Predictions of Annual Earnings using Quarterly Earnings, Annual Earnings and Dividend Payout Ratios

GERALD J. LOBO and R. D. NAIR
University of Wisconsin-Madison, Madison, WI, USA

This study empirically examines two issues related to forecasting annual accounting earnings. The first issue studied is the improvement in forecasts of annual earnings that can be obtained by including information about dividend payout along with the past earnings series in forecasting models. The second issue deals with the comparative ability of quarterly earnings time series models and annual earnings time series models to predict annual earnings. The results of this study indicate that considerable improvement in predictive ability can be obtained by expanding the information set to include the dividend payout ratio series. The empirical analysis also indicates that time series models developed using annual earnings generate more accurate predictions of annual earnings than do models developed using quarterly earnings.

INTRODUCTION

The time series properties of accounting earnings have received considerable attention in recent years. One reason for this attention is the use of time series models in capital market research. In this context, they are used for modeling aggregate capital market expectations in order to determine the sign and/or size of unanticipated earnings.[1] Another reason is the use of time series models in examining the income-smoothing hypothesis. These models have been used to provide benchmarks against which smoothing activities of firms' managements are compared.[2] Other uses of time series models include estimation of future earnings in studies dealing with estimation of cost of capital, and assessment of earnings variability as a surrogate for risk.[3]

Research on the time series properties of accounting earnings also has implications for managers and auditors. The SEC has evidenced consistent and continuing interest in the forecasting process and the role of financial statements in it. The SEC has indicated that if internal company forecasts show any substantial deviation from the trend of prior years' income then a disclosure obligation exists. At the same time the Financial Accounting Standards Board has indicted that accounting principles adopted in the future will be tested by the degree to which they assist in the predictive process. Finally, auditors may be required to attest to the reasonableness of management forecasts. Time series models provide a basis for evaluating such forecasts.

The purpose of this study is twofold. First, it examines whether the use of past earnings plus additional accounting information will result in more accurate predictions of annual earnings than those obtained from models based only on past earnings. Second, it compares the ability of quarterly earnings time series models to predict annual earnings with the ability of annual earnings time series models to predict annual earnings.

The next section describes the forecasting models used in this study. The third section outlines the sample selection criteria and describes the data. The empirical results are presented and discussed next. A summary of the results and the conclusions drawn are presented in the final section.

ALTERNATIVE MODELS FOR FORECASTING ACCOUNTING EARNINGS

This section is divided into two parts. The first part describes the forecasting models developed from past annual earnings series and from past quarterly earnings series. The second part presents forecasting models that utilize information contained in past quarterly or annual earnings series and in the payout ratio series.

Models Based on Past Earnings

The forecasting models used in this study consist of three models that rely on the past series of annual earnings and three models based upon quarterly earnings time series.

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The models based on annual earnings that were used in this study are

$$\text{Model 1 (M1):} \quad E_t = E_{t-1} + a_t \qquad (1)$$

$$\text{Model 2 (M2):} \quad E_t = E_{t-1} + \delta + a_t \qquad (2)$$

$$\text{Model 3 (M3):} \quad E_t = \beta_0 + \beta_1 E_{t-1} + a_t \qquad (3)$$

where

E_t = earnings per share in year t,
δ = drift term,
a_t = disturbance term,
β_0 and β_1 = regression coefficients.

Models 1 and 2 are commonly referred to as a random walk model and random walk with drift model, respectively. These models have been found to perform well, on the average, when compared with other models of annual earnings.[4] The drift term, δ, in model 2 was estimated as the average change in annual earnings during the fifteen-year period immediately preceding the year for which a forecast was desired. Model 3 is a relatively simple model for annual earnings. The parameters of model 3 were estimated by ordinary least squares using data from the fifteen years preceding the year for which a forecast was desired.

