THE INFORMATION CONTENT OF SECURITY PRICES*

William BEAVER and Richard LAMBERT
Stanford University, Stanford, CA 94305, USA

Dale MORSE
Cornell University, Ithaca, NY 14853, USA

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The study derives a relationship between price changes and earnings changes by expanding the information upon which earnings expectations are conditioned to include data other than prior earnings history. In particular, price is used as a surrogate for additional information available to market participants. This relationship provides an interpretation of the contemporaneous association between price changes and earnings changes previously observed by Ball and Brown (1968) and Beaver, Clarke and Wright (1979), among others. It also provides a basis for inferring from prices the earnings process and the expected future earnings as perceived by market participants. In doing so, it inverts the familiar price earnings relationship and uses price as a predictor of earnings. The study differs from previous research which has examined the time series behavior of earnings based solely on previous earnings realizations. This approach can potentially lead to earnings forecasting models that are more accurate than the random walk with a drift that has been robust against challengers. In particular, the evidence indicates that security prices behave as if earnings are perceived to be dramatically different from a simple random walk process. Preliminary evidence also indicates that price-based forecasting models are more accurate than the random walk with a drift model.

1. Introduction

In this paper, we infer market participants' expectations regarding future earnings from observed changes in security prices. Alternatively stated, we use price data to infer a characterization of the stochastic process generating earnings, as perceived by market participants.¹ The notion that prices convey

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¹The result is a 'theory' of price earnings behavior under uncertainty. The interpretation of the results to be reported here are dependent upon the valuation and stochastic process assumptions introduced. It is not our contention that these assumptions are either unique (i.e., the only ones consistent with the data) or even most predictive. However, they illustrate the nature of the assumptions required to construct such a theory, and they have the virtue of being simple and/or widely used in previous research. As such, they provide a benchmark for subsequent research using alternative assumptions.
information about expectations is pervasive. One of the earliest arguments for the richness of prices in this respect appears in Muth's (1961) seminal essay on rational expectations. Previous research can be viewed as using earnings changes as a 'predictor' (or explanatory variable) for price changes. In the spirit of Muth's rational expectations notion, we turn around the price-earnings relationship and use current price changes as a predictor of future earnings.

Our perspective differs from that of previous research which infers a stochastic process from observing past earnings. Ball and Watts (1972) and Beaver (1970) provide early examples of this literature. In general, the assessed distribution of future earnings conditional upon past earnings will differ from the assessed distribution of future earnings conditional upon past earnings and past prices. This will occur if prices convey information about future earnings that is not conveyed by the past earnings. Hence this is the motivation for our use of the term, the information content of security prices.

Previous research [e.g., Ball and Watts (1972), Albrecht, Lookabill and McKeown (1977), Watts and Leftwich (1977)] has suggested that annual earnings per share is well approximated as a random walk with a drift. This conclusion is based upon a time series extrapolation of previous earnings. However, if additional data are considered, earnings expectations may not be well described by a random walk with a drift. As a result, market participants' expectation of earnings may not be the same as that implied by random walk with a drift, notwithstanding the previous research.

In general, the expected value of future earnings conditional upon past earnings will not equal the expected value of future earnings conditional upon past earnings and past prices if earnings are the result of a compound process involving more than one stochastic variable. We shall characterize earnings as a mixture of two processes, where one process reflects the impact on earnings of events with no price implications and the other reflects the impact of events that imply price revisions. We will show that the compound process can produce an earnings series that behaves as if it were a random walk with a drift, yet security prices can be used to extract information about the process that implies expected earnings different from those of a random walk with a drift. Simply stated, we are expanding the information upon which earnings expectations are conditioned to include data other than prior earnings history. In particular, we use price as a surrogate for additional information available to market participants.

The results of our study are of potential relevance to researchers who rely upon some assumption regarding earnings expectations. Obvious candidates are those studies which examine the relationship between prices and earnings, such as the earnings announcement studies [e.g., Ball and Brown (1968)] or cross-sectional valuation studies. Our results could potentially lead to an alteration (or confirmation, for that matter) of the earnings
forecasting models used in the announcement effect studies and of specifications of the 'permanent earnings' component in the cross-sectional valuation models. The results reported here also have implications for non-security price contexts that make assumptions about expected earnings, such as an examination of the ability of experts to forecast earnings and the use of earnings data to predict insolvency.

Section 2 introduces a class of earnings processes which link current earnings and future earnings. Section 3 derives a theoretical relationship between prices and earnings within the context of a particular valuation assumption. Section 4 presents empirical evidence regarding the perceived earnings process. Section 5 provides a reinterpretation of price earnings ratios. Section 6 presents evidence on the ability of security price-based models to forecast earnings relative to forecasts which use only past earnings data. Section 7 consists of concluding remarks.

2. The stochastic process of accounting earnings

Under uncertainty, capital market equilibrium can be characterized as a mapping from states, preferences, and endowments into prices. Earnings can be characterized as a signal from an information system, which is a mapping from states into signals. Prices and earnings can be viewed as joint realizations from a state generating process. The relationship between prices and earnings will depend in part upon the nature of the two mappings and the other information available to market participants.

If the two mappings reflect similar attributes of the state, a contemporaneous relationship between earnings changes and price changes would be expected. Prices will be characterized as if they were a function of future, expected earnings. Price changes will depend upon changes in expectations regarding future earnings. The change in expectations will in turn depend on both earnings and other information. In this sense, prices ($P_t$) or price changes ($AP_t$) can be said to reflect both earnings ($X_t$) and other information ($Z_t$). As a result, prices may contain information about future earnings not reflected in current earnings.

Prices may convey information about future earnings for several reasons:2 (1) Annual earnings can be viewed as an aggregation of earnings for shorter time intervals (e.g., quarterly, monthly, daily). Prices can be used to extract

2This can be stated more formally as follows:

$$E(X_{t+k} | X_t, X_{t-1}, \ldots) \neq E(X_{t+k} | P_t, X_t, P_{t-1}, X_{t-1}, \ldots).$$

Alternatively, from the viewpoint of the ($P_t, X_t, \ldots$) series, the conditional expected value of $X_{t+k}$ cannot be expressed completely or exactly in terms of ($X_t, \ldots$) only. Nelson (1975) and Pierce (1975) have explored general conditions under which an inequality would be expected.
information about the preaggregated earnings series that has been lost in temporal aggregation. (2) Events which affect future earnings may not be reflected in current earnings. Examples are events conveying information regarding future capital expenditures, an anticipated strike, the discovery of oil, or the awarding of charters for casinos in New Jersey. Prices reflect such information and can be used to provide information about future earnings. (3) More generally, prices can convey information when earnings are a compound process consisting of more than one stochastic variable.

A link will now be derived between changes in earnings ($\Delta X_t$) and changes in the expected values of future earnings [$\Delta E(X_{t+k})$]. This link is one of the two steps required to interpret observed contemporaneous relationships between earnings changes and price changes [e.g., as in Ball and Brown (1968)] and to infer expectations regarding future earnings. The second step is the link between expected future earnings and security prices. The case where earnings are a simple process will be examined first. A link will then be derived for the more general case where earnings are a compound process.

2.1. Earnings as a simple process

Initially, we will assume that the time series of annual earnings are perceived by market participants as a first-order moving average process in the first differences (IMA(1,1)) of the following form:

$$X_t = X_{t-1} + a_t - \theta a_{t-1},$$

(1)

where $\theta$ is the moving average coefficient, and

$$E(a_t) = 0, \quad \sigma^2(a_t) = \sigma^2, \quad \forall t,$$

and

$$\sigma(a_t, a_s) = 0, \quad \forall t, s, \quad t \neq s.$$

There are several reasons for using this family of stochastic processes. First, well known stochastic processes are members of this family. If $\theta = 0$, the stochastic process becomes a random walk. On the other hand, $\theta = 1$ yields a mean reverting process. Second, this class has been studied extensively by previous research [Ball and Watts (1972), Albrecht et al. (1977), and Watts and Leftwich (1977), among others]. Third, the change in expectations of future earnings [$\Delta E(X_{t+k})$] is independent of $k$ as of a given time $t$. This can be seen by taking conditional expectations of the IMA(1,1)
The change in expectations of future earnings can be written as a function of the change in earnings. Hence, the unobservable change in expectations \([\Delta E(X_{t+k})]\) is expressed in terms of the observable change in earnings \((\Delta X_t)\).

\[
\Delta E(X_{t+k}) = (1 - \theta)\Delta X_t + (1 - \theta)\theta a_{t-1}.
\]

The change in expectations of future earnings can be written as a function of the change in earnings. Hence, the unobservable change in expectations \([\Delta E(X_{t+k})]\) is expressed in terms of the observable change in earnings \((\Delta X_t)\).

