulation of 240 firms originally employed in Bathke and Lorek (1984). The detection of the nonseasonal firms (12.1% of the sample) was accomplished using a procedure whereby firms were labeled as nonseasonal if autocorrelation coefficients at all three lag multiples of the seasonal span of the SACF (i.e., lags 4, 8, and 12) were less than their respective standard errors. The basic issue here is that the use of the seasonal premier ARIMA models may result in potential seasonal overdifferencing and/or parameter redundancy for nonseasonal firms. Moreover, the use of seasonal premier ARIMA models may also result in prediction models that are overly complex and provide reduced levels of predictive ability for nonseasonal firms. Lorek and Bathke identified a simple first-order autoregressive process [i.e., an AR (1)] for the nonseasonals and showed how it generated quarterly EPS predictions that were significantly more accurate than predictions obtained from the premier, seasonal ARIMA models. They also reported that idiosyncratic nonseasonal firms were widely represented in the samples of other studies ranging from 7.25% in Foster's study to 55.6% in Coates (1972) study.

3.2. Multivariate prediction models

The utilization of univariate ARIMA models as proxies for the quarterly earnings expectation model of choice was challenged by researchers in accounting and finance who had access to quarterly earnings predictions of sell-side analysts. Fried and Givoly (1982) and Brown, Hagerman, Griffin, and Zmijewski (1987), among others, demonstrated the forecasting superiority of analysts, on average, vis-à-vis univariate time-series ARIMA models. This led accounting researchers to expand the conditioning set of variables upon which the statistically-based quarterly earnings forecast models were based in an effort to level the playing field.

Hopwood (1980) and Hopwood and McKeown (1981) are representative of the aforementioned efforts. They expanded the database upon which statistically-based models were formulated by either incorporating a contemporaneous market and/or industry price index. For example, Hopwood invoked a single premier transfer function ARIMA model employing a non-random sample of 30 firms in the airlines industry where:

$$Y_t = Y_{t-4} + \theta_0 + \omega_0(X_t - X_{t-4}) + \phi_1 \quad (4)$$

where:

Y_t = quarterly earnings at time t

X_t = quarterly earnings market index at time t

$\theta_0, \omega_0, \phi_1$ = transfer function parameters.

Hopwood and McKeown (1981) employed a sample of 267 calendar-year firms obtained from the quarterly *Compustat* file. They also employed a single premier transfer function ARIMA model similar

to Eq. (4). Both studies reported an “economically insignificant” improvement in predictive power over that obtained by univariate premier ARIMA models. Additionally, Hopwood (1980: 87) noted that the improvement in predictive power might simply be an artifact of the intensive multivariate modeling process.

The premier ARIMA models discussed previously were all univariate in nature limiting the conditioning database to past quarterly earnings. Since sell-side analysts have access to firm-specific, industry, and market data, their conditioning database is far more extensive. The documented superiority of quarterly earnings forecasts attributed to sell-side analysts dampened the use of premier ARIMA models as the proxy of choice for the market's expectation of quarterly earnings. Nevertheless, analysts' dominance appears confined to relatively short-run EPS forecasts with statistically-based prediction models dominating over relatively longer forecast horizons.⁴

3.3. Firm-size

Refinements in statistically-based quarterly earnings prediction models continued when Bathke et al. (1989) assessed whether firm-size has an impact on common-model ARIMA structure, parameter values of ARIMA models, and/or predictive ability of quarterly earnings data. Their objective was to assess whether firm-size could be used as an independent variable in isolating inter-firm differences in the time-series properties of quarterly earnings. Scherer (1973) provided evidence that larger firms exhibit more stable and less volatile growth patterns relative to smaller firms allowing them to diversify into alternative products or services more readily. The extent to which such behavior is captured in the quarterly earnings autocorrelation patterns of firms is an empirical issue upon which Bathke et al. provide evidence. Additionally, Bamber's (1986) findings that analysts' forecasts are more accurate for larger rather than smaller firms are particularly salient here.

Bathke et al. obtained a subpopulation of 374 calendar year-end NYSE firms which had complete quarterly earnings data from 1967 to 1982 on the quarterly *Compustat* file. They eliminated 16 firms due to missing security price data, 126 firms that experienced idiosyncratic nonseasonal behavior in their quarterly earnings data, and 123 firms that experienced volatile growth and/or inconsistent size-strata membership. These additional controls, unique to this study, served to increase the internal validity of the analysis and the generalizability of its findings.