Models based on quarterly earnings that were used in this study are

$$\text{Model 4 (M4):} \quad Q_t = Q_{t-4} + \phi_1(Q_{t-1} - Q_{t-5}) + a_t + \Delta_1 a_{t-1} \qquad (4)$$

$$\text{Model 5 (M5):} \quad Q_t = Q_{t-4} + \phi_1(Q_{t-1} - Q_{t-5}) + a_t \qquad (5)$$

$$\text{Model 6 (M5):} \quad Q_t = Q_{t-4} + (Q_{t-1} - Q_{t-5}) + a_t - \theta_1 a_{t-1} - \Delta_1 a_{t-4} + \theta_1 \Delta_1 a_{t-5} \qquad (6)$$

where

Q_t = earnings per share in quater t,
ϕ_1 = first-order autoregressive parameter,
θ_1 = first-order moving average parameter,
Δ_1 = first-order seasonal moving average parameter,
Δ_1 = disturbance term.

Models 4, 5 and 6 are ARIMA models that have been found to perform well in forecasting quarterly earnings and annual earnings. These models were identified by examining cross-sectional autocorrelation and partial autocorrelation functions, using the Box and Jenkins (1970) approach.

Model 6, which is a seasonally differenced first-order moving average and seasonal moving average model, was proposed by Watts (1975) and by Griffin (1977). Foster (1977) showed that model 5 produced one-quarter-ahead forecasts of quarterly earnings with lower absolute percentage errors than did individually identified ARIMA models.[5] Noting that model 5 did not fit the data well, Brown and Rozeff (1979) proposed a seasonally differenced first-order autoregressive and moving average model as shown in Eqn (4). They provided evidence which indicated that for one-quarter-ahead, five-quarter-ahead and nine-quarter-ahead forecasts, model 4 outperformed models 5 and 6.

Lorek (1979) and Collins and Hopwood (1980) analyzed the relative ability of models 4, 5 and 6 to make accurate annual earnings forecasts by aggregating quarterly forecasts. The results of their studies were conflicting. Collins and Hopwood found that for annual forecasts made in the first quarter, model 4 produced more accurate forecasts than did models 5 and 6. On the other hand, Lorek determined that model 6 generated the most accurate forecasts of annual earnings. Lorek's findings also indicated that forecasts produced using models 1 and 2 were, on the average, lower in absolute percentage error than were forecasts from models 4 and 5. The inconsistencies in the results of these two studies provide additional motivation for this research.

Models 4, 5 and 6 are parsimonious models that are imposed on the time series of each firm's quarterly earnings. By pre-specifying the structure of the models, the identification stage of the three-stage Box and Jenkins modeling approach is eliminated. Models 4, 5 and 6 were estimated using the 60 quarters of earnings data immediately preceding the year for which a forecast was desired. One-, two-, three- and four-quarter-ahead forecasts were obtained for each firm for a given year and model, and forecasts for the four quarters wre summed to yield the forecast of annual earnings for a given firm by a given model for a given year. Forecasts of annual earnings were generated for each firm using each of the six earnings models for the period 1974–9. These forecasts were then used in the combination models described below.

Models Utilizing Earnings and Other Accounting Information

A commonly used means of conveying information about firms' prospects is the declaration of dividends. Miller and Modigliani (1961) suggested that dividends may serve as signals of future earnings. The 'information content of dividends' hypothesis asserts that managements set cash dividends on the basis of their assessments of future earnings. If dividends provide information about managements' expectations of the future earnings of firms, then it should be possible to utilize this information to obtain earnings forecasts that are more accurate than those obtained without the use of dividend information. In this study, information contained in dividend declarations is incorporated into forecasting models by using the dividend payout ratio. Models utilizing earnings and payout ratio information are referred to as combination models (CM).

Combination models, CM1–CM6, were developed by combining forecasts of annual earnings from each of models M1–M6 with forecasts of the dividend payout ratio. The following pooled time-series, cross-sectional models were estimated:

$$E_t = \gamma_{0j} + \gamma_{1j} FE_{ijt} + \gamma_{2j} FP_{it} + \varepsilon_{ijt} \qquad (7)$$

where

FE_{ijt} = annual earnings forecast for firm i in year t using model j ($j = 1, \ldots, 6$), provided by the methods described above,

FP_{it} = forecasted payout ratio for firm i in year t,

ε_{ijt} = disturbance term,

γ_{0j}, γ_{1j} and γ_{2j} are regression coefficients.

Equation (7) was estimated by pooling the forecasted earnings and forecasted payout ratios for the sixty firms for 1974 and 1975. The estimated model was then used to generate earnings forecasts for 1976. For forecasts of 1977 earnings, the coefficients of Eqn (7) were re-estimated using pooled data from 1974 to 1976. Similarly for forecasts of 1978 and 1979 earnings, pooled data from 1974 to 1977 and from 1974 to 1978, respectively, were used.