2.2. Earnings as a compound process

We now introduce a broader class of stochastic processes. If earnings were a simple process as described in expression (1), prices would not convey any information not already contained in the past earnings series (assuming \(\theta\) and \(a_t\) are 'known'). Another model of the earnings process is to view earnings \((X_t)\) as a mixture of two processes, \(x_t\) and \(\varepsilon_t\). The first process, \(x_t\), is the earnings series that reflects events that also affect prices. It is assumed to be an \(IMA(1, 1)\) process. We will be more precise about this relationship of \(x_t\) to prices in section 3. The second process, \(\varepsilon_t\), represents the impact on earnings of adjustments or events that have no effect on security prices. Hence, \(\varepsilon_t\) is independent of \(P_t\) or \(\Delta P_t\). One example of such events is a change in the mandatory treatment of deferred taxes [Cassidy (1976)]. A year-end adjustment is another possible example. Observed earnings \((X_t)\) can be viewed as a 'garbling' of \(x_t\) because of the existence of \(\varepsilon_t\). More formally,

\[
X_t = x_t + \varepsilon_t,
\]
where
\[
\Delta x_t = a_t - \theta a_{t-1},
\]
\[
\Delta X_t = a_t - \theta a_{t-1} + \epsilon_t - \epsilon_{t-1},
\]
\[
\sigma(a_t, \epsilon_s) = 0, \quad \forall t, s,^3
\]
a_t being 'white noise', and
\[
E(x_{t+k} | x_t, \ldots) = x_t - \theta a_t
\]
\[
= X_t - \theta a_t - \epsilon_t.
\]

Analogous to (2a) and (3a)
\[
\Delta E(x_{t+k}) = (1 - \theta)a_t, \quad \forall k > 0,
\]
\[
\Delta E(x_{t+k}) = (1 - \theta)\Delta x_t + (1 - \theta)\theta a_{t-1}
\]
\[
= (1 - \theta)\Delta X_t + (1 - \theta)\theta a_{t-1} - (1 - \theta)\Delta \epsilon_t.
\]

The introduction of a compound process provides an opportunity for prices to convey information regarding future earnings. Prices (P_t) provide information regarding x_t, that cannot be extracted from X_t because of the garbling. In other words,
\[
E(X_{t+k} | x_t, \epsilon_t, \ldots) \neq E(X_{t+k} | X_t, X_{t-1}, \ldots).
\]

Because P_t conveys information about x_t and indirectly about \epsilon_t,
\[
E(X_{t+k} | P_t, X_t, \ldots) \neq E(X_{t+k} | X_t, X_{t-1}, \ldots).
\]
Hereafter, x_t will be called ungarbled earnings.

The introduction of the compound process may seem to be an unnecessary complication. However, the characterization of earnings as a compound process is critical to understanding the rationale for grouping the data in our empirical investigation and is also critical to reconciling our findings with those of previous research based solely on past realizations of earnings.

^3The assumption of zero covariance may initially appear to be restrictive. If managements 'smooth' earnings, some non-zero correlation might be posited (e.g., a negative covariance between a_t and \epsilon_t). However, expression (4) can be viewed as an artificial partitioning of X_t into two orthogonal components. Hence, the zero covariance condition holds by construction and in this sense is analogous to the systematic versus unsystematic return decomposition as set forth by Beja (1972) and Fama (1973). Obviously, such a construction may influence the value of \theta.
3. The relationship between security price changes and earnings changes

We now turn to an explicit assumption regarding the relationship between price changes and earnings changes. This link is the second of the two steps required to interpret contemporaneous relationships between earnings changes and price changes and to infer expectations regarding future earnings.

We introduce the following valuation assumption for each security:

\[ P_t = \rho E(x_{t+k} | Z_t, x_t, Z_{t-1}, x_{t-1}, \ldots) \]

(5)

where all other factors that might influence price are implicitly imbedded in \( \rho \). Such factors might include the interest rate, risk, dividend payout, earnings growth, and accounting method used to derive earnings. In general, \( \rho \) would be expected to differ across securities. Although this valuation assumption seems rather simplistic, it can be viewed as having arisen from a more primitive setting \([\text{Harrison and Kreps (1978), Ohlson (1979), Garman and Ohlson (1978)}]\). However, our study is silent on the primitive attributes and the valuation process that give rise to a security price. As a result, \( \rho \) is not necessarily the reciprocal of the expected return on the security nor does it necessarily bear any simple relationship to expected return. Obviously, interpretation of the empirical results is conditioned upon the choice of a valuation assumption. Some evidence on the sensitivity of the inferences drawn here to the valuation assumption will be presented in section 4.

By further assuming that \( \rho \) does not vary over time, the percentage changes in price will equal percentage changes in expected ungarbled earnings,

\[ \frac{\Delta P_t}{P_{t-1}} = \frac{\Delta E(x_{t+k})}{E(x_{t+k} | x_{t-1}, \ldots)} \]

(6)

Note that \( \rho \) may vary across securities. However, in the percentage change formulation of expression (6), \( \rho \) cancels out. Hence, \( \rho \) need not be constant across securities. At the analytical level, we have assumed that percentage price changes are only a function of percentage changes in expected ungarbled earnings. We expect, however, that percentage price changes are a function of other factors as well. At the empirical level, it will be assumed that, if such price effects exist, they are uncorrelated with earnings changes (i.e., they constitute uncorrelated omitted variables).

Given the assumption that market participants perceive earnings to be a compound process as described in expression (4), the following relationship
can be derived:

$$\frac{\Delta P_t}{P_{t-1}} = \frac{\Delta E(x_{t+k})}{E(x_{t+k}|x_{t-1}, \ldots)}$$

$$- (1 - \theta) \Delta X_t + (1 - \theta) \theta a_{t-1} - (1 - \theta) \Delta \epsilon_t$$

$$X_{t-1} - \theta a_{t-1} - \epsilon_{t-1}$$

Prices are assumed to act as if $\theta, (a_t, a_{t-1}, \ldots)$, and $(\epsilon_t, \epsilon_{t-1}, \ldots)$ are 'known' to market participants. While such information is known to market participants, the researcher is able to observe $(X_t, X_{t-1}, \ldots)$ but not $(a_t, a_{t-1}, \ldots), (\epsilon_t, \epsilon_{t-1}, \ldots)$. Hence $(x_t, x_{t-1}, \ldots)$ are treated as unobservable to the researcher. The observable $X_t$ can be viewed as measuring $x_t$ with 'error' because of the garbling of $\epsilon_t$. Moreover, $x_t$ can be viewed as measuring $E(x_{t+k})$ with error because of the influence of $a_t$. $E(x_{t+k})$ can be thought of as 'permanent earnings' and $\theta a_t + \epsilon_t$ as the 'transitory component' of $X_t$.\(^4\) The transitory component reflects the difference between $X_t$ and $E(x_{t+k})$ and in this sense is the extent to which observed earnings measures permanent earnings with error.