Their findings suggest that firm size does not affect the appropriateness of the choice of common-model structure of the ARIMA time-series models. In other words, the Foster, Brown & Rozeff, and Griffin & Watts ARIMA models fit both larger and smaller firms with comparable descriptive power. However, firm size did have a more contextual effect in that it explained differences in the autoregressive parameters of the Foster and Brown & Rozeff ARIMA models where the values of such parameters were systematically larger for the upper strata (large) versus the middle and lower strata (small) firms. This finding is consistent with autocorrelation levels being greater, on average, for larger firms than smaller firms and suggests that controlling for firm size might be beneficial in predictive ability and capital market association testing. Finally, they provide evidence consistent with a pervasive firm-size effect on predictive ability where larger firms have significantly smaller forecast errors than smaller firms. This finding is of particular importance to researchers interested in employing prediction models for smaller firms not covered by analysts which exhibit relatively poorer information environments than larger, covered firms.

⁴ See Bradshaw, Drake, Myers, and Myers (2012) for recent empirical results supportive of this finding.

3.4. Analytical review procedures

Kinney (1978) is credited with introducing advanced statistical approaches in conducting analytical reviews in auditing. His analysis employed a sample of monthly operating revenues of six southwestern United States railroads. He assessed the efficacy of employing transfer function ARIMA models, univariate ARIMA models, regression-based models, and relatively naïve martingale and submartingale models in this setting. The latter set of random-walk type models was included because naïve models are typically employed by auditors in real-world settings and are virtually costless to implement. While Kinney concluded that ARIMA-based models are potentially beneficial, they were not recommended as an alternative to simpler models. Despite the fact that the transfer-function ARIMA models provided superior predictive performance, they require the most information and the greatest computational effort. Therefore, the determination of the best analytical review procedure model is essentially an empirical issue based on cost-benefit considerations of the auditor.

Lorek, Branson, and Icerman (1992) provide evidence that the analytical review procedures employed in practice are limited to naïve data-scanning methods consistent with the random-walk model where prior and current year balances are simply compared. Motivated by the AICPA's (1988) suggestion that the component disaggregation of quarterly earnings may lead to further enhancement of predictive ability, Lorek et al. assessed the predictive ability of three quarterly income statement series: (1) net income, (2) sales revenue, and (3) cost of goods sold; four quarterly balance sheet components: (1) - accounts receivable, (2) accounts payable, (3) inventory, and (4) total assets; and four ratios: (1) inventory turnover, (2) receivable turnover, (3) gross margin, and (4) return on investment. Quarterly data were obtained from *Compustat* for 45 to 82 firms depending upon the specific account and/or ratio in question, across the 1977–1989 time interval.

The quarter-to-quarter (consecutive) and quarter-by-quarter (seasonal) dependencies well documented for the quarterly earnings series by first generation time-series researchers also pertain to disaggregated component accounts and ratios. Moreover, the descriptive validity of the premier univariate ARIMA models on the disaggregated series suggests that data-scanning techniques currently employed by auditors may be suboptimal. Although the descriptive fit of the premier ARIMA models may allow auditors to bypass the time-consuming model identification phase of the Box-Jenkins model building process, Lorek et al. were hesitant to recommend ARIMA models as analytical procedures. While predictive ability was enhanced versus random-walk models, supplementary tests clearly revealed the imprecision of the ARIMA predictions relative to a materiality proxy. This mixed evidence motivated Lorek et al. to agree with Kinney's reservations pertaining to the use of ARIMA-based models in analytical review settings.

Finally, Lorek, Wheeler, Icerman, and Fordham (1995) expanded the set of statistically-based models to include: regression, univariate ARIMA, Census X-11, and simple martingale models. Despite employing a more sophisticated set of expectation models, their conclusions did not differ from Kinney and Lorek et al. (1992). While sophisticated statistically-based models seem to enhance predictive performance marginally, they have not been adopted by auditors due to cost-benefit considerations.