Forecasted payout ratios which were used in Eqn (7) for each firm for each year were obtained by the following two-step procedure. First, the average payout ratio for the cross-section of 60 firms was regressed on the average payout ratio for the previous period using the following model:

$$AP_t = \delta_0 + \delta_1 AP_{t-1} + \varepsilon_t \qquad (8)$$

where

AP_t = average payout ratio in year t for the sample of firms,

δ_0 and δ_1 are regression coefficients.

Then, the estimated coefficients $\hat{\delta}_0$ and $\hat{\delta}_1$ obtained from estimating Eqn (8) were used to obtain forecasted payout ratios FP_{it} for each firm for each year from 1974 to 1979 as follows:

$$FP_{it} = \hat{\delta}_0 + \hat{\delta}_1 P_{i,t-1} \qquad (9)$$

where

$P_{i,t-1}$ = actual payout ratio for firm i in period $t-1$.

Data from 1962 to 1973 were used to estimate δ_0 and δ_1. The estimates were then used to determine FP_{it} in 1974. Equation (8) was then re-estimated each year using data from 1962 to the year preceding the one for which forecasted payout ratios were desired.

Estimated values of δ_0 and δ_1 from Eqn (8), along with the corresponding t-statistics are reported in Table 1. Also reported are the adjusted R^2's for each regression. The estimates of γ_0, γ_1 and γ_2 from Eqn (7) and their corresponding t-values are presented in Table 2, for each of the six earnings models. For all of the regressions, the estimated values of γ_2 are negative, indicating a negative correlation between actual earnings and forecasted payout ratios. The t-statistics for γ_2 range from −2.95 to −10.39. The t-statistics and adjusted R^2's are presented in Tables 1 and 2 to

Table 1. Summary Statistics for Payout Ratio Regressions

Model: $AP_t = \delta_0 + \delta_1 AP_{t-1} + \varepsilon_t$

Estimation period	1962–73	1962–74	1962–75	1962–76	1962–77	1963–78
δ_0	0.2210	0.1951	0.2389	0.2201	0.2064	0.1718
(t-value)	(1.15)	(1.47)	(2.05)	(1.84)	(1.94)	(1.69)
δ_1	0.5352	0.5841	0.5028	0.5301	0.5558	0.6197
(t-value)	(1.44)	(2.23)	(2.16)	(2.21)	(2.58)	(2.98)
$\bar{R}_2$	0.10	0.27	0.24	0.23	0.29	0.35

Table 2. Summary Statistics for Combination Models

Model: $E_t = \gamma_{0j} + \gamma_{1j} FE_{ijt} + \gamma_{2j} FP_{it} + \varepsilon_{ijt}$, $j = 1, \ldots, 6$