Moving from the middle equation in (7a), expressed in terms of unobservable permanent earnings, to the right-hand equation, expressed in terms of observable $X_t$, involves the introduction of $a_{t-1}, \epsilon_t$, and $\epsilon_{t-1}$. There are situations where expression (7a) simplifies to observable variables. If earnings are a simple random walk process [i.e., governed by expression (1) with $\theta = 0$], expression (7a) becomes

$$\frac{\Delta P_t}{P_{t-1}} = \frac{\Delta X_t}{X_{t-1}}.$$  \hspace{1cm} (7b)

The random walk case is potentially relevant because the previous research supports the apparent robustness of this model. A second simplifying case occurs when $a_{t-1}, \epsilon_t$, and $\epsilon_{t-1}$ equal zero. Expression (7a) becomes

$$\frac{\Delta P_t}{P_{t-1}} = (1 - \theta) \frac{\Delta X_t}{X_{t-1}}.$$  \hspace{1cm} (7c)

\(^4\) $X_t = x_t + \epsilon_t$ but $E(x_{t+k}) = x_t - \theta a_t, X_t = E(x_{t+k}) + \theta a_t + \epsilon_t, X_t - E(x_{t+k}) = \theta a_t + \epsilon_t.$
Percentage changes in price would be directly proportional to percentage changes in earnings, where $(1 - \theta)$ is the proportionality factor. Obviously, $a_{t-1}$, $\epsilon_t$, and $\tilde{e}_{t-1}$ will not in general be zero, and percentage changes in observed earnings ($X_t$) will measure with error the percentage change in permanent earnings. However, in section 4 we introduce a method of grouping the data that is designed to approximate the $a_{t-1} = \epsilon_t = \tilde{e}_{t-1} = 0$ condition. Loosely stated, the grouping technique permits us to diversify out of the transitory elements in earnings to obtain a condition where percentage changes in earnings for the grouped data will be approximately proportional to the percentage changes in permanent earnings.

4. Preliminary empirical results regarding the relationship between price changes and earnings changes

In the previous section, we combined the link between past and future earnings with the link between prices and future earnings to provide an interpretation of the contemporaneous relationship between price changes and earnings changes. The model permits us to infer the perceived stochastic process from the observed contemporaneous relationships. In this section, we apply our model empirically.

For a sample of Compustat-CRSP firms with a December 31 fiscal-year end, a cross-sectional regression in each of the years from 1958 through 1976 was conducted of the following form:

$$G_{it} = x_i + \gamma_t g_{it} + u_{it},$$

where $t$ is 1958, ..., 1976 inclusive; $G_{it}$ is the percentage change in price (adjusted for stock splits and stock dividends) for security $i$ in year $t$ (computed from December 31 to December 31), i.e., $(P_{it} - P_{it-1})/P_{it-1}$; and $g_{it}$ is the percentage change in earnings per share (adjusted for stock splits and stock dividends) before non-recurring items for security $i$ in year $t$, i.e., $(X_{it} - X_{it-1})/X_{it-1}$.

The number of firms in each year is reported in Table 1. With respect to $G_{it}$, a December 31 to December 31 rule was chosen to ensure that prices were not reflecting any nonearnings information released after year-end.

5There was an earlier paper by Ball and Brown (1971) which examined the relationship between price changes and earnings changes. However, that paper differs from ours in several respects. (1) They considered only an MA(0) and a random walk process while the class of processes for which we derive results is broader. (2) They examined only individual security data, while we will explore grouping the data by percentage change in price. (3) Our paper will introduce the use of price data to forecast future earnings.

6The simple process described in expression (1) of section 2.1 can be thought of as a special case of the process described in (4), where there is no garbling.
Unfortunately, it also means that fourth quarter earnings may not have been publicly announced. This will tend to bias the regression coefficient toward zero.

4.1. Predictions of the regression coefficients

As indicated earlier, previous research suggests that earnings behavior is well approximated by a random walk. If earnings are a simple process characterized by expression (1) with \( \theta = 0 \) (i.e., the random walk case), the regression coefficient \( \hat{\beta} \) is expected to be one. However, if earnings are governed by a compound process, then \( g_u \) contains measurement error. It is extremely difficult to derive the distributional properties of the error in \( g_u \), because error components appear in both the numerator and denominator of \( g_u \) as seen in expression (7a). Moreover, no assumption has been made regarding the \( \epsilon_i \) process.

The results at the individual security level provide a benchmark against which to compare the effects of grouping the data. In conducting the cross-sectional regression, the regression coefficient is treated as a constant across securities. This assumption of intersecurity homogeneity is analogous to that made in previous research [Ball and Watts (1972) and subsequent studies] which apply the same earnings process to all securities. Given the apparent robustness of the random walk model in the Albrecht et al. (1977) and Watts and Leftwich (1977) studies, such an assumption appears to be a reasonable one, if earnings were a simple process. Later we shall provide a rationale for intersecurity homogeneity based upon temporal aggregation. In any event, this assumption is a logical first step in this initial study and can serve as a benchmark for subsequent research using alternative assumptions.

4.2. Results at the individual security level

The results of the 19 years (1958–1976) are reported in table 1. The average regression coefficient is 0.12 with each year’s coefficient between zero and one.\(^7\) This result is inconsistent with the joint assumption of expression (5) and a simple random walk process [expression (1) with \( \theta = 0 \)]. Under these conditions, the expected slope coefficient would be one. Assuming that each year’s data provide an independent drawing, the probability of observing these results if the population regression coefficient were in fact one (and the probability of \( \hat{\beta} < 1 \) is 0.5) is \((0.5)^{19}\) or approximately \(2 \times 10^{-6}\). Hence,

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\(^7\)In order to determine the sensitivity of the results to ‘aberrant’ observations, regressions were also run with negative \( X_{it} \), and with \(|g_u| > 300 \) percent deleted. The mean slope coefficient increased to 0.37. Yet the slope was above zero but below one in each year.
Table 1

Slope coefficient ($\hat{\gamma}_t$) from cross-sectional regression of percentage change in security prices on percentage change in earnings ($G_{it} = \alpha_{it} + \gamma_{it} g_{it} + u_{it}$).

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample size</th>
<th>Ind. sec.</th>
<th>100 ports.</th>
<th>50 ports.</th>
<th>25 ports.</th>
<th>10 ports.</th>
<th>5 ports.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1958</td>
<td>363</td>
<td>0.20</td>
<td>0.87</td>
<td>1.73</td>
<td>2.33</td>
<td>2.87</td>
<td>2.65</td>
</tr>
<tr>
<td>1959</td>
<td>373</td>
<td>0.13</td>
<td>0.58</td>
<td>1.49</td>
<td>1.74</td>
<td>1.79</td>
<td>1.95</td>
</tr>
<tr>
<td>1960</td>
<td>379</td>
<td>0.06</td>
<td>0.78</td>
<td>1.19</td>
<td>1.23</td>
<td>1.34</td>
<td>1.53</td>
</tr>
<tr>
<td>1961</td>
<td>482</td>
<td>0.09</td>
<td>0.14</td>
<td>1.75</td>
<td>1.92</td>
<td>2.32</td>
<td>2.23</td>
</tr>
<tr>
<td>1962</td>
<td>504</td>
<td>0.04</td>
<td>0.34</td>
<td>0.77</td>
<td>1.07</td>
<td>1.22</td>
<td>1.28</td>
</tr>
<tr>
<td>1963</td>
<td>537</td>
<td>0.06</td>
<td>1.14</td>
<td>1.40</td>
<td>1.62</td>
<td>1.97</td>
<td>1.93</td>
</tr>
<tr>
<td>1964</td>
<td>563</td>
<td>0.07</td>
<td>1.07</td>
<td>1.37</td>
<td>1.58</td>
<td>1.61</td>
<td>1.48</td>
</tr>
<tr>
<td>1965</td>
<td>590</td>
<td>0.19</td>
<td>1.86</td>
<td>2.16</td>
<td>2.33</td>
<td>2.41</td>
<td>2.29</td>
</tr>
<tr>
<td>1966</td>
<td>611</td>
<td>0.07</td>
<td>1.05</td>
<td>1.60</td>
<td>1.73</td>
<td>2.07</td>
<td>2.10</td>
</tr>
<tr>
<td>1967</td>
<td>642</td>
<td>0.64</td>
<td>3.33</td>
<td>4.06</td>
<td>3.52</td>
<td>3.79</td>
<td>4.00</td>
</tr>
<tr>
<td>1968</td>
<td>650</td>
<td>0.16</td>
<td>2.23</td>
<td>2.29</td>
<td>2.65</td>
<td>2.78</td>
<td>2.91</td>
</tr>
<tr>
<td>1969</td>
<td>676</td>
<td>0.03</td>
<td>0.98</td>
<td>1.28</td>
<td>1.56</td>
<td>1.71</td>
<td>1.92</td>
</tr>
<tr>
<td>1970</td>
<td>709</td>
<td>0.05</td>
<td>0.39</td>
<td>1.08</td>
<td>1.17</td>
<td>1.15</td>
<td>1.41</td>
</tr>
<tr>
<td>1971</td>
<td>722</td>
<td>0.05</td>
<td>1.03</td>
<td>1.43</td>
<td>1.55</td>
<td>1.63</td>
<td>1.79</td>
</tr>
<tr>
<td>1972</td>
<td>732</td>
<td>0.03</td>
<td>1.19</td>
<td>1.88</td>
<td>2.60</td>
<td>2.90</td>
<td>2.88</td>
</tr>
<tr>
<td>1973</td>
<td>748</td>
<td>0.06</td>
<td>0.89</td>
<td>1.55</td>
<td>1.66</td>
<td>2.17</td>
<td>2.08</td>
</tr>
<tr>
<td>1974</td>
<td>748</td>
<td>0.08</td>
<td>0.55</td>
<td>0.76</td>
<td>0.76</td>
<td>0.97</td>
<td>1.04</td>
</tr>
<tr>
<td>1975</td>
<td>748</td>
<td>0.10</td>
<td>1.42</td>
<td>1.94</td>
<td>1.98</td>
<td>2.05</td>
<td>2.02</td>
</tr>
<tr>
<td>1976</td>
<td>748</td>
<td>0.09</td>
<td>0.95</td>
<td>1.11</td>
<td>1.17</td>
<td>1.61</td>
<td>1.42</td>
</tr>
</tbody>
</table>

