Stock Price, Earnings and Dividends: A Time Series Analysis

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Abstract

This study analyzes the empirical implications of the present value model for stock prices, dividends and earnings using cointegration and structural VAR techniques. Consistent with the theoretical model, we find that stock price, earnings and dividends share a single common trend. However, we also find that the cointegration vectors are not stable and contrary to the dividend smoothing hypothesis, earnings, not dividends, is the common trend component of the system.
1 Introduction

The valuations of equities in the U.S. have reached such high levels over the last decade that a question arises as to whether these stocks are overvalued or are they just fairly valued. In this paper we attempt to address this issue using a common theoretical framework and some recent innovations in time series analysis. Our theoretical setup is based upon the present value model. Using this common approach our paper is more easily compared to existing work in this area and extensions can be readily derived. The basic implications of the model are that stock prices should be driven by (expected) dividends. This has important implications for the time series behavior of stock prices and dividends, see Crowder and Wohar (1998). We extend this model to include earnings and we demonstrate that earnings should also share the common time series properties of stock prices and dividends.

Using the implied theoretical relationships we estimate an empirical model and test the present value restrictions. While the empirical results are not completely supportive of the theoretical model, the basic implications are consistent with our estimated model.

The finance literature has conducted a large number of studies attempting to resolve the debate about whether or not stock prices have a strong predictable component. If true, this would yield evidence against the efficient market hypothesis. Early studies by Fama (1970) and others, found stock prices to behave according to a random walk process, supporting the efficient market hypothesis. Later studies by Kleidon (1986), Marsh and Merton (1986, 1987), Campbell and Shiller (1987, 1989b) found that stock price and dividend series follow a more general nonstationary process, which suggests that they may be affected by more than one type of disturbance. This finding justifies modeling stock price and dividend series as the sum of temporary and permanent components. It is notable that the two components of stock prices and dividends may not behave independently of one another, but instead, the two components in stock prices may be related to the two components in dividends. For example, stock price valuation models are one way in which stock prices are linked to dividends. Specifically, stock prices are equal to the present discounted value of future dividends. In addition, Fama and French (1988b) and Campbell and Shiller (1988a, 1989b) found that the spread between stock price and dividend (dividend yield) provides information in predicting stock returns. There have been two approaches taken to investigate these issues. The first approach involves studies which
model the behavioral characteristics of stock prices with no consideration for any underlying macroeconomic variables. This group of studies provides empirical evidence that stock returns contain a strong predictable component at long-term investment horizons. This implies that there is mean reversion of stock prices towards a fundamental value as opposed to stock prices being a random walk. The second approach focuses on identifying fundamental variables (e.g., dividend yields, price-earning ratios, and other macroeconomic indicators) that help to explain fluctuations in stock prices or stock returns. This second group of studies attempts to identify variables that help to predict stock prices movements or stock returns. For example, Fama and French (1988b) propose dividends per share as being a significant factor in explaining stock returns. Campbell and Shiller (1988a) find that in addition to the dividend-price ratio, dividend growth and long-term earnings per share are also significant in explaining stock returns, particularly at longer terms investment horizons. An additional strand of literature investigates whether earnings or dividends have greater explanatory power in predicting stock returns. Kornandi and Lipe (1987), Campbell and Shiller (1988a) find that earnings have significant power in predicting stock returns. The current paper follows the second strand of literature and models stock prices as being dependent upon a stochastic earnings and dividend process. Once we establish that a long-run relationship exists between stock prices and dividends, our second objective is to model the implied dynamic behavior of the two series when subjected to innovations in both the permanent and transitory components. Previous short-run modeling of stock prices has exploited the Vector Autoregressive (VAR) methodology and, in particular, used the VAR to test the set of restrictions implied by the present value model. The approach to the modeling of stock prices taken in this paper is somewhat different to that adopted by other researchers. In particular, we are concerned with the dynamic adjustment of stock prices and dividends to their long-run equilibrium values. Drawing from previous literature which finds that stock prices and dividends are nonstationary processes, this paper employs a structural cointegrated trivariate VAR (TVAR), to decompose stock prices and dividends into permanent and transitory components based on a single cointegrating vector. The identification procedure employed is similar to that of Blanchard and Quah (1989). But unlike Blanchard and Quah (1989) the identification of the structural model from the reduced form estimates uses no additional restrictions beyond arbitrary normalization and structural error independence. Specifically, we do not impose any restrictions on the
representation of the bivariate VAR of stock price and dividend beyond those implied by the cointegration between these two variables. We also investigate the relative importance of each component in predicting future variations in stock prices by analyzing the one-step-ahead forecast error variance.

Since 1982, US stock prices have trended upwards (with some deviations around this trend). Following this upwards trend has been an increased interest in empirical research as to whether stock prices have deviated from their fundamental value. The conventional present value Gordon (1962) model predicts that a stock price is fundamentally determined by the discounted value of its expected future dividends, which in turn are derived from future earnings. When investors expect earnings growth to be high in the future, stock prices will increase. High stock prices forecast higher future dividends. In addition, the higher the price-earnings (P/E) ratio the more investors are paying for a share of stock and hence the more earnings growth they are expecting. In recent years, the P/E ratio for the S&P 500 stock index has been increasing above its historic average and the dividend-price ratio has fallen to historic lows. Recent concern has centered around whether the upward trend in stock prices is justified by fundamentals. If the increase in stock prices is not justified by these fundamental factors then there is a risk of a decline in stock prices in the future.

The extent to which stock price movements are due to market fundamentals versus non-fundamental factors has been an important inquiry of financial research. Since the early 1980s, studies have not found strong empirical support for the simple present value model, with a constant discount factor. These studies also find that stock returns are too volatile relative to market fundamentals. In particular, stock prices fluctuate more than stock price movements implied by the Gordon valuation rule, especially after 1950. Barsky and De Long (1993), and Carlson and Sargent (1998**heck source) report that stock prices fluctuate 50 percent more than the Gordon model implies. A number of reasons have been offered as to why the simple present value model may not completely explain stock price movements in the short-run. These include time-varying discount factors, ii) fads, iii) speculative bubbles, iv) inaccurate measurement of dividends, v) the omission of other important non-fundamental variables such as retained earnings, the change in the 20-year moving average of stock returns, etc. Two major factors contributing to the failure of the simple present value model that this paper will focus on are i) a time-varying discount factor and ii) a non-fundamental component not accounted for in the model. If stock prices deviate from mar-
ket fundamentals by a large amount, and this deviation is mean reverting, then the excess volatility of stock prices suggests that a substantial portion of stock price movements are the result of either i) a non-fundamental component (which plays a role in the mean reversion; see DeBondt and Thaler (1985) and Summers (1986)) or ii) a time-varying discount factor (which may contribute to the mean reversion (see Cochrane (1991, 1992)).