4. Recent trends in assessing the time-series properties of quarterly earnings

While “golden age” time-series researchers were preoccupied with identifying a singular premier ARIMA model for quarterly earnings that was appropriate for all firms and time, Brown (1999), among others, cautioned that all firms quarterly earnings series may not follow the same time-series model. This appears plausible due to several factors. First, early time-series work in the “golden age” employed

sampling filters that systematically excluded high-technology and regulated firms (i.e., banks, insurance companies, and utilities) from entering test samples. Such work implicitly biased samples toward larger, manufacturing-oriented, New York Stock Exchange firms (i.e., so-called “old-economy” firms). Second, Baginski, Branson, Lorek, and Willinger (2003) provide empirical evidence that earnings persistence has declined through time casting doubt upon the ability of the premier seasonal ARIMA models to track autocorrelation in quarterly earnings during more recent time periods. Third, Klein and Marquardt (2006) provide empirical evidence that losses occur with increased frequency in more recent time periods. Hayn (1995) has demonstrated that losses are far less informative about future earnings prospects than positive earnings since they disrupt firms' autocorrelation patterns. Finally, Lorek et al. (2008) provide empirical evidence that the incidence of nonseasonal firms has increased dramatically over time. Collectively, these empirical findings provide a rationale for researchers to partition sample firms into various categories and identify ARIMA prediction models tailored to the quarterly earnings of the firms in each category.

Recent work has attempted ARIMA modeling using the aforementioned partitioning approach. Lorek et al. (2008) extended the earlier nonseasonal work of Lorek and Bathke (1984) and Brown and Han (2000). They provide evidence that a sizable and growing percentage of firms exhibit quarterly earnings patterns that are clearly nonseasonal – firms for which the seasonal premier ARIMA models are clearly misspecified. Specifically, 36% of their sample firms were nonseasonal compared to 12% in Lorek and Bathke (1984) and 17% in Brown and Han (2000). We observe that Lorek et al.'s (2008) holdout period extends to 2003 providing more current time-series data than other studies.

Thomas (1993) has speculated that quarterly earnings time-series properties have gradually changed over time due to such factors as increased mergers and acquisitions, diversity in product lines, and increasing numbers of loss quarters contributing to a decline in earnings persistence. The increasing nonseasonals in Lorek et al.'s sample are consistent with Thomas' conjecture. Interestingly, their predictive findings indicate that the random walk model provides significantly more accurate quarterly earnings predictions than the AR (1) ARIMA model popularized by Lorek and Bathke (1984). Lorek et al. attribute the superior performance of the random walk model to its parsimonious model structure, the reduced levels of autocorrelation in the quarterly earnings series of their sample firms relative to those exhibited in previous works, and the significantly greater frequency of loss quarters evidenced in their holdout period. Finally, 43.6% of the nonseasonal firms in their sample had no analyst coverage enhancing interest in the specification of statistically-based quarterly earnings predictions models for these uncovered firms.

Lorek and Willinger (2007) provide further empirical evidence on the contextual nature of quarterly earnings prediction models consistent with the notion of sample partitioning. They obtained a subpopulation of 1216 firms which had complete quarterly earnings data from 1990 to 2002 on the quarterly *Compustat* file. Three sample partitions were employed: (1) high-technology firms ($n = 202$), (2) regulated firms ($n = 218$), and (3) a default sample ($n = 796$). They provide empirical evidence that the random walk with drift model provides significantly more accurate quarterly earnings predictions for high-technology firms. This finding is particularly salient given that researchers in the “golden age” were unable to assess the time-series properties of quarterly earnings for “new-economy” firms. The authors speculate that the parsimonious nature of the random walk with drift model coupled with the more volatile earnings environment experienced by sample firms in the holdout period made it less susceptible to structural change issues than the more complex, seasonal, and premier ARIMA models. Predictive results were specific, however, to the partition of firms analyzed. That is, the Griffin–Watts seasonal ARIMA model dominated predictive ability for the regulated firm subsample. In any case, it appears that the appropriateness of the

seasonal premier ARIMA models for all firms has been called into question.

5. Quarterly CFO

Bowen, Burgstahler, and Daley (1986) argue that analysts, retail investors, and accounting researchers are interested in cash-flow forecasting. This interest stems from a diverse set of decision settings for which CFO predictions serve as inputs including: risk assessment, the accuracy of credit-rating predictions, and firm valuations using discounted cash flows. Barniv, Myring, and Thomas (2005), however, document the current unavailability of analysts' multi-step ahead quarterly CFO forecasts. Yet, financial statement analysis texts underscore the need for long-term CFO forecasts for firm valuations (Palepu & Healy, 2013). Therefore, research on statistically-based quarterly CFO models takes on added importance in this setting.