Mean $\hat{\gamma}_t$: 0.12 1.10 1.62 1.80 2.02 2.05
Mean $R^2$: 0.07 0.55 0.72 0.82 0.90 0.95

Mean $\hat{\gamma}_t$ with grouping by $g_{it}$: 0.12 0.10 0.10 0.16 0.32 0.48

* $G_{it}$ is the percentage change in price for security $i$ in year $t$; $g_{it}$ is the percentage change in earnings per share for security $i$ in year $t$.

* In each case, the data were grouped according to $G_{it}$ before computing the regression coefficients.

* The coefficients are significantly different from one at the 0.000002 level.

there is an extremely small probability that $\gamma - 1$.\(^8\) Taken at face value, these results may appear paradoxical when compared with the time series of earnings research.

The analysis suggests that earnings are perceived to be a more complex process than has been previously modelled. In particular, earnings are not

\(^8\) Being concerned about potential cross-sectional dependence among the residuals in a given year, we do not assume each security within a given year is an independent observation. However, previous research has indicated that both $G_{it}$ and $g_{it}$ are approximately serially uncorrelated. A time series test is adopted in this study, which assumes observations in different years constitute independent drawings. For further discussion, see Beaver, Clarke and Wright (1979).
perceived to be well approximated as a random walk, when viewed from the perspective of other information reflected in prices. This apparent disparity between the two types of evidence can be resolved by viewing earnings as a compound process as described in expression (4). The results imply that $E(X_{t+k} | X_t, \ldots) \neq E(X_{t+k} | X_t, P_t, \ldots)$, and the inequality of expected values would be expected if earnings were a compound process.

4.3. Grouping by percentage change in price

It is difficult to interpret the slope coefficients, because of the error in $g_{it}$. Grouping is one approach that has been used to reduce the errors-in-variables problem [see Black, Jensen and Scholes (1972), Fama and Macbeth (1973), and Beaver and Manegold (1975), among others]. Previous studies, such as Ball and Brown (1968) and Beaver, Clarke and Wright (1979), have grouped data by the earnings variable. Grouping by the earnings variable may have several undesirable properties. Instead, we group observations by the percentage change in price ($G_{it}$).

The errors-in-variables problem is reduced if the grouping procedure is uncorrelated with the error and is highly correlated with the 'underlying' variable. In this case, the 'underlying' variable is the change in expected ungarbled earnings [i.e., $AE(x_{t+k})$], and the error is a function of $a_{t-1}$, $e_t$, and $e_{t-1}$. Grouping by $g_{it}$ (the percentage change in earnings) will violate condition (1) and may not meet condition (2) as well as grouping on $G_{it}$. By contrast, $G_{it}$ will be uncorrelated with $a_{t-1}$, $e_t$, and $e_{t-1}$. Moreover, $G_{it}$ is expected to be highly correlated with changes in permanent accounting earnings [$AE(x_{t+k})$]. If changes in expected earnings were the only factor inducing price changes, the correlation would be perfect.

We assume that the portfolio grouping by $G_{it}$ will produce the following properties:

$$E(a_{pt-1} | g_{pt}) = E(e_{pt} | g_{pt}) = E(e_{pt-1} | g_{pt}) = 0,$$

and

$$\sigma^2(a_{pt-1}), \sigma^2(e_{pt}) \text{ and } \sigma^2(e_{pt-1}) \text{ become smaller as the number of securities in each portfolio increase.}$$

This implies that

$$(1 - \theta) \Delta x_{pt} \approx \Delta E(x_{pt+k}) = (1 - \theta) a_{pt},$$
similarly,

\[ X_{pt-1} \simeq E(x_{pt+k} \mid x_{pt-1}, \ldots) \]

\[ G_{pt} = \frac{\Delta E(x_{pt+k})}{E(x_{pt+k})} \simeq (1 - \theta) \frac{\Delta X_{pt}}{X_{pt-1}} = (1 - \theta) g_{pt}, \]

where the \( p \) subscript refers to group \( p \), and a variable subscripted by \( p \) represents the average of that variable for the securities in that group. If the above assumptions are met, OLS procedures will produce consistent estimates of the slope coefficient \((1 - \theta)\).

In order to obtain regression coefficients on grouped data for each year, 1958 through 1976, the securities were first ranked according to \( G_{it} \). The data were then grouped into portfolios based on \( G_{it} \). For example, starting in 1958, 100 portfolios were formed. The one percent of the securities with the highest \( G_{it} \) were placed in the first portfolio, the next highest one percent in the second portfolio, and so forth until the one-hundredth portfolio contains those one percent of the securities with the lowest \( G_{it} \) in 1958. The median \( G_{it} \) and \( g_{it} \) were selected as the portfolio price change \( G_{pt} \) and portfolio growth \( g_{pt} \), respectively. Medians were used on the growth data because \( |g_{it}| \) becomes very large as \( X_{it-1} \) approaches zero. The use of means would make \( g_{pt} \) particularly sensitive to such \( g_{it} \). This procedure resulted in 100 observations for 1958, on which a cross-sectional regression was run. This process was repeated for each of the following years, 1959–1976. In each year \( t \) the data were grouped according to \( G_{it} \) (i.e., they were regrouped each year). Since \( G_{it} \) is essentially uncorrelated over time, this represents a fresh regrouping each year. This process was then repeated for grouping into 50, 25, 10, and 5 portfolios.

Table 1 reports the results of cross-sectional regressions for the years, 1958–1976. The average slope coefficient increases as the data are grouped into fewer portfolios. At the level of 5 portfolios, the average coefficient is 2.05. At the individual security level, the presence of \( a_{t-1}, t, \) and \( v_{t-1} \) in \( AX_{it} \)

9Forming portfolios based on \( G_{it} \) (the dependent variable) may introduce econometric problems, if there are correlated omitted variables. This approach may induce a higher correlation between \( g_{pt} \) and the omitted variables, and the slope coefficient will reflect the effects of the correlated omitted variables.

10Although not reported here \( g_{pt} \) was also calculated as \( \sum_{i=1}^{n} AX_{it} \) divided by \( \sum_{i=1}^{n} X_{it-1} \), with essentially the same results as those reported here based on medians.

