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Stock earnings and bond yields in the US 1871–2017: The story of a changing relationship

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ABSTRACT

Using historical data spanning almost 150 years, we examine whether there is a long-run equilibrium relationship between the stock's earnings and bond yields. The novelty of our econometric methodology consists in using a vector error correction model where we allow multiple structural breaks in the equilibrium relationship. The results of our analysis suggest the existence of an equilibrium relationship over 1871–1932 and 1958–2017. On the two historical segments, our analysis finds that the stock's earnings yield followed the bond yield in both the short run and long run, but not the other way around. Perhaps the most important and surprising finding of our empirical study is that, after the break in 1932, a completely new equilibrium relationship re-emerged in 1958 that was later termed the “Fed model.” Our main argument for the emergence of a new equilibrium relationship is that a major “paradigm shift” in the stock valuation theory occurred in the late 1950s. To support our argument, we highlight the main historical events that potentially could have caused the transition from the old to the new paradigm. Finally, we identify the primary impetus for the paradigm shift.

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1. Introduction

The majority of academics and investment professionals agree that there should be a positive relationship between the stock's earnings yield and bond yield. There are two strong arguments that support this rationale. The first argument is based on the idea that stocks and bonds are two major asset classes that compete for investors capital. Hence, if the bond yield increases, stock prices should decrease in order for the stock's earnings yield to increase to maintain the competitiveness of stocks. The second argument is grounded on the idea that the stock price is the discounted present value of its future cash flow. Therefore, if interest rates fall, the present value rises and, consequently, the stock's earnings yield decreases.

The most widespread model among the investment professionals is the “Fed model”, which postulates that the stock's earnings yield should be approximately equal to the long-term bond yield. Formally, the Fed model postulates

$$\frac{E}{P} = Y, \quad (1)$$

where E/P is the stock market earnings-to-price ratio and Y is the yield on the long-term (government) bonds. However, even though strong empirical support for this model is found in many academic studies, there are two problems with the Fed model. First, the Fed model lacks a solid theoretical underpinning. Specifically, the theoretical problem with the Fed model is that it seems to imply that investors do not require risk premium for holding stocks. Second, several academic studies report that the Fed model is supported by data that start from around 1960 only. Prior to this date, there is no empirical support for the Fed model.

The Fed model is very restrictive and was first mentioned for the US in a July 1997 Federal Reserve Monetary Policy Report to

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Congress by Alan Greenspan. Long before Alan Greenspan's mentioning of the Fed model, [Graham and Dodd \(1934\)](#) advocated for a much less restrictive relationship between the stock's earnings and bond yields. Specifically, they presumed that the stock market yield should be equal to the bond yield times a suitable "multiplier"

$$\frac{E}{P} = M \times Y, \quad (2)$$

where $M > 1$ denotes a multiplier on Y . The rationale for this multiplier is that stocks are riskier than bonds and that investors should therefore require compensation for bearing the risk.

Understanding the historical relationship between the stock's earnings yield and bond yield is very crucial in many aspects. First, the knowledge of the relationship provides important insights to both investment professionals and academics on how investors have been valuing stocks versus bonds and how this valuation has been changing over time. Second, financial markets play an increasingly important role in the economy. Typically, a financial crisis is followed by an economic recession. The Fed uses monetary policy to offset the effects of a recession. Therefore, it is necessary to understand the effects of monetary policy on asset prices. In this regard, it is particularly interesting to investigate the causality relationship between the stock's earnings and bond yields. The knowledge of the causality relationship is paramount for academics, investment professionals, and monetary policymakers. In particular, armed with the knowledge of the causality relationship between the stock's earnings and bond yields, monetary policymakers are able to predict the effect of a new monetary policy on the stock prices and yields. At the same time, investment professionals are able to make optimal capital allocation decisions, and academics are able to refine their theories.

This paper aims to examine the empirical validity of the Graham and Dodd model using US data spanning a very long historical period, 1871–2017. Regarding the econometric methodology, we use a cointegrated vector autoregressive model, also known as a vector error correction model (VECM), which allows us to investigate both the short-term and long-term dynamics of the relationship between the stock's earnings and bond yields. The latter is the most important for our study because our hypothesis is that there is a long-run equilibrium relationship between the stock's earnings yield and the bond yield. Specifically, the existence of a long-run equilibrium relationship implies that a deviation from the long-run equilibrium, the error, serves as the restoring force that brings the relationship back towards equilibrium. The VECM also helps us to establish the causality relationship between variables. In particular, our econometric methodology allows us to determine which of the two yields is the cause of the change in the value of the other yield in the relationship.