Early studies found stock prices to behave according to a random walk process, supporting the efficient market hypothesis, while later studies found that stock price and dividend series follow a more general nonstationary process, which suggests that they may be affected by more than one type of disturbance. Recent studies have observed a negative autocorrelation in long-horizon returns, suggesting that not all shocks to stock prices are permanent and that stock prices are mean reverting at long-horizons. Fama and French (1988a) and Poterba and Summers (1988) explain the autocorrelation by adding a temporary component into a model of stock prices (which already contained a permanent component) (see Cochrane 1994). Most studies, however, have found little evidence of mean reversion in stock prices for US stock markets over long horizons (See Goetzmann (1993)). It was not until later studies by Lee (1995, 1996a, 1996b, 1998) and Crowder and Wohar (1998) that the sources of these permanent and temporary component of stock prices and dividends were identified and their linkages analyzed. Deviations of log stock price from log dividend may be stationary or persistent depending on the nature of the nonfundamental components. An examination of fundamental and non-fundamental factors continues to be an important issue. If deviations of stock price from fundamentals decreases as the time horizon increases this may suggest that the over-reaction of the stock prices and the mean reversion of stock prices is primarily the result of changes in excess returns and to non-fundamental factors (see DeBondt and Thaler (1985)). Changes in stock prices brought about through changes in dividends and earnings are referred to as fundamental components of stock price. Any deviation of stock price from this specification would suggest evidence that other nonfundamental factors cause movements in stock prices. This would suggest that stock price movements are the result of both fundamental and nonfundamental components. A number of reasons have been offered as to why the simple present value model may not completely explain stock price movements. These include time-varying discount factors, ii) fads, iii) speculative bubbles, iv) inaccurate measurement of dividends, v) the omission of other important non-fundamental variables. Both in fads and in bubbles
the stock price deviates from the present value of future dividends (or fundamentals) due to noise, irrational expectations (i.e. optimism or pessimism based on momentum effects), feedback trading (i.e. trading base on past price changes), or other inefficiencies. Fad and bubble price deviations differ in nature. While fad price deviations are slowly reverse themselves, bubble price deviations are expected to last forever (Cochrane (1991 p. 471)). The two factors most relevant to the current paper are a time-varying discount factor and a non-fundamental component not accounted for in the model. If deviations of stock price from fundamentals decreases as the time horizon increases this may suggest that the over-reaction of the stock market and the mean reversion of stock returns is primarily the result of changes in excess returns and to non-fundamental factors. (see Thaler (1985) and Summers (1986)). Deviations of log stock price from fundamentals may be stationary or persistent depending on the nature of the nonfundamental components.

An examination of fundamental factors continues to be an important issue. This paper extends the standard present value model to incorporates additional fundamental factors beyond dividends and earnings. Examples of fundamental factors which we consider are the short-term interest rate and inflation. In addition, we investigates the extent to which non-fundamental factors contribute to movements in stock prices. This paper examines the response of stock prices, dividends, earnings, interest rate, and inflation, to permanent and transitory innovations in these variables. By taking into account cointegrating relations between these variables and imposing long-run and short-run restrictions on our model, we are able to identify innovations to these variables. The relation between stock prices, dividends, earnings, interest rate, and inflation is investigated along with the effects of fundamental innovations (permanent and transitory) on stock prices. The decomposition of stock prices, earnings, and other fundamental variables has important implications. We examine deviations of stock prices from the present value model. The deviation of stock prices from the present value model is reflected in a non-fundamental component that is represented as innovations to a first difference of a 20 month moving average of stock returns. We look at permanent and transition shocks to fundamental and non-fundamental innovations. In this way we allow for a time-varying discount rate and non-fundamental factors. We can examine the dynamic effects of various types of shocks to earnings, dividends, earnings, interest rates, inflation and non-fundamentals. This will allow us to test the empirical validity of a number of issues. For example, an important issue in dividend policy modeling is whether dividends
are determined by changes in some measure of permanent earnings (e.g. see Marsh and Merton (1987)) or current earnings. The decomposition of earnings into permanent and transitory components and the linkages between the two, may help to provide some evidence related to this issue. Our analysis is also important in that the introduction and interest rate and inflation into the present value model allows us to investigate issues related to the proxy-hypothesis that as of yet have not been explored. In this way, our model integrates together many different strands of literature. A well documented empirical fact in the US is the existence of a negative and significant correlation inflation and the returns on common stocks during the post-WW II period (See Jaffe and Mandelker (1976), Bodie (1976), Nelson (1976), Fama and Schwert (1977) and Fama (1981)). These findings refute the common belief that common stock are a hedge against unexpected inflation. Fama (1981) was the first to over an explanation for the seemingly perverse negative stock return-inflation relation. He called the proxy-hypothesis. The central theme of the proxy-hypothesis is that the observed inverse correlation between inflation and stock returns is spurious because this linkage is induced by a positive relationship between stock returns and expected economic activity, and an inverse relationship between inflation and expected economic activity. In this view, inflation is simply serving as a proxy for expected economic activity in a regression of stock returns on inflation. The explanation is based on two things. First, high current inflation rates anticipate low rates of growth of real economic activity. This comes about as investors expect the growth of economic activity to slow, which leads to a decrease in the growth rate of real cash balances, which in turn leads to an increase in future expected and current inflation. Second, high real stock returns are an indication that investors expect high growth rate of economic activity in the future. As a result, inflation and stock returns move in the opposite direction by expected economic fluctuations, and are inversely related. Geske and Roll (1983) extend Fama’s explanation, and argue that the countercyclical fiscal policy that the US pursued during the post-WW II period, resulted in a procyclical behavior of the US money supply, as a result of deficit monetization. This reinforced the proxy-hypothesis mechanism because of higher inflation rates during recession. While early studies by Fama (1981), Geske and Roll (1983), and Kaul (1987) provide some empirical support for the proxy hypothesis, more recent studies by McCarthy, Najand, and Seifert (1990), Liu, Hsueh, and Clayton (1993), Cochran and DeFina (1993) and Lee (1996) present evidence rejecting the proxy hypothesis for the US as well as other
industrialized countries. The present value model states that stock prices reflect the present value of expected future dividends. Dividends are in turn a function of firms future expected earnings, which depend on economic activity. Thus, stock returns should be related to expected economic activity. By adding inflation and interest rates to the present value model, and employing permanent and transition structural VAR methodology, we are able to provide a measure of the strength of the correlation between stock returns and inflation according to the origin of the perturbations affecting the system. We can also break down the total covariance between different series into temporary and permanent components due to innovations in different variables. Question which we wish to answer are: i) Is the contemporaneous correlation between inflation and stock returns always negative regardless of the origin of the innovation? ii) Do inflation and stock returns exhibit stronger correlation when the inflation rate itself is the variable being shocked? iii) Do innovations in the inflation rate account for most of the negative covariance between inflation and stock returns? We then extend the analysis by investigating the effect of adding the short-term nominal interest rate series. Are inflation and stock returns strongly correlated in response to interest rate shocks? Do interest rate innovations account for a significant portion of the covariance between stock returns and inflation (i.e. do interest rate innovations play a significant role)? Since earnings is a good proxy for economic activity we can also ask questions about shocks to earnings. But in order to compare our results with those of Fama (1981) we must make some identifying assumptions about the causality structure. Innovations in earnings (being a proxy for production) and inflation (a proxy for money growth) are predetermined relative to innovations in the other variables of the system. This is consistent with Fama’s view of the economy where production and money growth are the forcing variables, while inflation, stock prices (stock returns), and dividends are determined endogenously. We also must allow innovations to earnings (proxying for production) to affect inflation (proxy for money growth), but not vice versa. That is, shocks to inflation (money growth) cannot affect earnings (production). This is for two reasons: i) earnings is the common trend, and ii) this restriction is necessary to reflect the lag of monetary policy effects on economic activity. Another restriction is that inflation innovations are affected by earnings (production) and inflation (money growth) innovations. Furthermore, within quarter stock returns should be affected by all variables, but should not affect any of them. (earnings (production) −→ money growth −→ inflation −→ stock returns) Another
interesting identification scheme might be that the interest rate is affected by innovations in earnings (proxy for production) and, inflation (proxy for money growth). (earnings (production) –> money growth –> inflation –> interest rate –> stock returns) We first establish that a long-run relationship exists between stock prices, dividends, earnings, interest rates, and inflation. We then model the implied dynamic behavior of these five series when subjected to innovations in both the permanent and transitory components. Previous short-run modeling of stock prices has exploited the Vector Autoregressive (VAR) methodology and, in particular, using the VAR to test the set of restrictions implied by the present value model. We are concerned with the dynamic adjustment of stock prices, dividends, earnings, interest rates and inflation to their long-run equilibrium values. Drawing from previous literature which finds that stock prices and dividends are nonstationary processes, this paper employs a structural cointegrated 5 variable VAR), to decompose stock prices, dividends, earnings, interest rates, and inflation into permanent and transitory components based on a system of five variables with 3 cointegrating vector (CIV) system of. The cointegrating vectors are [1,-1] between stock price and dividends, [1,-1] between stock price and earnings, and [.7,-1] between inflation and the short-term interest rate. We also investigate the relative importance of each component in predicting future variations in stock prices and other variables, by analyzing the one-step-ahead forecast error variance. Variance decompositions are also employed. We find that deviations of stock price from fundamentals decreases as the time horizon increases. In particular, the long-term trend in stock prices is due to the permanent change in fundamental (e.g. dividends and earnings) while short-term volatility of stock prices is due to changes in the discount factor which are brought about by changes in short-term interest rates and inflation.