11We also grouped the data into portfolios based on \( g_{it} \). The prediction is that the procedure will not be as effective in eliminating the errors-in-variables bias, because the aggregation procedure is correlated with the error. As a result, we would expect the coefficients to increase (because the procedure is probably partially effective). However, the coefficients would be expected to be less than those obtained by security return ranking, because it is not as effective a ranking procedure. The last row in table 1 reports the results, which confirms the predictions.
leads to a slope coefficient which is closer to zero and is an average of the security price responsiveness to $\Delta E(x_{t+k})$ and the responsiveness to $a_{t-1}$, $\varepsilon_t$ and $\varepsilon_{t-1}$ (assumed to be zero). As the data are grouped into portfolios according to $G_{t_i}$, the influence of $a_{t-1}$, $\varepsilon_t$, and $\varepsilon_{t-1}$ on $\Delta X_t$ is diversified away and $\Delta X_{pi} \approx \Delta x_{pi} \approx a_{pi}$. The regression coefficient becomes a consistent estimate of $(1 - \theta)$.

The empirical results imply that $\gamma = (1 - \theta) = 2$ and hence $\theta = -1$.

The interpretation would be that events that caused $x_t$ to be $a_t$ above $E(x_t)$ in period $t$ are expected to induce an additional impact of $a_t$ on $E(x_{t+k})$, because

$$\Delta E(x_{t+k}) = (1 - \theta)a_t = 2a_t \Rightarrow E(x_{t+k} | x_t, \ldots) = x_t + a_t$$

for $\theta = -1$.

The earnings reflect the cumulative effects of $a_t$ with a lagged response. One-half of the cumulative impact of $a_t$ on the level of the $x$ series occurs in year $t$ and the remaining one-half occurs in year $t+1$ (i.e., with a lagged response). There are a number of explanations that would be consistent with a lagged response. A general discussion of these appeared in section 2. One explanation is simply temporal aggregation of earnings, whose implications are explored in the next section.

The first-order serial correlation of $\Delta x_t$ is $-\theta/(1 + \theta^2)$ or 0.5 for $\theta = -1$. In order for $\Delta X_t$ to exhibit near-zero (actually slightly negative) serial correlation as observed in previous empirical studies, $\Delta \varepsilon_t$ would have to exhibit negative first-order serial correlation. Thus $X_t$ would appear to approximate a random walk because it is a mixture of two processes, each of which induces first-order serial correlation in $\Delta X_t$ of the opposite sign. For example, suppose $\varepsilon_t$ were an IMA(1,1) process with a $\theta > 0$ where $\varepsilon_t - \varepsilon_{t-1} = \varepsilon_t - \theta \varepsilon_{t-1}$ and $\varepsilon_t$ is ‘white noise’.

The results of the cross-sectional

\[\begin{align*}
\theta a_t + \varepsilon_t &= \text{transitory component of } X_t, \\
\Delta X_t &= \Delta x_t + \Delta \varepsilon_t, \\
&= \Delta E(x_{t+k}) + (a_t - a_{t-1}) + \Delta \varepsilon_t, \\
&= \Delta E(x_{t+k}) + \theta \Delta a_t + \Delta \varepsilon_t.
\end{align*}\]
regression are perfectly consistent with the previous evidence from the time series of earnings studies. The reconciliation is accomplished by recognizing that earnings are not a simple process, as they have been treated in the previous studies. Rather earnings are a compound process implying dramatically different behavior than that implied by a random walk. Prices were used to extract information about this compound process.

The interpretation of the results depends on the valuation assumption described in (5). In an attempt to provide some evidence on the robustness of the findings, two other security price variables were used as dependent variables. The first was the security's return [i.e., $R_{it} = \frac{P_{it} + D_{it} - P_{it-1}}{P_{it-1}}$] and differs from the previous dependent variable by the inclusion of the dividend yield ($D_{it}/P_{it-1}$). The second is unsystematic (or residual) return ($U_{it}$), which is defined as $R_{it} - a_i - b_i R_{mt}$. The coefficients, $a_i$ and $b_i$, are obtained from a time series regression of $R_{it}$ on $R_{mt}$ (the return on a market portfolio) for sixty months prior to the year in which the residual is computed. The residuals are estimated on a monthly basis and summed to obtain an annual number.

Table 2 provides a comparison of the mean estimate of the slope coefficient ($\gamma_i$) under each specification. In all three cases, the coefficients increase as portfolio aggregation increases, and the mean slope coefficient at the five portfolio level is approximately 2. The coefficients appear to be essentially invariant to the choice of the dependent variable. The $G_{it}$ and $R_{it}$ formulations produce similar results probably because cross-sectional differences in dividend yields constitute a minor portion of the cross-sectional variation in $R_{it}$. Hence, in this context, $G_{it}$ and $R_{it}$ are virtually the same variable.

The use of $U_{it}$ extracts variation from $R_{it}$ due to factors reflected in $R_{mt}$. To the extent that it extracts the effects of uncorrelated omitted variables, the expected value of the coefficient estimated would remain unchanged, but more efficient estimates would be obtained. To the extent it extracts the effects of correlated omitted variables, the coefficient would change.

The similarity of the mean coefficients in $U_{it}$ specification with those in the $G_{it}$ and $R_{it}$ specifications is consistent with there being no correlated omitted variables influencing the magnitude of ($\gamma_i$). Obviously, the $U_{it}$ specification deals with correlated omitted variables only to the extent they would be

With $\theta < 0 \Rightarrow \theta \Delta B_t$, will exhibit positive serial correlation. However if $\Delta E_t$ exhibits corresponding negative serial correlation, the transitory component ($\theta \Delta a_t + \Delta e_t$) will exhibit zero serial correlation. For example, consider $e_t$ as an IMA(1,1) process with $\theta > 0$. It is reasonable to posit that $\Delta e_t$ would exhibit negative serial correlation. Consider $e_t$ 'white noise' which implies $\theta = 1$ or accounting adjustments that have offsetting effects in adjacent years (implying $\theta > 1$). Of course, the change in permanent earnings, $\Delta E_t(x_{t+1})$, will exhibit zero serial correlation because it is equal to $(1 - \theta)a_t$, and $a_t$ is serially uncorrelated.
Table 2

Mean intercept ($\hat{\beta}$) and slope coefficient ($\hat{\gamma}$) under alternative specifications of the dependent variable.

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Ind. sec.</th>
<th>Level of grouping by dependent variableb</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ports.</td>
</tr>
<tr>
<td>Panel A: $G_{it} = \alpha_i + \gamma_i \delta_{it} + u_{it}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage change in price $\hat{\beta}_i$</td>
<td>0.13</td>
<td>0.00</td>
</tr>
<tr>
<td>Percentage change in price $\hat{\gamma}_i$</td>
<td>0.12</td>
<td>1.10</td>
</tr>
<tr>
<td>Panel B: $R_{it} = \alpha_i + \gamma_i \delta_{it} + u_{it}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Returns $\hat{\beta}_i$</td>
<td>0.15</td>
<td>0.11</td>
</tr>
<tr>
<td>Returns $\hat{\gamma}_i$</td>
<td>0.08</td>
<td>0.53</td>
</tr>
<tr>
<td>Panel C: $U_{it} = \alpha_i + \gamma_i \delta_{it} + u_{it}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residual $\hat{\beta}_i$</td>
<td>0.00</td>
<td>-0.07</td>
</tr>
<tr>
<td>Residual $\hat{\gamma}_i$</td>
<td>0.14</td>
<td>0.39</td>
</tr>
</tbody>
</table>

$G_{it}$ is the percentage change in price in security $i$ in year $t$; $R_{it}$ is the security return (including dividends) of security $i$ in year $t$; $U_{it}$ is the unsystematic or residual return (including dividends) of security $i$ in year $t$, where $U_{it} = R_{it} - \alpha_i - b_i R_{mt}$ ($R_{mt}$ is the return on the market portfolio in year $t$, $a_i$ and $b_i$ are obtained from a time series regression of $R_i$ on $R_m$ for 60 months prior to year $t$); $g_{it}$ is the percentage change in earnings per share for security $i$ in year $t$.

*In each case, the data were grouped according to the dependent variable: $G_{it}$ for Panel A, $R_{it}$ for Panel B, and $U_{it}$ for Panel C. Note the individual security level involves no grouping.