Estimation period	1974–5	1974–6	1974–7	1974–8
PANEL A: MODEL CM1				
γ_{01}	297.72	312.34	299.72	297.60
(t-value)	(8.34)	(9.34)	(11.11)	(12.26)
γ_{11}	0.812	0.812	0.852	0.894
(t-value)	(16.62)	(18.16)	(23.97)	(29.67)
γ_{21}	−559.72	−546.88	−536.46	−540.44
(t-value)	(−7.53)	(−7.66)	(−9.37)	(−10.39)
$\bar{R}^2$	0.73	0.67	0.72	0.76
PANEL B: MODEL CM2				
γ_{02}	298.69	313.57	300.14	297.49
(t-value)	(8.25)	(9.23)	(10.94)	(12.04)
γ_{12}	0.766	0.762	0.803	0.844
(t-value)	(16.30)	(17.74)	(23.42)	(28.98)
γ_{22}	−554.27	−540.04	−528.68	−531.83
(t-value)	(−7.36)	(−7.46)	(−9.09)	(−10.06)
$\bar{R}^2$	0.72	0.66	0.71	0.75
PANEL C: MODEL CM3				
γ_{03}	332.34	334.18	328.78	327.82
(t-value)	(8.23)	(9.42)	(10.51)	(11.24)
γ_{13}	0.683	0.726	0.763	0.831
(t-value)	(13.61)	(16.40)	(18.99)	(22.62)
γ_{23}	−575.66	−564.37	−559.11	−579.72
(t-value)	(−6.75)	(−7.39)	(−8.33)	(−9.19)
$\bar{R}^2$	0.64	0.62	0.62	0.65
PANEL D: MODEL CM4				
γ_{04}	215.14	254.14	260.25	278.16
(t-value)	(5.82)	(7.71)	(8.99)	(9.94)
γ_{14}	0.721	0.714	0.774	0.807
(t-value)	(16.80)	(19.19)	(22.23)	(24.71)
γ_{24}	−302.46	−353.28	−384.30	−419.38
(t-value)	(−4.13)	(−5.20)	(−6.42)	(−7.11)
$\bar{R}^2$	0.73	0.69	0.69	0.69
PANEL E: MODEL CM5				
γ_{05}	210.74	242.45	234.26	244.23
(t-value)	(5.43)	(6.86)	(7.92)	(8.87)
γ_{15}	0.624	0.640	0.693	0.724
(t-value)	(15.80)	(17.51)	(21.98)	(25.84)
γ_{25}	−270.29	−304.32	−309.27	−327.26
(tvalue)	(−3.53)	(−4.21)	(−5.13)	(−5.72)
$\bar{R}^2$	0.71	0.65	0.69	0.71
PANEL F: MODEL CM6				
γ_{06}	205.34	245.95	246.54	260.87
(t-value)	(5.24)	(6.89)	(8.03)	(8.84)
γ_{16}	0.589	0.576	0.637	0.661
(t-value)	(15.64)	(17.20)	(20.64)	(23.16)
γ_{26}	−228.96	−276.35	−294.74	−314.35
(t-value)	(−2.95)	(−3.78)	(−4.69)	(−5.11)
$\bar{R}^2$	0.70	0.65	0.66	0.66

provide some indication of the goodness of fit of Eqns (7) and (8). No statistical tests of significance are conducted. This is because the data used in these regressions are drawn from a cross-section of firms with different sizes. This could result in heteroscedastic disturbances which would cause the estimates of the standard errors of the coefficients to be biased. As a result of this, the t-statistics reported in Table 2 may be biased. Note that the estimates of the coefficients are unbiased. These unbiased estimates are used to generate the earnings forecasts. The principal interest here is in the model's ability to accurately forecast annual earnings.

Sample Selection and Data Description. The sample used in this study consisted of sixty New York Stock Exchange firms with calendar year-ends. The following criteria were required to be satisfied:

(1) Each firm had quarterly earnings per share data available in Moody's Industrials Manual for the period 1959–79. Earnings per share figures were adjusted for stock splits and dividends. These data were required for estimating the parameters of earnings forecast models.
(2) Each firm had cash dividend and earnings available to common shareholders data available on the COMPUSTAT Annual Industrials Tape for the period 1962–79. These data were required for obtaining forecasts of the dividend payout ratio.

The sample contained firms from thirty-six industries (Standard Industrial Two-Digit Classification). It did not include utilities and banks. The maximum number of firms from any single industry was four (6.67%).

EMPIRICAL ANALYSIS AND RESULTS

A metric that is commonly used to evaluate the predictive ability of forecasting models is the mean square forecast error. This is obtained for a given model by summing squared forecast errors for each firm for each year as follows:

$$\frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}(F_{itk}-E_{it})^2 \qquad (10)$$

where

F_{itk} = forecasted annual earnings per share for firm i in year t using forecasting model k,
E_{it} = actual earnings per share for firm i in year t,
N = number of firms in the sample,
T = number of years for which forecasts are evaluated.

However, if forecast errors are measured in terms of levels of earnings, then as the level of earnings increases in absolute magnitude, so will the absolute magnitude of the forecast errors. Therefore, in a sample that consists of firms with a wide dispersion of earnings levels, the measure of predictive ability will be biased against firms with high levels of absolute earnings and biased in favor of firms with low levels. In order to adjust for cross-sectional differences in levels of absolute earnings, forecast errors are defined in terms of percentage changes in earnings per share.