2 Literature Review

The finance literature has conducted a large number of studies attempting to resolve the debate about whether or not stock prices have a strong predictable component. If true, this would yield evidence against the efficient market hypothesis. Early studies by Fama (1970) and others, found stock prices to behave according to a random walk process, supporting the efficient market hypothesis. Later studies by Kleidon (1986), Marsh and
Merton (1986, 1987), Campbell and Shiller (1987, 1989b) found that stock price and dividend series follow a more general nonstationary process, which suggests that they may be affected by more than one type of disturbance. This finding justifies modeling stock price and dividend series as the sum of temporary and permanent components. It is notable that the two components of stock prices and dividends may not behave independently of one another, but instead, the two components in stock prices may be related to the two components in dividends. For example, stock price valuation models are one way in which stock prices are linked to dividends. Specifically, stock prices are equal to the present discounted value of future dividends. In addition, Fama and French (1988b) and Campbell and Shiller (1988a, 1989b) found that the spread between stock price and dividend (dividend yield) provides information in predicting stock returns. There have been two strands of literature investigating these issues.

2.1 Mean Reversion in Stock Prices

The first approach involves studies which model the behavioral characteristics of stock prices with no consideration for any underlying macroeconomic variables. This group of studies provides empirical evidence that stock returns contain a strong predictable component at long-term investment horizons. This implies that there is mean reversion of stock prices towards a fundamental value as opposed to stock prices being a random walk. Early studies found stock prices to behave according to a random walk process, supporting the efficient market hypothesis, while later studies found that stock price and dividend series follow a more general nonstationary process, which suggests that they may be affected by more than one type of disturbance. Recent studies have observed a negative autocorrelation in long-horizon returns, suggesting that not all shocks to stock prices are permanent and that stock prices are mean reverting at long-horizons. Fama and French (1988a) and Poterba and Summers (1988) explain the autocorrelation by adding a temporary component into a model of stock prices (which already contained a permanent component) (see Cochrane 1994). The mean reversion literature, including Fama and French (1988a) and Poterba and Summers (1988), require that stock prices exhibit negative autocorrelation in order to enable stock prices to eventually revert to their 'fundamental value'. (See Campbell (1991) for a counter example).
2.2 Present Value Model and Variance Bound Tests

An alternative procedure to test the random walk null hypothesis of stock prices against the alternative of mean reverting (or averting behavior in which the temporary component is positively autocorrelated) has been based on an investigation of the relationship between the variance of the permanent component of stock returns the variance of stock returns themselves. See Lo and MacKinlay (1988, 1989); Poterba and Summers (1988), and Mills (1991). If there is no temporary components in stock prices then the ratio of these variances will be unity. If on the other hand, the variance of the permanent component is smaller (larger) than the variance of stock returns, then the mean reversions (aversion) of stock returns is concluded. The variance ratio tests are based on the univariate behavior of stock prices alone. Early studies by Shiller (1981) and LeRoy and Potter (1981) using a simple present value model with a constant discount rate, utilizing variance bounds tests, found that stock price were too volatile relative to dividends. Kleidon (1986) and Marsh and Merton (1986) questioned the reliability of these volatility tests on the grounds that stock prices and dividends are nonstationary processes. The estimation technique of variance bounds assumed that the series under investigation was stationary. Flavin (1983) provided another criticism of the variance bounds tests based on small samples. In response to the nonstationarity criticism, West (1988a) developed a variance bounds test that was valid when dividends where non-stationary. One problem with these tests, pointed out by Cochrane and Sbordone (1988), is the low power of such tests. This low power is a consequence large standard errors resulting from few overlapping long horizons of data. Cochrane and Sbordone (1988) argue that one might be able to increase the power of these variance ratio tests by calculating them in a multivariate framework through the incorporation of the common trend in dividends implied by the stationarity of the price-dividend ratio. However, this still does not allow one to identify the permanent component in stock prices. As Quah (1992) demonstrates, all univariate measures of the size of the random walk component of a time series are equivalent and equal to the spectral density of the changes in the series at frequency zero. The problem is that the various innovations impinging upon price-dividend ratio are not economically identified in a univariate analysis.
2.3 Identification of Permanent Components

Taking into account the non-stationarity of dividends and stock prices, Campbell and Shiller (1987) have derived testable implications of the simple present value model. Many authors have tested the simple present value model and found statistically significant excess volatility of stock prices and have rejected the simple present value model formulation in the short-run. Subsequently long-run cointegration tests of the present value model have been conducted most recently by Lee (1995, 1996a, 1996b, 1998) and Crowder and Wohar (1998). Crowder and Wohar (1998) employing cointegration and permanent transitory decomposition techniques, find support for the present value model for the long-run. Lee (1995) and Crowder and Wohar (1996) attempt to identify the permanent component of stock prices and dividends for the US. Mills (1995), employing annual data from 1920-1990 and monthly data from 1965-1990, on nominal UK stock prices and dividends, find that (the logarithm of) stock prices and dividends are cointegrated with a cointegrating vector of (1,-1). That is, they find that stock prices and dividends contain a common permanent component, such that the price-dividend ratio is stationary, as implied by the present value model of stock prices. The monthly results of Mills (1995) confirm the results of Mills (1991, 1993) where UK stock prices are found to exhibit mean aversion rather than pure random walk behavior. The find UK stock returns to be positively correlated over long time horizons and are thus predictable, rejecting the present value model of stock prices which implies that stock prices are not predictable. Mills argues that he finds support for this by fitting an AR(3) model to the log first difference of stock prices which yields parameter values such that the estimate of the long-run response of stock price to an innovation is statistically significant and greater than unity. These estimates are in agreement with his variance ratio tests which yield values significantly less than unity rejecting the random walk hypothesis. For UK annual data, Mills (1991, 1993, 1995) find much less evidence against the random walk hypothesis with variance ratio statistics insignificantly different from unity, concluding that returns are unpredictable. Using a similar annual data set for the UK but different statistical techniques (variance bounds analysis), Bulkley and Tonks (1989) found evidence not inconsistent with the annual results of Mills (1991, 1993, 1995). Mills (1995) write that "Knowing this fact, (that the price-dividend ratio is stationary and prices and dividends contain a common permanent random walk component), however, does not help us to estimate the common
random walk any more precisely than just using the information contained in prices alone, because for both data sets it is stock prices that are closest to a random walk and hence they that provide the best estimate of the permanent component”.