**$\hat{\beta}_i$ was positive (negative) at the 5 portfolio level 7(12), 8(11), and 5(14) times, respectively, for the three specifications. $\hat{\gamma}_i$ was above (below) one 19(0), 19(0), and 18(1) times, respectively, at the 5 portfolio level.

reflected in the ($-a_i - b_i R_{mt}$) adjustment. For example, we would expect certain macro-induced alterations in $\rho$ (e.g., interest rate changes and risk premium changes) to be reflected in the adjustment and hence extracted from $U_{it}$.

4.4. Temporal aggregation of earnings

If earnings are a compound process as described in expression (4), the empirical results imply that $dx_i$ has positive serial correlation and $x$ has a lagged response to $a_i$. Both would occur if ungarbled annual earnings ($x_i$) were the result of a process derived from temporal aggregation of earnings for shorter time intervals. If the preaggregated series is IMA(1,1), Tiao (1972)
has shown that the aggregated series \( (x_t) \) will also beIMA(1, 1) and the \( \theta \) of the aggregated series will approach \(-0.268\), as the number of preaggregated elements per aggregated element \( (J) \) increases. At the individual security level, Lambert (1978) has shown that the slope coefficient would approach 0.75 as \( J \) increases, if there were no garbling \( (i.e., X_t = x_t) \). In the presence of \( \varepsilon_t \), the slope coefficient would be between 0.75 and zero. If the data are grouped according to \( G_{ij} \), the influence of \( \varepsilon_t \) will be diversified away and the slope coefficient will approach 2.0 as the diversification becomes more effective.\(^{14}\)

Needless to say, our results are consistent with the predictions of a temporal aggregation model.

Temporal aggregation has several implications: (1) The \( \theta \) of the ungarbled aggregated series \( (x_t) \) is only \(-0.268\) instead of \(-1\) as implied by the analysis in the previous section. The first-order serial correlation of \( (\Delta x_t) \) would be only 0.25, instead of 0.50. Hence, the relative importance of the garbling variable \( (\varepsilon_t) \) required to induce near-zero first-order correlation in \( (\Delta X_t) \) is not as large as implied by the analysis in the previous section. (2) Regardless of the \( J \) of the preaggregated earnings series, in the limit the \( \theta \) of the aggregated series \( (x_t) \) will be the same \( (i.e., -0.268) \). This provides one rationale for the interfir homogeneity of \( \theta \), which was assumed in the

\(^{14}\)This result can be explained via a simple illustration that deals with a single shock of preaggregated (quarterly) earnings. Let \( Y_t \) equal the earnings at some preaggregated level. Assume price \( P_t = \rho E(Y_{t+h}) = \rho Y_t \) \( (i.e., Y_t \ is \ a \ random \ walk \ process, \ \theta = 0) \). Suppose in year one, quarterly earnings per share is \$0.25 \ (implying an annual EPS of \$1.00). If \( \rho = 40 \), price would be \$10 per share \( (40 \cdot \$0.25 = \$10 \ per \ share) \). Suppose in year two, the quarterly series was \$0.25, \$0.25, \$0.275, \$0.275, induced by a single shock of \$0.025 in the third quarter. Because the process is a random walk, the shock has a 'permanent' effect on the level of earnings. The price per share at the end of year two would be \$11 \ (40 \cdot \$0.275) and the annual earnings per share would be \$1.05. Percentage changes in price \( [e.g., (\$11 - \$10)/\$10 \ or \ 10 \ percent \ in the \ third \ quarter] \) are equal to percentage changes in earnings \( [e.g., (\$0.275 - \$0.25)/\$0.25 \ or \ 10 \ percent \ in the third quarter] \) at the quarterly level. However, at the annual level, the annual percentage change in price \( [(\$11 \ - \$10)/\$10 \ or \ 10 \ percent \ for \ the \ year] \) is twice as large as the annual percentage in earnings \( [(\$1.05 \ - \$1.00)/\$1.00 \ or \ 5 \ percent] \).

Moreover, the expected price change for year three is zero \( [(\$11 - \$11)/\$11] \) but the expected earnings growth is almost 5 percent \( [(\$1.10 - \$1.05)/\$1.05] \) where \$1.10 is the expected annual earnings per share implied by \$0.275 earnings per share per quarter. Under such circumstances, the fitted regression coefficient of annual \( G_t \) on annual \( g_t \) would be two even though the coefficient would be one at the quarterly level. This occurs because annual earnings reflect an 'average' earnings level over the year while year-end price reflects the level of earnings at the end of the year. Hence, price changes reflect the change in \( Y \) from the beginning to the end of the year, while changes in annual EPS reflects the difference between the 'average' \( Y \) for year \( t \) versus \( t-1 \). Hence \( \Delta P \) and \( \Delta X \) are not synchronous when \( X \) contains a summation of the \( Y \)'s \( (i.e., when temporal aggregation occurs) \). While this special case of a random walk and a single shock provides a simple illustration of temporal aggregation, Lambert (1978) has shown that a slope coefficient of two would be expected for repeated random shocks on any IMA(1, 1) process subject to temporal aggregation, when the data are grouped according to \( G_{ij} \) before conducting the regression. Working (1960) examined the autocorrelation properties of averages of a random walk and is a special case of the Tiao analysis. We are indebted to the late Paul Cootner for suggesting that the stochastic process of annual earnings be viewed from the perspective of temporal aggregation.
regression analysis. Temporal aggregation disguises the character of the underlying series and all securities' earnings behave identically at the annual level. (3) Studies of quarterly earnings may be subject to as much aggregation as annual earnings. If the preaggregated series is in fact perceived as a weekly, daily, or (in the limit) continuous process, quarterly earnings are effectively as aggregated as annual earnings. Tiao shows that the asymptotic properties of temporal aggregation are well approximated when $J \geq 10$, where $J$ equals the number of preaggregated elements contained in a single aggregated element. For example, if the preaggregated earnings were perceived as a weekly process, $J = 13$ for quarterly earnings. (4) If $x_t$ are subject to temporal aggregation and $X_t$ is the result of a garbling of $x_t$ via $\varepsilon_t$, $E(X_{t+k})$ cannot be written as any simple function of past realizations of $X_t$, but instead is a function of the structure (i.e., the random shocks and $\theta$) of the preaggregated series and the structure of $\varepsilon_t$. In this case, other information ($Z_t$) may partly consist of quarterly earnings, quarterly dividends, and information on intra-quarterly earnings. In other words, the accounting system may be reporting these events in a timely fashion, but the temporal aggregation into annual earnings induces a lagged response relative to price changes.

In concluding this section, we hasten to restate that temporal aggregation is by no means the unique, albeit a simple, interpretation of our results. Any of the more general reasons for a lagged response, as discussed in section 2, are equally consistent. However, our primary concern is not with identifying a unique interpretation. Instead, our major conclusion is that future expected earnings, as perceived by market participants, differ dramatically from those implied by a simple extrapolation of past earnings.

4.5. Subsequent growth behavior

The compound process model described in expression (4) can be viewed as a decomposition of those events affecting earnings into two elements: those events related to stock price ($x_t$) and those events independent of prices ($\varepsilon_t$). This decomposition suggests that earnings reflect events of the first kind with a lag. If so, the percentage change in price in year $t$, $G_{it}$, is expected to be positively correlated with the percentage change in earnings in year $t + 1$, $g_{it} + 1$.