Therefore, the predictive ability of forecasts from each model is evaluated using Theil's (1966) U^2 statistic which is defined as follows:

$$U_k^2=\frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}(f_{itk}-e_{it})^2 \qquad (11)$$

where

U_k^2 = Theil's U^2 statistic for forecasting model k,

$f_{itk}=\dfrac{(F_{itk}-E_{i,t-1})}{|E_{i,t-1}|}$ = the forecasted percentage change in earnings per share of firm i from year $t-1$ to year t using forecasting model k,

$e_{it}=\dfrac{(E_{it}-E_{i,t-1})}{|E_{i,t-1}|}$ = the actual percentage change in earnings per share of firm i from year $t-1$ to year t.

Theil's U^2 statistic is calculated for each model k using data pooled across the sixty firms and over the four years examined in this study. If the forecasts from a given model were to be exactly realized, then $(f_{itk}-e_{it})$ will be zero and so will U_k^2. Increasing values of U_k^2 indicate increasingly poor predictive ability.

Several useful insights into the causes of forecast error can be obtained by decomposing U_k^2. The following decomposition will prove most useful for evaluating the models' predictive abilities:[6]

$$U_k^2=(\bar{f}_k-\bar{e})^2+(S_{f_k}-r_kS_e)^2-(1-r_k^2)s_e^2 \qquad (12)$$

where

$\bar{f}_k$ = the mean value of f_{itk},
$\bar{e}$ = the mean value of e_{it},
S_{f_k} = the standard deviation of f_{itk}
S_e = the standard deviation of e_{it}
r_k = the correlation coefficient between f_{itk} and e_{it}.

In this decomposition, $U_k^B=(\bar{f}_k-\bar{e})^2/U_k^2$ can be described as the percentage of forecast error due to unequal central tendency (bias), $U_k^I=(S_{f_k}-r_kS_e)^2/U_k^2$ as the percentage of forecast error due to unequal variation (inefficiency), and $U_k^R=(1-r_k^2)S_e^2/U_k^2$ as the percentage of forecast error due to imperfect covariation (residual variation). Obviously, $U_k^B+U_k^I+U_k^R=1$.

If we found $U_k^B=0$, then the forecasts would be unbiased in the sense that mean forecast and actual values would be equal. If $U_k^I=0$, then the forecast series would be efficient in that the forecast and the actual series would have equal variation when perfectly correlated. In order for $U_k^R=0$ the predicted series would have to have either zero variation or perfect positive correlation with the forecast series.

Table 3. Summary Statistics of Forecast Errors

	MODEL	U^2	U^{B}*	U^{I}*	U^{R}*
Earnings-based models	M1	0.454	14.18	0	85.82
	M2	0.418	10.82	16.67	72.51
	M3	0.388	9.84	0.25	89.91
	M4	0.485	10.61	12.46	76.93
	M5	0.513	6.62	18.58	74.80
	M6	0.611	5.97	30.52	63.51
Combination models	CM1	0.269	3.91	0.63	95.46
	CM2	0.279	3.74	1.21	95.05
	CM3	0.271	1.43	9.30	89.27
	CM4	0.309	0.90	10.38	88.72
	CM5	0.310	1.87	7.96	90.17
	CM6	0.342	1.34	12.94	85.72

* U^B, U^I and U^R are expressed in percentages.

In this case there would be no residual variation. If perfect forecasts are not possible, then it would seem desirable to have a source of error distribution where $U^B + U^I = 0$ and $U^R = 1$. This is because small proportions of U^B and U^I indicate that systematic errors play a small role in the overall level of forecast error.

Values of U_k^2 for each model's forecast errors are reported in Table 3 along with values of U_k^B, U_k^I and U_k^R. Examination of the U_k^2 values for the earnings-based models, M1–M6, indicates that models M1–M3 have lower values than do models M4–M6. This leads us to conclude that, on the basis of Theil's U^2, models based on annual earnings outperform models based on quarterly earnings. Additional support for this conclusion can be obtained by examining the values of U_k^R for the earnings-based models. For models M1 and M3, U_k^R is considerably larger than for models M4–M6. Large proportions of U_k^R indicate that systematic errors due to bias and inefficiency contribute little to overall forecast error.

Forecast errors of annual earnings-based models have larger proportions due to bias than do forecast errors of quarterly earnings-based models. If this bias can be detected and adjusted for, then the corrected forecasts will be just as useful as forecasts that contain no bias. However, this may not be without cost. In terms of error due to inefficiency, annual earnings-based forecasts are more efficient than quarterly earnings-based forecasts.