2.4 Predictability of Stock Price and Fundamentals

The second branch of research focuses on identifying fundamental variables (e.g. dividend yields, price-earning ratios, and other macroeconomic indicators, such as short-term interest rates and inflation) that help to explain fluctuations in stock prices or stock returns. This second group of studies attempts to identify variables that help to predict stock prices movements or stock returns. For example, Fama and French (1988b) propose dividends per share as being a significant factor in explaining stock returns. Campbell and Shiller (1988a) find that in addition to the dividend-price ratio, dividend growth and long-term earnings per share are also significant in explaining stock returns, particularly at longer terms investment horizons. A subset of this literature investigates whether earnings or dividends have greater explanatory power in predicting stock returns. Kornendi and Lipe (1987), Campbell and Shiller (1988a) find that earnings have significant power in predicting stock returns. More recently, Chiang, Davidson, and Okunev (1997) present empirical results that imply that changes in earnings per share and the level of earnings per share are helpful in predicting stock returns. Shiller (1984) and Fama and French (1988b) estimate univariate regression results for stock returns on regressed on lagged dividend yield versus earnings yield. They find that both have explanatory power in predicting returns, but that the dividend yield has more. Fama and French (1988b) argue that the reason for this is that earnings are more volatile than dividends, and if this higher volatility is uncorrelated with the variation of expected returns, then the earnings yield will be a noisier measure of expected returns than the dividend yield. Previous research as regarded quarterly earnings as noise that should be disregarded or smoothed. Lamont (1998) investigates this issue in greater detail and finds that the higher variability of earnings is not noise but is in fact related to the variation in expected stock returns at short-horizons. He shows, employing multivariate regression analysis, that this results stems from the fact that the dividend payout ratio (dividend/earnings) forecasts has predictive power for stock returns. Since both higher current prices and high current earnings forecast low returns, then using earnings yields alone
to forecast returns is not a good idea according to Lamont. Furthermore, high dividends forecast high future returns, so using dividends alone to forecast returns is preferred since it will yield better results. Lamont investigates the dividend payout ratio’s forecasting ability for asset returns over the period, 1947-1994. Lamont presents two reasons for the predictive ability of the payout ratio. First, he finds that the level of dividends predicts stock returns. He interprets this as being due to the fact that dividends measure the permanent component of stock prices, due to managerial behavior in setting dividends. Second, the payout ratio is helpful in predicting stock returns because the level of earnings helps to forecast returns. The level of earnings is a good measure of business conditions. Risk are found to covary inversely with current economic activity. If investors require high expected returns in recessions, and low expected returns during expansions, then since earnings, vary positively with economic activity, current earnings predict future returns. Put simply, dividends contain information about future returns because they help measure the value of future dividends, and earnings contain information because they are correlated with business conditions. An important aspect of Lamont’s paper is that he considers current dividends and earnings, not as normalizing variables for stock prices, but instead as predictive variables in their own right. Lamont argues that dividends and earnings and not "harmless scaling variables when used to normalize stock prices" (Lamont p. 1564). Both of these series contain information about future stock returns, above that contained in the current level of stock prices. However, Lamont finds that dividends and earnings are important for forecasting short-term movements in expected returns. Lamont finds that stock price is the only relevant variable for forecasting long-horizon returns. Normalization for long-horizon returns does not matter. Lamont argues that dividing price by any smooth accounting variable capturing nominal growth, produces about the same results. Dividends and earnings help to predict short-term returns, but are not important for forecasting long-run returns. In the mid-1990s, US stock prices were high relative to any accounting benchmark. Lamont, concludes that recent low forecasts long-horizon stock returns are only due to the fact that stock prices are high. The predictability of stock returns (over long horizons) is closely linked to the investigation of permanent components in stock prices. If stock returns are not predictable, then all changes in stock prices will be permanent and stock prices will not contain a transitory component. In other words, stock prices will follow a random walk. In contrast, if stock returns are predictable (from past returns), then stock prices will not follow
a pure random walk (with possible drift). Instead, stock prices will contain a
transitory component (which is serially correlated) which allows stock prices
to diverge from their equilibrium values for possibly long periods of time.
Much attention has been devoted to the predictability of returns calculated
over long time horizons of ten years or more. Lo and MacKinlay (1988,
1989), Poterba and Summers (1988), Fama and French (1988a), Richardson
and Stock (1989), and Cutler, Poterba and Summers (1991) have all de-
veloped empirical estimation procedures designed to investigate the behavior
of long horizon asset returns and have employed these procedures to inves-
tigate the properties of US stock returns. Cutler, Poterba, and Summers
(1991) examine the extent to which equity returns in different countries ap-
pear to demonstrate predictability in the same way that returns in the US
have been shown to be somewhat predictable. Such predictability may be
due to fads, overreaction, or other type of irrationality, or it may be due to
time varying risk within an equilibrium framework. In this regard, Fama and
French (1988a), and Poterba and Summers (1988), modeled the log of stock
prices as the sum of a transitory component (described as a first-order autore-
gressive process), and a permanent component (modeled as a pure random
walk). They used this model to explain the mean reverting behavior of stock
returns. While a number of studies have found evidence against the hypothe-
sis that fundamentals are the primary factor driving stock returns, it has
been argued that these empirical studies are subject to a small sample bias,
which may lead one to find that stock returns are more predictable than they
really are. It has been pointed out that the use of overlapping data in multi-
period return forecasts, results in a small sample bias (to smaller values) in
asymptotic t-values. The t-statistics from regression models of stock returns
on lagged financial fundamentals (e.g. price-earnings ratio or dividend-price
ratio) and other broad macroeconomic indicators have been shown to be sub-
ject to a small sample bias that makes stock returns look predictable when
they in fact may not be. Studies have investigated this bias for both bivari-
ate regressions and VARs with lagged dependent variables. See for example,
Mankiw and Shapiro (1986), Campbell and Shiller (1989b) Kim, Nelson and
Startz (1991), Hodrick (1992), Goetzmann and Jorion (1993), Nelson and
Kim (1993), Richardson (1993), and most recently, Staumauaugh (1998).
3 Theoretical Model

The most widely used model to describe the valuation of assets is the present value model. The present value model models the stock price \( P_t \) as the present discounted value of the future expected dividends \( D_{t+j} \). This is expressed as,

\[
P_t = E_t \left[ \sum_{j=1}^{K} \left( \frac{1}{1 + R_t} \right)^j D_{t+j} \right] + E_t \left[ \left( \frac{1}{1 + R_t} \right)^K P_{t+K} \right]
\]  

(1)

where, \( E_t \) is the conditional expectations operator based on information available to market participants at time \( t \), \( R_t \) is the rate of return used by market participants to discount future values and \( K \) is the investors time horizon or holding period. Standard transversality conditions imply that as \( K \) gets large the last term on the right vanishes.\(^1\) For estimation purposes, we use a log-linear approximation to the above valuation model termed the dynamic Gordon model or dividend-ratio model. It relates the log dividend-price ratio \( (d_t - p_t) \) to the present value of the change in log dividends \( (\Delta d_t) \) and has been used previously by Campbell and Shiller (1988a, 1989b). Equation (2) below depicts the representation of the dynamic Gordon Model.

\[
d_t - p_t = c + \sum_{j=1}^{\infty} \omega^j (\Delta d_{t+j})
\]  

(2)

If dividends are assumed to be an I(1) process, then the dividend-price ratio is related to the present discounted value, where \( \omega \) is a discount factor, of a stationary series implying that the log dividend-price ratio must also be stationary.

To describe the long-run relationship between dividends and earnings, we rely on the dividend smoothing model in which changes in dividends are primarily the result of changes in some measure of permanent earnings. The dividend smoothing hypothesis is similar in reasoning to the permanent income-life cycle consumption hypothesis in that firms attempt to smooth their dividend payments over time as an optimal response to a more volatile earnings stream. Let \( Q_t \) be the level of earnings at time \( t \) and \( \delta \) a discount factor used by investors to discount future values and the dividend smoothing hypothesis takes form of equation (3).