If ungarbled earnings (i.e., $x_t$) are subject to a lagged response as described earlier, then we would predict that the security price variable in year $t$ would not only be positively correlated with $(x_t - x_{t-1})/x_{t-1}$ but also would be positively correlated with $(x_{t+1} - x_t)/x_t$ in the subsequent year. To diversify out of the effects of $\varepsilon_t$, the data have been ranked and grouped into twenty-five portfolios according to each of the three security price variables. Table 3
<table>
<thead>
<tr>
<th>Year</th>
<th>Independent variable used</th>
<th>$G_{it}$</th>
<th>$R_{it}$</th>
<th>$U_{it}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1959</td>
<td></td>
<td>-0.01</td>
<td>0.06</td>
<td>0.09</td>
</tr>
<tr>
<td>1960</td>
<td></td>
<td>0.06</td>
<td>-0.22</td>
<td>0.05</td>
</tr>
<tr>
<td>1961</td>
<td></td>
<td>-0.02</td>
<td>0.05</td>
<td>0.03</td>
</tr>
<tr>
<td>1963</td>
<td></td>
<td>-0.11</td>
<td>-0.10</td>
<td>0.07</td>
</tr>
<tr>
<td>1964</td>
<td></td>
<td>-0.01</td>
<td>0.12</td>
<td>0.08</td>
</tr>
<tr>
<td>1965</td>
<td></td>
<td>0.14</td>
<td>0.16</td>
<td>0.06</td>
</tr>
<tr>
<td>1966</td>
<td></td>
<td>0.23</td>
<td>0.31</td>
<td>0.37</td>
</tr>
<tr>
<td>1967</td>
<td></td>
<td>0.16</td>
<td>0.23</td>
<td>0.25</td>
</tr>
<tr>
<td>1968</td>
<td></td>
<td>0.07</td>
<td>0.05</td>
<td>0.10</td>
</tr>
<tr>
<td>1969</td>
<td></td>
<td>0.10</td>
<td>0.01</td>
<td>-0.01</td>
</tr>
<tr>
<td>1970</td>
<td></td>
<td>0.28</td>
<td>0.26</td>
<td>0.13</td>
</tr>
<tr>
<td>1971</td>
<td></td>
<td>-0.26</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>1972</td>
<td></td>
<td>-0.03</td>
<td>0.01</td>
<td>0.14</td>
</tr>
<tr>
<td>1973</td>
<td></td>
<td>0.14</td>
<td>0.14</td>
<td>0.26</td>
</tr>
<tr>
<td>1974</td>
<td></td>
<td>0.54</td>
<td>0.47</td>
<td>0.47</td>
</tr>
<tr>
<td>1975</td>
<td></td>
<td>-0.02</td>
<td>-0.08</td>
<td>-0.04</td>
</tr>
<tr>
<td>1976</td>
<td></td>
<td>0.05</td>
<td>0.05</td>
<td>0.19</td>
</tr>
<tr>
<td>Mean $\tilde{\gamma}_{t+1}$</td>
<td></td>
<td>0.07</td>
<td>0.09</td>
<td>0.13</td>
</tr>
<tr>
<td>Mean $R^2$</td>
<td></td>
<td>0.26</td>
<td>0.27</td>
<td>0.24</td>
</tr>
</tbody>
</table>

The results refer to three separate regressions: $g_{it+1} = \gamma_{t+1} + \tilde{\gamma}_{t+1} G_{it} + u_{it}$, $g_{it+1} = \gamma_{t+1} + \tilde{\gamma}_{t+1} R_{it} + u_{it}$, and $g_{it+1} = \gamma_{t+1} + \tilde{\gamma}_{t+1} U_{it} + u_{it}$, respectively.

Note that this test constitutes an 'independent' confirmation of the lagged response of earnings, because $g_{it}$ and $g_{it+1}$ are essentially uncorrelated as shown by Ball and Watts (1972), among others. The regression coefficients ($\tilde{\gamma}_{t}$) reported in tables 1 and 2 may be biased if there are correlated omitted variables. Hence, our interpretation of $\gamma_{t+1} > 0$ as evidence of a lagged response.

Reports the slope coefficient ($\tilde{\gamma}_{t+1}$) of earnings growth in year $t+1$ on $G_{it}$, $R_{it}$, and $U_{it}$, respectively. The coefficient was positive in eleven, fifteen, and fifteen of the eighteen years studied. Under a simple non-parametric test where the null hypothesis is that $\tilde{\gamma}_{t+1}$ is zero and that probability of $\gamma_{t+1} > 0$ is 0.5, the level of significance is 0.24, 0.0038, and 0.0038, assuming independence over time.
was conditional upon assuming no such bias existed. However, there is no obvious reason why omitted variables correlated with \( g_{it} \) would also induce a positive correlation between \( g_{it+1} \) and \( G_{it} \), \( R_{it} \), or \( U_{it} \), respectively. Hence, we find it less likely that the inclusion of additional variables would alter this basic finding of a lagged response.

5. A reinterpretation of price-earnings ratios

The compound earnings process described in expression (4) provides reinterpretation of the price-earnings ratio and its positive correlation with subsequent earnings growth. \( X_t \) contains a transitory component, \( \theta d_t + \epsilon_t \), and hence \( X_t \neq E(x_{t+k}) \). Yet the price \( (P_t) \) is proportional to \( E(x_{t+k}) \) according to expression (5). From this perspective, a high price-earnings ratio \( (P_t/X_t) \) occurs when \( X_t > E(x_{t+k}) \) (i.e., when the \( X_t \) contains a negative transitory component). Similarly a low \( P_t/X_t \) ratio would be expected when \( X_t < E(x_{t+k}) \). A positive association would be expected between the price-earnings ratio and subsequent growth, and ‘mean reversion’ in the price-earnings ratio would also be expected. Both were observed in the Beaver and Morse (1978) study.

The positive correlation occurs because price-earnings in year \( t \) and growth in year \( t+1 \) contain the same common denominator \( (X_t) \). If a portion of \( X_t \) varies independently of \( P_t \) and \( X_{t+1} \), a positive correlation could be induced between the two ratios \( P_t/X_t \) and \( X_{t+1}/X_t \), even if \( P_t \) were independent of future earnings. Hence, the correlation may be evidence of the irrelevancy of at least a portion of earnings, rather than any ability of prices to forecast future earnings.

In this study, the predicting variable \( (G_{it}) \) is defined exclusively in terms of prices and there is no question of dependency arising because of a common use of earnings in the definitions of the variables. The results presented here establish a relationship between prices and future earnings growth. Of course, a contemporaneous relationship was apparent from Ball and Brown (1968) and Beaver, Clarke and Wright (1979). However, our results extend the relationship one step further by also uncovering a relationship between price changes in year \( t \) and earnings changes in year \( t+1 \).

Basu (1977, 1978) recently observed the reversion of price-earnings ratios toward an economy-wide mean, similar to that reported by Beaver and Morse (1978). However, his interpretation differs considerably from ours. He viewed this as evidence of the lagged behavior of prices and hence a form of market inefficiency. As a result, price-earnings ratios in year \( t \) were used to

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\(^{15}\) The mean reversion could also occur for other reasons. For example, year-end price may not fully reflect the information contained in fourth quarter earnings. However, this would imply that prices are a lagged function of earnings which potentially impairs the forecasting ability of prices.
6. Using prices to forecast earnings

Viewing earnings as a compound process not only implies an interpretation of price-earnings ratios but also provides a basis for forecasting earnings. This section will present the results of a preliminary excursion into the use of price-based forecasting models. We examine two forecasting models.

The first model, a simple price-based forecasting model, draws upon the analysis of section 5. In particular, $g_{t+1}$ is expected to be high for securities with high price earnings ratios and low for securities with low price-earnings ratios. As a result, a price-based forecasting model is examined, where

$$F(\tilde{X}_{t+1}) = F(g_{t+1} | P_t/X_t)X_t + X_t = [1 + F(g_{t+1} | P_t/X_t)]X_t,$$

$F(g_{t+1} | P_t/X_t)$ being the forecasted value of earnings growth in year $t + 1$, forecasted conditional upon the security's price earnings ratio in year $t$.

$F(g_{t+1} | P_t/X_t)$ is determined in the following manner. For each of the years 1957 through 1975, a security was assigned to one of ten portfolios based upon its price-earnings ratio in that year. Portfolio 1 in year $t$ contains those securities with the lowest price-earnings ratios (10 percent of the securities) in year $t$, while portfolio 10 contains those securities with the highest price-earnings ratios (also 10 percent of the securities) in year $t$. The median growth in earnings was computed for each portfolio for the subsequent year $(t + 1)$. This results in a $(19 \times 10)$ matrix of portfolio (median) growth ratios. From this matrix, the forecasted growth for portfolio $j$ $(j = 1, 10)$ for year $t + 1$, forecasted as of year $t$, is the median growth rate computed for portfolio $j$ during the years, 1958 through year $t$. $F(g_{t+1} | P_t/X_t)$ for security $i$, which appears in portfolio $j$ in year $t$, is the forecasted growth for portfolio $j$ for year $t + 1$, forecasted as of year $t$.