Results similar to those for earnings-based models are obtained for combination models. Models CM1–CM3, which are combination models of payout ratio forecasts and earnings forecasts from annual earnings-based models, have lower U_k^2 values than do models CM4–CM6. Models CM4–CM6 are combination models of payout ratio forecasts and earnings forecasts from quarterly earnings-based models. In terms of U_k^B, U_k^I and U_k^R, comparisons between models CM1–CM3 and models CM4–CM6 yield results which are similar to those obtained for earnings-based models M1–M6. Models CM1–CM3 have large proportions of forecast error due to bias, smaller proportions due to inefficiency, and larger proportions due to residual variation.

Pairwise comparisons between forecast errors from earnings-based models M1–M6 and forecast errors from the corresponding combination models CM1–CM6 indicate that, in all six comparisons, forecast errors from the latter set of models have lower U_k^2 values. Thus, on the basis of overall forecast error, combination models outperform earnings-based models. In terms of the proportion of systematic error ($U^B + U^I$), except for comparison (M3, CM3), combination models have lower proportions of error. For every comparison, the proportion of forecast error due to bias is greater for the earnings-based models than it is for the combination models. Except for comparisons (M1, CM1) and (M3, CM3), the proportion of error due to unequal variation is lower for the combination models.

To summarize, the empirical evidence presented in this study strongly supports the hypothesis that forecasting models developed using past series of annual earnings generate more accurate forecasts of annual earnings than do forecasting models that are based on the past series of quarterly earnings. Our results also lead us to conclude that forecasts generated by models developed from past earnings and payout ratios outperform those generated by models based only on past earnings.

SUMMARY AND CONCLUSIONS

This study compared the ability of quarterly earnings time series models and annual earnings time series models to predict annual earnings. It also examined whether the use of payout ratios along with past earnings resulted in more accurate predictions of annual earnings than those obtained from models based only on past earnings. To examine these questions, the accuracy of forecasts generated by six earnings-based models and six combination models was evaluated for sixty firms over a period of four years. Theil's U^2 statistic and a decomposition of this statistic were used to evaluate the predictive ability of these models.

The results of this study indicate that models developed using annual earnings generate more accurate forecasts of annual earnings than do models developed using quarterly earnings. Furthermore, forecasts from models based on payout ratios and earnings are better than forecasts from models based on earnings alone.

The finding that annual earnings-based models outperform quarterly earnings-based models has implications for studies examining the information content of annual earnings announcements, managements' earnings forecasts and analysts' earnings forecasts. More accurate forecasts from statistical models will reduce the probability of misclassification of firms into 'good news' and 'bad news' portfolios for assessing information content. They will also provide more accurate inputs for valuation models utilizing earnings forecasts. Another implication of this finding is that quarterly earnings contain more noise than annual earnings and therefore, models based on quarterly earnings do not perform as well as models based on annual earnings.

The second major conclusion of this study is that forecasting models developed using an enlarged information set outperform models using only past earnings. A considerable amount of the literature on the time series properties of earnings has concluded that annual earnings follow a random walk (model M1) or a random walk with drift (model M2). Recently, Freeman *et al.* (1982) have shown that, by enlarging the information set to include accounting rate-of-return information, the 'random walk hypothesis' can be rejected. This study provides additional evidence that enables rejection of the 'random walk hypothesis' when the prediction information set is expanded to include dividend payout.

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NOTES

1. Ball and Brown (1968), Beaver *et al.*, (1979) and Penman (1980) use models of annual earnings. Brown and Kennelly [1972] and Foster [1977] utilize models of quarterly earnings.
2. See Beaver (1970).
3. Examples are Miller and Modigliani [1966] and Foster [1977].
4. Ball and Watts (1972), Beaver (1970), Brealey (1969), Little and Rayner (1966) and Lookabill (1976), among others, conclude that undeflated earnings appear to follow a martingale or martingale with drift process.
5. Model M5 does not contain a drift term, whereas the model proposed by Foster (1977) does. Brown and Rozeff (1979) provide evidence that this term is insignificant.
6. See Theil (1958, pp. 33–5) and Granger and Newbold (1973, p. 46).

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