\(^1\)Price bubbles are the result of violations of this transversality condition.
\[ D_t = E_t \sum_{j=1}^{\infty} \delta^j Q_{t+j} \]  

(3)

We can generate a log-linear approximation in much the same way that the dynamic Gordon model is derived and relate the log dividend-earnings ratio to the discounted present value of future earnings changes.

\[ d_t - q_t = E_t \sum_{j=1}^{\infty} \gamma^j (\Delta q_{t+j}) \]  

(4)

Equation (4) states that the log dividend payout ratio is proportional to the expected present value of all future earnings growth rates. If earnings growth is a stationary process, then \( d_t - q_t \) will be also.

4 Empirical Methodology and Results

This section presents the estimates of the empirical model. We find that the long-run relationship between stock prices, dividends and earnings has not been stable over the sample period. We present results from both a standard model, i.e., one that assumes stability of the equilibria, and a model adjusted for the structural shifts that are detected by the stability tests. Comparing the results will demonstrate the importance in establishing the stability of the long-run equilibria.

4.1 Data and Univariate Results

The data used are nominal values of the S&P 500 stock price index and the corresponding dividends and earnings. The data are sampled quarterly and run from the first quarter 1947 to fourth quarter 1994.\(^2\) The data are plotted in figure 1.

The potential for trends in time series data has important implications for the choice of appropriate estimators. Specifically, if the data are characterized by stochastic trends then the use of Ordinary Least Squares (OLS) or a variant of OLS, i.e. GLS, 2SLS, etc., is inappropriate because of the non-standard distribution of the parameter estimates and their standard errors.

\(^2\)We also investigated real values of each variable by deflating by the CPI with no qualitative difference in results.
Figure 1: Stock Price, Dividends and Earnings, 1947 - 1994
Several procedures exist to test for the presence of stochastic trends in time series data. The most commonly applied is the Dickey-Fuller (1979) test based on equation (5).

\[
\Delta X_t = \mu + \delta t + \rho X_{t-1} + \sum_{j=1}^{k} \gamma_j \Delta X_{t-j} + \varepsilon_t \quad (5)
\]

The null hypothesis, \( \rho = 0 \), can be tested using a t-statistic. The lag length of the augmentation terms, \( j \), is chosen as the minimum necessary to reduce the residuals to white noise. The distribution of this test is, however, not standard. Critical values for this Dickey-Fuller (DF) test have been calculated using Monte Carlo methods, most accurately by MacKinnon, et al. (1991). Each series was subjected to a battery of standard unit root tests, i.e., Dickey and Fuller (1979), Phillips and Perron (1988) and Kwiatkowski et al. (1989). The results, not presented for the sake of brevity, all yield results consistent with each series being characterized as I(1) or first difference stationary.

Perron (1989) has demonstrated that such standard tests are subject to misspecification bias and size distortion when the series involved have undergone structural shifts. Since we also argue that structural breaks can influence multivariate results significantly, we address this issue by using the procedure advocated by Zivot and Andrews (1992). Zivot and Andrews (1991) developed a recursive test for stochastic trends based upon equation (6).

\[
\Delta X_t = \mu + \delta t + \theta D_t + \rho X_{t-1} + \sum_{j=1}^{k} \gamma_j \Delta X_{t-j} + \varepsilon_t \quad (6)
\]

The variable \( D_t \) is a dummy variable that takes a value of one when \( t \) is greater than \( \lambda T \), where \( T \) is the sample size and \( \lambda \in [0.1, 0.9] \), and a value of zero otherwise. Figure 2 plots the recursive estimates of the Zivot-Andrews test statistics normalized by the appropriate 95% critical values provided in Zivot and Andrews (1991). There is no evidence of stationarity induced by the possible structural shifts in the underlying data.

### 4.2 Multivariate Methodology

We use Johansen’s (1988, 1991) procedure to estimate and test the long-run equilibrium relationship between stock prices, dividends and earnings. Johansen’s (1988, 1991) gaussian MLE is based upon a \( p^{th} \) order vector time
Figure 2: Zivot-Andrews Unit Root Tests
series $X_t$ that is assumed to follow a finite order vector autoregressive (VAR) process given in (7),

$$
\Pi(L) \ X_t = \mu_t + \varepsilon_t
$$

where $\Pi(L)$ is a $k^{th}$ order matrix polynomial in the lag operator where $\Pi(0) = I$, $\mu_t$ contains deterministic components which may depend upon time and $\varepsilon_t$ is a vector white noise error term. Equation (7) can be transformed into error-correction model (VECM) form as in (8).

$$
\Delta X_t = \mu_t + \Pi \ X_{t-1} + \sum_{j=1}^{k-1} \Gamma_j \Delta X_{t-j} + \varepsilon_t
$$

The long-run multiplier matrix $\Pi = -\Pi(1)$ can be decomposed into two $p \times r$ matrices such that $\alpha \beta' = \Pi$. The $p \times r$ matrix $\beta$ represents the cointegrating vectors or the long-run equilibria of the system of equations. The $p \times r$ matrix $\alpha$ is the matrix of error-correction coefficients which measure the rate each variable adjusts to the long-run equilibrium. Maximum likelihood estimation of (8) can be carried out by applying reduced rank regression. Johansen (1988, 1991) suggests first concentrating out the short-run dynamics by regressing $\Delta X_t$ and $X_{t-1}$ on $\Delta X_{t-1}$, $\Delta X_{t-2}$, ..., $\Delta X_{t-k+1}$ and $\mu_t$ and saving the residuals as $R_{0t}$ and $R_{1t}$, respectively. Calculate the product moment matrices $S_{ij} = T^{-1} \sum_{t=1}^{T} R_{it} R_{jt}'$ and solve the eigenvalue problem $|\lambda S_{11} - S_{10} S_{01}^{-1} S_{01}| = 0$. The likelihood ratio statistic testing the null hypothesis of at least $r$ cointegrating relationships in $X_t$ is given by $-T \sum_{i=r+1}^{p} \ln(1 - \hat{\lambda}_i)$ and is called the trace statistic by Johansen (1988, 1991). The distribution of this statistic is non-standard and depends upon nuisance parameters. Critical values have been tabulated by MacKinnon et al. (1996) using response surface regressions.

The estimate of $\beta$, $\hat{\beta}$, is given by the $r$-largest eigenvectors associated with the eigenvalues $\hat{\lambda}$. Hypothesis tests on $\hat{\beta}$ can be conducted using likelihood ratio (LR) tests with standard $\chi^2$ inference. Let the form of the linear restrictions on $\beta$ be given by $\beta = H \varphi$ where $H$ is a $p \times s$ matrix of restrictions and $\varphi$ is a $s \times r$ matrix of unknown parameters. The LR test statistic is given by,
\[ T \sum_{i=1}^{r} \ln \left[ \frac{(1 - \lambda_i)}{(1 - \lambda_i)} \right] \sim \chi_{r(p-r)}^2 \]  

where \( \lambda_i \) are the eigenvalues from the restricted MLE.

The estimated cointegration parameters are assumed to be constant throughout the sample. This may not be the case if the variables are subject changing economic environments, policy regimes, etc. Hansen and Johansen (1993) have developed a recursive procedure to test the stability of the cointegration parameters. They suggest basing the \( \hat{\beta} \) stability tests on the model with the short-run dynamics set to their full-sample values. This simply means basing the \( \hat{\beta} \) stability tests on the equation \( \hat{R}_{it} = \alpha \hat{\beta} \hat{R}_{it} + \epsilon_t \), where \( \hat{R}_{it} \) and \( R_{it} \) have been defined earlier. The hypothesis of interest is that \( \beta_t = \beta \forall t = T_0, \ldots, T \) so that \( H = \beta \) and \( \varphi \) is the \( r \times r \) identity matrix. For each period \( t \) the LR test is calculated as,

\[ T \sum_{i=1}^{r} \ln \left[ \frac{(1 - \lambda_i)}{(1 - \lambda_i)} \right] , t = T_0, \ldots, T , \]  

which is distributed \( \chi_{r(p-r)}^2 \) at each iteration.