The second model, based solely on the earnings series, is a random walk with a drift, where the forecasted value of earnings per share for year $t + 1$, forecasted as of year $t$, is

$$F(X_{t+1}) = X_t + d_t,$$

d$_t$ being security-specific drift term, defined as $N^{-1} \sum_{j=1}^{N} (X_{t+1-j} - X_{t-j})$, where $N$ is the number of years of earnings data available, prior to year $t + 1$. forecasted of year $t$. 

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This model has been extensively used in previous research [e.g., from Ball and Brown (1968) onward] and has been shown to be robust against a broad class of alternatives [Albrecht, Lookabill and McKeown (1977) and Watts and Leftwich (1977)].

Years with $X_t < 0$ were eliminated. Also there had to be at least two years from which to compute $d_t$, the drift term. This resulted in 6840 earnings forecasts for the years, 1967 through 1976. The forecast error was defined as the percentage difference between actual and expected earnings (with actual earnings used in the denominator). The mean absolute percentage error and the mean square percentage error are reported in Table 4. Both are marginally lower for the price-based forecasting model. The number of times each model produced the lower error is reported for each portfolio and for the total sample. The price-based model produces the lower error 55% of the time (3/754/6840). Assuming independence of security-years, the implied $t$-

<table>
<thead>
<tr>
<th>Portfolio</th>
<th>Price-earnings modelb</th>
<th>Random walk with driftc</th>
<th>Mean absolute error</th>
<th>Mean square error</th>
<th>Mean absolute error</th>
<th>Mean square error</th>
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<tr>
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<td>Times lower error</td>
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<td>Mean</td>
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<td>3754</td>
<td>3086</td>
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</table>

*The forecast error is actual earnings per share less forecasted earnings per share divided by actual earnings per share.

$F(X_{t+1}) = F(g_{t+1} | P_t / X_t) X_t + X_t$, where $F(X_{t+1})$ is the forecasted earnings per share, $F(g_{t+1} | P_t / X_t)$ is the forecasted earnings growth conditional on the price-earnings ratio, and $X_t$ is earnings per share in year $t$.

$F(X_{t+1}) = X_t + d_t$, where $F(X_{t+1})$ is the forecasted earnings per share in year $t$, and $d_t$ is the security-specific drift term.

Portfolios 1 and 10 are the lowest and highest price-earning ratio portfolios, respectively.

*Computation of $t$-value: $(actual - expected)/0.5 \sqrt{N} = (3754 - 3420)/0.5 \sqrt{6840} = 334/41.35 = 8.08$. 
value is 8.08, using a normal approximation of the binomial probabilities, and assuming that, under the null hypothesis, probability of a lower error is 0.5. Given our earlier remarks, the assumption of independence of contemporaneous observations may be suspect. If positive dependence is assumed, the probability of a type I error is understated by this test statistic.

If the forecast errors are examined on a portfolio by portfolio basis, the superiority of the price-based forecasting model appears stronger in the extreme portfolios (portfolios 1 and 10) and in the high price earnings portfolios (portfolios 6 through 10). The behavior in the extreme portfolios is expected because the earnings of these two portfolios are most likely to have large transitory components of the same sign within a given portfolio. The intermediate portfolios would be expected to have earnings with smaller transitory components and of mixed signs within a given portfolio. The effectiveness of the price-based model may be impaired by cross-sectional differences in price-earnings ratio due to other factors (e.g., different depreciation methods). The model ignores such differences and implicitly assumes all firms have the same $\rho$. The superiority in the extreme and higher price-earnings ratio portfolios is consistent with the findings of recent research by Brooks and Buckmaster (1976, 1979). They find non-random walk behavior when earnings changes are extreme and when earnings changes are negative.

While this obviously constitutes an extremely preliminary analysis, it suggests that earnings forecasting models which incorporate price data may be able to outperform a random walk model that has exhibited a robustness against challengers, since its use in the Ball and Brown study. This section is not intended to be an in-depth exploration of price-based forecasting models of earnings. This is a separate topic in itself, which we plan to pursue in subsequent research. In particular, we intend to use price data to infer the $x_t$ process. Together with the $X_t$ series, estimates of $x_t$ may permit us to ‘extract’ the $e_t$ from $X_t$. With the derived assessments of $x_t$ and $e_t$ series, we may provide better forecasts of $X_t$ than those reported here. However, from a security-price perspective, the relevance of forecasting $X_t$ is unclear. $e_t$ represents that portion of $X_t$ that is ‘irrelevant’ to the price formation process. Focusing on the $x_t$ series may be more important for many research contexts than forecasts of $X_t$.

In a similar vein, consider analysts’ earnings forecasts. If they are attempting to forecast $x_{t+k}$, evaluating their ability to forecast $X_{t+1}$ is not obviously relevant. Analysts’ forecasts may provide a more accurate assessment of ‘permanent earnings’ $E(x_{t+k})$, notwithstanding their inability to predict $X_{t+1}$ more accurately than statistical models which extrapolate the past earnings series. However, from the perspective adopted here, the use of analysts’ forecasts may be circular. Analysts may be doing exactly what we have done, namely, extracting information about future earnings from
observed prices. The issue then is whether analysts provide information via their forecasts that is not already reflected in security prices.

7. Concluding remarks

We have examined the empirical relationship between price changes and earnings within the context of assumptions regarding valuation [expression (5)] and the perceived earnings process [expression (4)]. Our interpretation of the results are contingent upon those assumptions. With this caveat, we offer several tentative conclusions:

1. Most prominently, an analysis of security prices suggests that earnings are perceived to be a more complex process than has been previously modelled. Negatively stated, earnings are not perceived to be well approximated as a random walk, when viewed from the perspective of other information reflected in prices. In particular, earnings can be viewed as a mixture of two processes. The first process is linked to prices and appears to exhibit a lagged response to the information reflected in prices. A number of explanations were offered, including temporal aggregation. The second process, called a garbling, is independent of prices, and, together with the first process, induces near-zero correlation in earnings changes.

2. A grouping technique based on price changes diversified away the 'transitory' elements in earnings and permitted an isolation of changes in 'permanent' earnings. This has several potentially desirable attributes relative to previous groupings based on earnings changes.

3. An alternative interpretation of price-earnings ratios offered here differs considerably from that offered in fundamental analysis and by some recent research drawing inferences regarding market efficiency.

4. Some preliminary evidence raises the possibility of price-based forecasting models that are more accurate than extant models based on a random walk with a drift.

5. Earnings forecasts by analysts are perhaps being evaluated on an 'incorrect' criterion, the ability to forecast next year's earnings. An intriguing issue with respect to these forecasts is their potential circularity, which could arise if analysts are acting as if they use security price to extract information regarding future earnings.

6. For some contexts, a large portion of earnings may not be relevant. Hence, the ability to forecast earnings per se is not an obviously important issue at least from a security price perspective.

There are several avenues for future research: (1) The implications of temporal aggregation could be explored more fully via an analysis of quarterly, weekly, and daily data. (2) Forecasting models which incorporate price data could be examined in much greater depth than has been done
here. (3) The sensitivity of the results to the assumptions made is a natural extension. In particular, an obvious candidate is the introduction of a more elaborate valuation model, incorporating risk, growth and other factors.

With respect to quarterly earnings, the evidence indicates that earnings at the annual level could not literally follow a random walk [Watts and Leftwich (1977)]. An obvious extension would be to compare forecasts of annual earnings based on quarterly information with those provided by price data. The results reported here may be entirely due to temporal aggregation of quarterly earnings data. However, as indicated earlier, quarterly earnings may also be subject to temporal aggregation and the analysis of quarterly earnings may provide little or no additional insight (e.g., with respect to forecasting future earnings). The efficacy of examining quarterly data is still an open issue to be addressed by future research.

In the interim, these results provide a tentative first attempt to link prices and earnings and hopefully serve as a benchmark against which alternative specifications may be judged. These efforts represent a modest attempt to address an ambitious question — the relationship between prices and earnings. They also represent a preliminary attempt to use security prices to extract information regarding expectations of market participants.

References
Beaver, W., R. Clarke and W. Wright, 1979, The association between unsystematic security returns and the magnitude of earnings forecast errors, Journal of Accounting Research, Autumn.