Hopwood and McKeown (1992) used an algorithm which added back depreciation and amortization charges on a quarterly basis to earnings in order to derive a proxy for quarterly CFO. Their sampling filters resulted in a relatively small sample of manufacturing firms ($n = 60$) with a complete time series of quarterly CFO from 1976 to 1987. The examination of SACFs revealed that the quarterly CFO series exhibited substantially lower levels of autocorrelation than their corresponding quarterly EPS series. Using the premier quarterly EPS seasonal ARIMA models, they provided predictive results that quarterly CFO was significantly more difficult to predict than quarterly EPS, consistent with the descriptive evidence on autocorrelation. Hopwood and McKeown called for future research to identify idiosyncratic prediction models for quarterly CFO with potentially unique model structures perhaps different from the premier models for quarterly EPS.

Lorek, Schaefer, and Willinger (1993) created a time series of quarterly CFO across the 1976–1986 time period using an algorithm similar to Hopwood and McKeown. They provide descriptive evidence that the time-series properties of quarterly CFO are at variance with quarterly EPS. Specifically, they identified the SAR (000) X (100) ARIMA model, in Box–Jenkins notation, which employs a singular seasonal autoregressive parameter. This model stands in marked contrast to the premier ARIMA models for quarterly EPS. The SAR ARIMA model only exhibits quarter-by-quarter (seasonal) characteristics while the latter models exhibit both quarter-to-quarter (adjacent) as well as quarter-by-quarter (seasonal) characteristics. A possible explanation for these differential time-series properties pertains to the artifactual autocorrelation induced by depreciation and amortization on the EPS series which is not present in the more pristine CFO series.

Lorek, Schaefer, and Willinger also provide predictive evidence for two samples of 80 and 66 firms across two forecast horizons, 1985 and 1986, respectively. Predictive results indicated that the SAR (000) X (100) ARIMA model provides significantly more accurate one-step ahead CFO predictions than a disaggregated-accrual regression model popularized by Wilson (1986, 1987).⁵ These results are interesting from at least two perspectives. First, the SAR (000) X (100) ARIMA model is considerably more parsimonious than the Wilson regression model since it is univariate in nature and only employs past values of CFO to predict future values of CFO. Wilson's model, on the other hand, employs a host of independent variables for sales, CFO, current and noncurrent accruals with varying lag structures. Second, Wilson's regression model is estimated cross-sectionally forcing parameter values to be identical across firms and time. It appears that the firm-specific parameter estimation employed in the SAR (000) X (100) ARIMA model captures idiosyncratic firm-specific behavior more accurately than Wilson's cross-sectional approach.

⁵ Wilson (1986, 1987) employed a vector of 15 independent variables comprised of current and lagged values of sales revenues, net earnings, CFO, current and noncurrent accruals, and the most recent annual capital expenditures in a complex regression-based model.

The aforementioned works all employed algorithms whereby non-cash expenses were simply added to earnings to derive a proxy series for CFO. Yet, [Hribar and Collins \(2002\)](#) provide empirical evidence that proxy CFO and CFO reported in accordance with SFAS No. 95 are not highly correlated. This casts doubt upon the external validity of all previous work on quarterly CFO and has motivated researchers to re-examine the time-series properties of quarterly CFO.

[Lorek and Willinger \(2008\)](#) re-examined the descriptive properties of quarterly CFO using data reported in accordance with SFAS No. 95 rather than an algorithmic proxy. This was facilitated by SFAS FASB Standard No. 95 which required cash flow statements for fiscal years after July 15, 1988 ([FASB, 1987](#)). They report evidence that the time-series properties of quarterly CFO exhibit both quarter-to-quarter (adjacent) as well as quarter-by-quarter (seasonal) autocorrelations more complex than the purely seasonal characteristics of the algorithmic proxy series. This evidence is consistent with [Hribar and Collins \(2002\)](#).