### 4.3 Identification in a Cointegrated System

In this system the number of distinct long-run relations or cointegrating vectors is dictated by the rank of the autoregressive total impact matrix, \( \Pi \), but the nature of these relations is not generally available without the imposition of identifying restrictions. When cointegration prevails in the system, the problem of identifying the long-run relations that characterize the system is an exercise that is distinct from the traditional quest for the identity of contemporaneous structure.\(^3\)

#### 4.3.1 Identification of Long Run Equilibria

Cointegration rank \( r < p \) in (7) implies the total impact matrix in representation (8) can be written as \( \Pi = \alpha \beta \) where \( \alpha \) denotes a \( p \times r \) matrix of error

\(^3\)Establishing the identity of the long-run relations is an exercise that is distinct from pinning down the complete contemporaneous structure as in the classical work of the Cowles Commission (see Koopmans (1950) and Koopmans and Hood (1953)). The precise link between complete contemporaneous identification of the system and identification of long-run structure is discussed in Hoffman and Rasche (1996).
correction coefficients and $\beta$ a $p \times r$ matrix of cointegration vectors. Without further information about the cointegration space, the elements of $\alpha$ and $\beta$ are not identified from $\Pi$ because there is an infinite number of $r$-dimensional nonsingular basis transformation matrices, $R$, such that $\alpha^* = \alpha R^{-1}$ and $\beta^* = \beta R$ are also consistent with the long run information embedded in $\Pi$. This is easily confirmed by noting $\Pi = \alpha \beta' = \alpha^* \beta'^*$.

Restrictions that limit the choice of feasible transformation matrices, $R$, may be used to identify $\alpha$ and $\beta$. Rank and order conditions for identification of $\beta$ can be established in a direct application of Fisher (1966) and Rothenberg (1973) and have been discussed in the context of cointegrated systems by Park (1990), Johansen (1992b), Hoffman and Rasche (1991a, 1996) and Pesaran and Shin (1994). This literature clearly illustrates that the identity of the cointegration space may be established with $r^2$ independent restrictions ($r(r-1)$ in addition to arbitrary normalization of each vector.)$^4$ When the cointegration space, $\beta$, is identified, the error correction coefficients, $\alpha$, are easily obtained. Similarly, knowledge of $\alpha$ can conceivably be used to obtain $\beta$. Most applications achieve long-run identification through restrictions on $\beta$.

4.3.2 Identifying Structural Innovations

Conventional structural VAR innovation identification in a $p-$dimensional system requires $(p(p-1))$ identifying restrictions. In conventional applications undertaken without incorporating knowledge of cointegration rank, $p(p-1)/2$ of these come from the assumption that the structural innovations are independent, i.e., that the structural error covariance matrix is diagonal. The remaining $p(p-1)/2$ restrictions must come from restrictions imposed by the econometrician.$^5$ The total number of restrictions imposed in these exercises is the same as that required for complete contemporaneous structure identification discussed in the original work of the Cowles Commission.

In a $p-$dimensional cointegrated system, establishing the identity of only

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$^4$Johansen (1988) identifies the cointegration space with a technical procedure that insures the individual vectors of $\beta$ are orthogonal. Pesaran and Shin (1994) offer a clear statement of general conditions under which identification is obtained and how cross equation and nonlinear restrictions may be employed to accomplish the task.

$^5$Early work focused on establishing a recursive pattern to the contemporaneous impact of the structural shocks on the data. More recent effort has employed long-run response patterns to identify structural innovations.
$k < p$ permanent structural innovations can be achieved exclusively from restrictions that impose long-run neutrality with respect to a subset of innovations. To illustrate, consider the Wold moving average representation of the system in (7) above,

$$\Delta X_t = C(L)(\mu + \varepsilon_t) = \delta + C(L)\varepsilon_t$$

and form a multivariate Beveridge-Nelson decomposition from (11) by separating the matrix polynomial into components associated with long-run and short-run information to obtain $C(L) = C(1) + C^*(L)(1 - L)$ where $C(1)$ is the sum of the moving average coefficients and $C_i^* = -\sum_{i=j+1}^{\infty} C_i$, $i = 1, 2, \ldots$.

The representation obtained by multiplying (11) by $(1 - L)^{-1}$ (e.g. accumulating the differences) is then

$$X_t = X_0 + C(1) \left( \mu t + \sum_{s=1}^{t} \varepsilon_s \right) + C^*(L)\varepsilon_t$$

The second term on the right side of equation (12) is the permanent portion of the vector process. When the vector process is nonstationary but not characterized by cointegration, $C(1)$ is full rank and $p$ distinct shocks leave a permanent imprint on the data. When the variables in the system are cointegrated there are a reduced number of trends which are common to each variable in $X_t$, thus (12) is called the common trends representation. When cointegration rank is $r$ the number of common trends is $k$ such that $r + k = p$ the dimension of $X_t$.

When cointegration characterizes the system $X_t$ it is possible to identify the $k < p$ permanent innovations by recognizing the reduced rank nature of the reduced form total impact matrix, $C(1)$. To illustrate, we make use of a parsimonious notation to express $C(1)$ as the product of two $p \times k$ matrices of rank $k$, $C(1) = \beta_\bot \alpha_\bot^\prime$. The first matrix is the factor loading that is by construction orthogonal to the cointegration space $\beta$. The second matrix is represented by $\alpha_\bot$ to correspond to the matrix that defines the

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6From Johansen’s (1991) proof of the GRT, $C(1) = \beta_\bot (\alpha_\bot^\prime \Pi_1(1)\beta_\bot)^{-1} \alpha_\bot^\prime$ where $\beta_\bot$ and $\alpha_\bot$ are $p \times k$ orthogonal complements for $\beta$ and $\alpha$ with $k = p - r$, and $\beta_\bot \beta = \alpha_\bot \alpha = 0$, $\Pi(L) = \Pi(1) + \Pi_1(1 - L)$, $\Pi_1^2(1) = \Pi + 1 - \sum_{i=1}^{q-1} \Pi_1^i L^i$, and $(\alpha_\bot^\prime \Pi_1^i(1)\beta_\bot)$ is nonsingular. Note that $\Pi_1^i(1) = \Pi_1 + 2\Pi_2 + 3\Pi_3 + \ldots + q\Pi_q$. To facilitate notation, our illustration does not distinguish $\beta_\bot$ from a simple matrix transformation, $\beta_\bot (\alpha_\bot^\prime \Pi_1^i(1)\beta_\bot)^{-1}$ or similarly $\beta_\bot$ from $(\alpha_\bot^\prime \Pi_1^i(1)\beta_\bot)^{-1} \alpha_\bot^\prime$. 

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\(k\) independent permanent shocks as linear combinations of the \(p\) reduced form innovations in the system. From this perspective, identification of the permanent innovations from knowledge of \(C(1)\) is the dual of establishing the identity of the cointegrating relations, \(\beta\) and error correction terms, \(\alpha\), from \(\Pi\). Accordingly, this requires \(k(k-1)\) restrictions. One-half of these can be obtained from innovation independence restrictions while the remaining \(k(k-1)/2\) imposed restrictions on \(C(1) = \beta_1\alpha_1'\).

Establishing the identity of the permanent innovations that underlie a nonstationary vector process partially identifies a system that, following the Granger representation theorem, can be represented by \(k\) permanent and \(r\) transitory distinct innovations. Several procedures for identifying the remaining transitory innovations are available, e.g. Sims (1980), Bernanke (1986), Sims (1986). Warne (1991) adopts the \textit{a priori} restriction that the transitory innovations lie in the space that is orthogonal to the permanent innovations. The advantage of this approach is that once the cointegration vectors are identified, the sets of permanent and transitory innovations may be identified in separate exercises. That is, imposing alternative identifying restrictions on the permanent portion of the system does not alter the identity of the transitory innovations. Warne demonstrates that transitory innovation identification is a straightforward exercise in identifying \(r\) distinct innovations requiring \(r(r-1)\) restrictions. One half of these restrictions may be obtained by imposing innovation independence. The remainder can come from restricting how shocks to certain transitory innovations affect variables in the first period.\(^7\)

The relationship between identification of the complete \(p\)-dimensional structural VAR and the identification conditions discussed above is now easily seen. In standard structural VAR applications \(p(p-1)/2\) restrictions are required in addition to the \(p(p-1)/2\) innovation orthogonality constraints to obtain identification (after arbitrary normalization). In the case of cointegrated VAR systems we can also utilize the \(p(p-1)/2\) innovation independence restrictions. But, knowledge of cointegration rank \(r\) implies that \(r\) structural innovations leave no long-run imprint on the \(p\) variables in the system and this information is useful in establishing the identity of the innovations. These \(pr\) homogeneous restrictions deliver an additional \(kr\) independent restrictions that can be applied toward the identification of

\(^7\)Warne’s proposal for transitory identification is the standard “ordering” assumption adopted in traditional VAR applications.
the model. These restrictions dictate the relative number of permanent and transitory shocks that underlie this system and parameterizations that adopt alternative numbers of permanent and transitory shocks are inherently misspecified. With the addition of the $k(k - 1)/2$ and $r(r - 1)/2$ restrictions required to sort out among the sets of permanent and transitory innovations respectively, the $p(p - 1)/2$ required for system identification are obtained. Knowledge of cointegration rank then reduces the number of restrictions required to identify the complete structure of the system by $kr$. At the same time, the origin of structural innovations that characterize cointegrated systems may be more difficult to establish than in conventional VAR analysis because the innovations are formed from linear combinations of reduced form residuals and are not easily associated with individual reduced form equations. Therefore, the identification exercise becomes even more focused on the imprint each innovation leaves on the data. Given that our system of variables $X_t$ has dimension of three, i.e. it is a trivariate VAR, that can be characterized by cointegration rank $r = 2$ thus implying that $k = 1$, the above discussion implies that no restrictions, beyond structural error independence, are needed to identify the permanent innovation in the model. In order to separately identify the transitory innovations, however, we must impose one restriction that is not testable on the contemporaneous structure of the model.

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8See Quah (1992) for a detailed technical discussion that includes a positive critique of the Warne procedure.

9From a purely technical perspective, knowledge of cointegration rank $r = p - k$ only establishes the rank of $C(1)$ at $k$. Following KPSW we have chosen to exploit the reduced rank nature of $C(1)$ to express the system as a function of $k$ independent permanent innovations. Of course, the system may actually be governed by more than $k$ permanent shocks, but clearly these could not be independent impulses. We simply choose to interpret each independent source of nonstationarity as a single shock—recognizing that each of these independent sources could actually comprise a number of innovations.
4.4 Multivariate Empirical Results

4.4.1 Cointegration Between Stock Prices, Dividends and Earnings

The results presented were obtained using the Johansen procedure discussed earlier with lag truncation $k = 7$.\(^{10}\) The estimated trace test statistics are 25.91, 6.67 and 0.18 for the null hypotheses of $r = 0$, $r \leq 1$ and $r \leq 2$, respectively, where $r$ is the number of cointegrating vectors. This can be compared to the 95% critical values of 29.8, 15.50 and 3.84, respectively. Figure 3 plots the recursive estimates of the trace statistics under the assumption that the short-run dynamics are equal to the full sample values (see Hansen and Johansen (1993)). This evidence suggests that there is no long-run relationship between these variables.\(^{11}\)

When imposing two cointegrating vectors on the system and testing the present value restrictions that the cointegration vectors are equal to

$$
\begin{bmatrix}
1 & 0 \\
0 & 1 \\
-1 & -1
\end{bmatrix}
$$

the LR test statistic from equation (9) is 5.35 which is distributed as a $\chi^2(2)$. The p-value of this test is 0.07 implying that we cannot reject the present value model restrictions at the 5% level of significance.

The Johansen tests for cointegration are often criticized for their low power relative to some recent alternatives. To address this we implemented the test proposed by Horvath and Watson (1995) which they show has greater power than the Johansen tests. Their test is appropriate when some or all of the cointegration vectors are known, as is the case for the present data. Imposing the cointegrating relationships implied by the present value model in equations (2) and (4), the Horvath-Watson test is a Wald test of the joint significance of the error correction terms in the cointegrated VAR. If all of the error correction terms are insignificant, there can be no cointegration among the variables. The calculated test statistic of 28.64 is compared to the 1% critical value of 25.35 for two known cointegration vectors and we can conclude that the data are cointegrated.

We examine the stability of the equilibria among the variables within the VECM using the procedure introduced by Hansen and Johansen (1993)

\(^{10}\)We used various lag lengths to examine the robustness of the Johansen results. We found no qualitative difference among results.

\(^{11}\)If one uses the 10% level of significance there is evidence of one cointegrating vector.
Figure 3: Recursive Trace Tests Normalized by 95% Critical Value
discussed in section 3.2. Figure 4 displays the recursive test for stability of the cointegration parameters. The tests statistics have been normalized by the 95% critical values such that statistics greater than one imply rejection of the null hypothesis of a stable set of cointegrating parameters.

There are at least three episodes of instability. The first in the early 1950s, the second in the late 1960s or early 1970s and the last in mid-1980s. Closer investigation reveals that the periods correspond to 1951:1 - 1955:4, 1971:1 - 1974:2 and 1985:1 - 1990:2.\textsuperscript{12} Using dummy variables defined over these dates

\textsuperscript{12}We chose these periods based on two criteria. First we picked the date at which the Hansen-Johansen test statistic is (locally) maximized as the starting point and then we picked the subsequent point where the statistic became insignificant. This seemed to
as proxies for the underlying structural (i.e., unknown) interventions and re-
estimating the VECM produced Johansen trace statistics of 53.66, 17.72 and
1.40, for the null hypotheses of $r = 0$, $r \leq 1$ and $r \leq 2$, respectively.\textsuperscript{13} Figure 5
plots the recursive trace statistics normalized by the appropriate 95\% critical
values. The evidence in this graph is much more favorable to the present value
model restrictions. There is evidence of two cointegration vectors. Figure
6 displays the Hansen-Johansen stability tests with the intervention dummy
variables included. There is no evidence of parameter instability and the
LR test of the present value restriction that the cointegration vectors are
\begin{align*}
  \begin{bmatrix}
    1 & 0 \\
    0 & 1 \\
    -1 & -1
  \end{bmatrix}
\end{align*}
is 1.05 with a p-value of 0.59.

In an effort to see how important the intervention dummies are in fitting
the empirical model, figure 7 plots the estimated cointegrating vectors with
and without the intervention dummies. The vectors derived using the inter-
vention dummy variables appear to be much more stable (stationary) than
the two without accounting for structural breaks in the relationship.

4.4.2 Common Stochastic Trends

Figure 8 displays the estimated common trends from equation (12) without
dummies and with dummies.