Lorek and Willinger obtained a primary sample of 198 calendar year-end firms with complete time-series data starting with the first quarter of 1989 and ending with the fourth quarter of 2005. They speculate that the SAR (000) X (100) ARIMA model lacks economic intuition since it is based on relatively stale, seasonal information four quarters ago ignoring the information impounded in the three most recent quarterly CFOs. Using a 56 observation database spanning 1989–2002 they identified the Brown & Rozeff (100) X (011) ARIMA model as a candidate prediction model for quarterly CFO. It generated significantly more accurate one-step ahead quarterly CFO predictions versus the random walk with drift, seasonal random walk with drift, and disaggregated-accrual MULT models.⁶ Supplementary analysis reported a firm-size effect wherein the predictions of larger firms were significantly more accurate than those of smaller firms. Finally, Lorek and Willinger eliminated the extensive accrual accounting data requirements necessary to operationalize the MULT model and expanded their test sample to 745 firms. They provide empirical evidence on the robustness of the Brown–Rozeff (100) X (011) ARIMA model as it provided significantly more accurate quarterly CFO predictions across 8940 firm/quarter predictions.

In their latest work, [Lorek and Willinger \(2011\)](#) obtained a primary sample of 192 calendar year-end firms with complete time-series data from the first quarter, 1989 to the fourth quarter, 2007. The prediction models [i.e., Brown & Rozeff (100) X (011) ARIMA model and the disaggregated-accrual MULT regression model] employed an identification database of 10,752 firm-quarter observations (i.e., 192 × 56) while employing a forecast holdout period comprised of the 20 quarters in the 2003–2007 time period. Supplementary analysis extended the predictive findings supporting the Brown & Rozeff (100) X (011) ARIMA model to 722 firms when the extensive data requirements pertaining to the MULT model were dropped.

Lorek and Willinger also provide evidence that the parameters of quarterly CFO models exhibit significantly smaller values than corresponding quarterly EPS models consistent with the notion that accrual accounting injects artifactual autocorrelation into the earnings stream via depreciation, amortization, and inventory flow assumptions. More importantly, they extend the empirical finding of one-quarter-ahead predictive superiority for the Brown & Rozeff (100) X (011) ARIMA model to longer-term one thru twenty step-ahead CFO predictions during the 2003–2007 time interval. This evidence is particularly salient to analysts, investors, and researchers who require long-term CFO predictions to conduct firm valuations.

⁶ The MULT model is a time-series regression model developed by [Lorek and Willinger \(1996\)](#) where lagged values of CFO, operating income, receivables, payables, and inventory are employed as independent variables.

5.1. Suggestions for future research and concluding remarks

Researchers in the “golden age” of time-series research identified the Foster, Brown & Rozeff, and Griffin & Watts ARIMA models employing relatively small samples of firms dominated by “old economy” manufacturing firms. [Lorek and Willinger \(2007\)](#) provide more recent empirical evidence that high-technology firms exhibit quarterly earnings time-series properties at variance with such earlier work. They suggest that these varying time-series properties may be due to at least two factors: (1) an increase in the number of loss quarters experienced by sample firms, and (2) the reduced levels of earnings persistence exhibited by such firms. Lorek and Willinger also suggest that the predictive power of statistically-based quarterly earnings prediction models may be considerably more contextual than previously indicated. For example, the random walk with drift model provides significantly more accurate predictions than the premier ARIMA models for a subsample of high-technology firms ($n = 20$) in their study. This suggests that future research should partition firms into categories (i.e., high-technology, financial institutions, regulated firms, etc.) and develop statistically-based prediction models tailored to each category.

Recent evidence by [Lorek et al. \(2008\)](#) reveals a dramatic increase in the number of firms whose quarterly earnings time-series properties may be characterized as nonseasonal. While [Lorek and Bathke \(1984\)](#) originally reported that 12% of their sample firms were nonseasonal, Lorek, Willinger, and Bathke’s more recent evidence indicates that 36% of their sample firms exhibited nonseasonal characteristics. Future research needs to identify ARIMA model structures specific to these nonseasonal firms to enhance predictive performance. This research issue is especially salient considering that 43.6% of Lorek, Willinger, and Bathke’s nonseasonal firms had no analyst coverage. The development of statistically-based quarterly earnings prediction models takes on added importance in this setting given the current unavailability of long-term CFO analysts’ forecasts.

It appears that the time-series properties of quarterly CFO are consistent with the Brown & Rozeff (100) X (011) ARIMA model ([Lorek & Willinger, 2011](#)). While additional research is necessary to substantiate these results, it appears that the lag structure in the Brown & Rozeff ARIMA model might be employed in a disaggregated-accrual, time-series regression model to further enhance predictive performance. In this manner, the question of whether the use of accrual accounting data enhances cash-flow predictions may be further assessed. This type of research is particularly salient since analysts, investors, and researchers require relatively accurate long-term CFO predictions as inputs to firm valuations.

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