The intervention dummies make the largest impact on the fit of the stock
price common trend. In the top left panel of figure 8 the estimated common
trend of stock prices or its permanent component only passes through the
actual series seven times over the entire sample period. This may explain,
in part, the poor performance of models that use ”fundamentals” to forecast
stock prices. The top right panel of figure 8 shows that when the periods of
instability, as measured by instability in the long-run equilibrium relation-
ship, are modelled, the permanent component of stock prices ”fits” the actual
series much more closely. This can also be seen by examining the transitory
components obtained with and without intervention dummies in figure 9.

---

\textsuperscript{13} The standard critical values for the Johansen trace statistics are no longer valid when intervention dummies are included in the VECM. We simulated appropriate critical values using the program DisCo (1993) by Bent Nielsen.
Figure 5: Recursive Trace Statistics with Intervention Dummies
Figure 6: Test of Stability of Cointegration Vectors with Intervention Dummies
Figure 7: Cointegration Vectors
Figure 8: Estimated Common Stochastic Trends
Figure 9: Transitory Components
4.4.3 Impulse Responses and Historical Decompositions

We calculate impulse response functions (IRFs) from the common trends representation of equation (12). Since there are two cointegrating relationships among the three variables, we need one extra restriction in order to identify a structural model for the interpretation of IRFs, as discussed in section 3.3.2. The restriction we impose is that transitory stock price innovations have no contemporaneous (within the quarter) effect on earnings. This seems to be a reasonable restriction from an intuitive standpoint since it would be hard to argue why transitory shocks to the stock price, not originating from either of the other variables, would alter earnings contemporaneously.\footnote{An alternative identifying restriction would be to restrict transitory earnings shocks to have no immediate impact on dividends. While the dividend smoothing hypothesis would support such a restriction, the fact that it is earnings and not dividends that is weakly exogenous makes this assumption difficult to support.}

Figure 10 plots the IRFs of each variable to a permanent shock. We can identify the source of this shock econometrically by noting that earnings is the only variable that is weakly exogenous to the long-run parameter set and therefore permanent earnings shocks must be the source of the common trend.\footnote{The likelihood ratio test of the restriction that earnings is weakly exogenous is 1.84 which is distributed as a $\chi^2(2)$ variate. The analogous tests for stock price and dividends is 13.79 and 8.80, respectively.} The response of stock prices is interesting in that they appear to "overshoot" their long-run equilibrium value driving the equilibrium P/E ratio temporarily higher. Note that the dividend payout ratio is not significantly affected implying that if firms set dividends to equal the permanent component of earnings they do a fairly good job at accurately measuring that permanent component.

Figure 11 plots the IRFs from a transitory shock to earnings. Here a temporarily higher earnings level does not elicit an increase in dividends by firms, the response of dividends is statistically insignificant, consistent with the dividend smoothing hypothesis. But perhaps the most interesting response pattern is that of stock prices. Stock prices actually fall in response to a temporary increase in earnings. This effect is difficult to explain.

Figure 12 displays the IRFs attributable to a transitory stock price increase. There is a very small short-term effect on dividends, perhaps as firms attempt to "signal" that the rise in stock price is not warranted by earnings. Earnings are also affected in the short run, most likely through the increase in stock price expanding the availability of capital.
Figure 10: IRFs and 90% Confidence Bands
Figure 11: IRFs and 90% Confidence Bands
Figure 12: IRFs and 90% Confidence Bands
Figure 13: Historical Decomposition of Stock Prices

Figure 13 plots the estimated historical decomposition of stock price into an "explained" or fitted component and then components attributable to each of the structural innovations. There are several interesting results here. First, the largest contributor to stock price variation is clearly transitory stock price shocks. Since these shocks are not associated with changes in any identified "fundamentals", one may consider these "bubbles". The second interesting result is that since the mid-1980s, permanent earnings shocks, but especially transitory earnings shocks, have become more important in explaining the variability of stock prices. This suggests that the recent increase in stock prices may not be unjustified based on the changes in identified fundamentals.

To see just how important accounting for the structural instability in the
Figure 14: IRFs and 90% Confidence Bands - No Dummies

equilibria is, we estimated IRFs for the model without dummies but with the present value restrictions imposed. These are found in figures 14 to 16. The most striking difference from the IRFs in figure 14 compared to those in figure 10 is the response of stock prices. Without accounting for the structural instability in the long-run relationships, the model misses the overshooting of stock prices to permanent earnings shocks. Similarly, transitory earnings shocks have no significant effect on stock prices or dividends (or on earnings for that matter). The responses associated with the transitory stock price innovations, figure 16, are not qualitatively much different from those in figure 12.

Finally we estimated the historical decompositions associated with the
Figure 15: IRFs and 90% Confidence Bands - No Dummies
Figure 16: IRFs and 90% Confidence Bands - No Dummies
no-intervention-dummies model. These are displayed in figure 17. Like in figure 13, most of the "unexplained" stock price variation is captured by movements in transitory stock price shocks. But the relative contributions of earnings shocks, both transitory and permanent, are much larger in this specification, especially in the late 1970s and early 1980s. Most telling is that the historical decomps imply that the recent runup in stock prices is not supported by innovations in the fundamentals of permanent earnings shocks.
5 Conclusions

In this paper we provide a more detailed investigation of empirical linkages between stock prices, dividends and earnings, that have previous research. In order to analyze the long-run equilibrium linkage between stock prices, dividends, and earnings, we employ a cointegrated structural VAR technique using quarterly data (expressed in natural logs) over the period 1947:1-1994:4. Our results find empirical evidence consistent with valuation models that imply that stock prices, dividends and earnings, share a single common trend. We find that we cannot reject two cointegrating vectors in this system when we account for instability during the early 1950s, the early 1970s and the later half of the 1980s. Accounting for this instability, we find that we cannot reject the cointegrating restrictions suggested by present value models relating stock prices to dividends and earnings. A structural cointegrated VAR approach is employed to identify permanent and transitory components of all three series, price, dividend, and earnings. Contrary to the dividend smoothing hypothesis, earnings, not dividends, is found to be the common trend component of the trivariate system. We next calculate impulse response functions from the common trends representation of trivariate system with two cointegrating vectors. In order to identify the transitory component, we impose the transitory restriction that transitory stock price innovations have no contemporaneous (within quarter) effect on earnings. We first plot IRF for each variable to a permanent shock. We identify the source of this shock econometrically by noting that earnings is the only variables that is weakly exogenous to the long-run parameter set and hence, permanent earnings shocks must be the source of the common trend. We find that, in response to a permanent shock to earnings, stock prices overshoot their long-run equilibrium value, moving the equilibrium P/E ration temporarily higher. The payout ratio (D/E), however, is not significantly affected. This suggests that if firms set dividends equal to the permanent component of earnings they do a reasonably good job of measuring that permanent component. We also report IRFs from a transitory shock to earnings. A temporary high earnings does not lead to a significant increase in dividends by firms, a finding consistent with the dividend smoothing hypothesis. One puzzling result is that stock prices actually fall in response to a transitory shock to earnings. We next plot the estimated historical decompositions of stock price into an explained or fitted component, and then components attributable to each of the structural innovations. We find that the largest contributor to
stock price variation is transitory stock price shocks. As these shocks are not associated with any changes in any identifiable with any "fundamentals" one may consider these "bubbles". In addition, we find that since the mid-1980s permanent earnings shocks, and especially temporary earnings shocks, have become more important in explaining the variability in stock prices. This suggests that the recent increase in stock prices may not be unjustified based on the changes in identifiable fundamentals. When we re-examine our results, without accounting for instability during the time periods mentioned above, our findings are not consistent with theoretical restrictions and implications.
References