Although there are already several empirical studies on testing the Fed model using a cointegration analysis ([Estrada, 2009](#); [Koivu, Pennanen, & Ziemba, 2005](#)), the novelty of our econometric methodology is twofold. First, we use a much longer historical period that spans almost 150 years. Second, we allow multiple structural breaks in the equilibrium relationship.¹ Specifically, in all previous studies, the researchers focus their attention on the relatively recent period that starts from the early 1960s or even later. In our study, on the other hand, the historical period starts from 1871. Whereas in all preceding studies no structural breaks in the relationship between the two yields were allowed, we employ the modern methodology of testing for multiple structural changes.

¹ In brief, the motivation for allowing multiple structural breaks is as follows. Over a very long run, the dynamics of financial markets are subject to evolutionary changes ([Evstigneev, Hens, & Schenk-Hoppe, 2009](#); [Lo, 2004, 2017](#)). Therefore, the equilibrium relationship between the two yields can also be subject to evolutionary changes.

This methodology of detecting multiple breakpoints was developed in the late 1990s ([Bai, 1997](#); [Bai & Perron, 1998](#)). However, efficient and robust algorithms of dating multiple structural changes were developed only in the early 2000s ([Bai & Perron, 2003](#); [Zeileis, Kleiber, Kramer, & Hornik, 2003](#)). As a result, the broad practical application of the methodology for dating multiple structural changes has started relatively recently.

The uniqueness of our analysis can be summarized as follows. Our working hypothesis is that there is a long-run equilibrium relationship between the stock's earnings and bond yields, but this relationship is subject to structural changes over time. Given the very long historical data, the goal of this paper is to find the structural breaks in the relationship, investigate the direction of causality in the relationship, and try to explain the causes of the breaks.

The first contribution of this paper is to provide statistically significant evidence in support of our working hypothesis. The main empirical findings in the paper can be summarized as follows. Our structural break analysis identifies two major breaks in the relationship between the stock's earnings and bond yields: in 1932 and in 1958. Moreover, our cointegration analysis advocates for the presence of the equilibrium relationship between the two yields over the periods 1871–1932 and 1958–2017. That is, the relationship broke down in 1932 and was later re-established in 1958. On both historical segments 1871–1932 and 1958–2017, our analysis finds a unidirectional short- and long-run Granger causality running from the bond yield to the stock's earnings yield. In other words, on both segments, the stock's earnings yield followed the bond yield in both the short run and the long run, but not the other way around. Perhaps the most important and surprising finding of our empirical study is that the multiplier in the relationship $E/P = M \times Y$ has changed from $M \approx 2$ over the period from 1871 to 1932 to $M \approx 1$ over the period from 1958 to 2017.

The second contribution of this paper is to suggest plausible explanations for the breaks in the relationship between the stock's earnings and bond yields and for why the multiplier in the equilibrium relationship has changed from 2 to 1. In brief, our story goes as follows. The breakdown of the equilibrium relationship in 1932 is explained by the stock market crash at the end of 1929 and the following Great Depression forcing the Fed to start conducting an expansionary monetary policy by lowering the short-term interest rate to nearly zero and decreasing substantially the long-term interest rate. Due to the government need to finance World War II (WWII) and the subsequent recession that ended in 1949, the interest rates were deregulated only after 1951. We demonstrate that the Fed monetary policy was responsible for the abnormal relationship between the short- and long-term interest rates over the period from 1930 to 1959. It is much more challenging to explain the re-establishment of a completely new equilibrium relationship between the stock's earnings and bond yields in 1958. Our main argument is that a major "paradigm shift" in the stock valuation theory occurred in the late 1950s. To support our argument and explain the transition from the old to the new paradigm, we highlight the main historical events, which took place during 1910–1960, that potentially could have caused the transition from one paradigm to another. Finally, we identify the primary impetus for the paradigm shift.

The remainder of this paper is organized as follows. Section 2 reviews the theoretical and empirical literature, while Section 3 presents the econometric methodology. Section 4 describes the data employed in the paper, identifies the breaks in the relationship using structural break analysis, and investigates the direction of causality in the relationship. Section 5 suggests the key forces behind the breaks in the relationship between earnings and bond yields. Section 6 provides the reader with the explanations of the breaks. Finally, Section 7 concludes the paper.

2. Review of the theoretical and empirical literature

Graham and Dodd (1934) distinguish between the “old-fashioned” (or “traditional”) theory of stock investing and the “modern-era” theory. According to Graham and Dodd, the shift from the traditional approach to stock selection to the new approach occurred at some point in 1927.

In the traditional theory, the chief emphasis was laid upon the stability of dividends and earnings in the durable past and reasonable relation between the earnings and the price. Specifically, the stock investors at that time sought to place themselves as nearly as possible in the position of the bond investors. In other words, they aimed primarily at a steady income return from common stocks. Since common stocks were perceived to be much riskier than bonds, the investors required that the income from common stocks must be greater than that from bonds. That is, the stock dividend yield (a.k.a. dividend-to-price ratio, D/P ratio) must be greater than the bond yield. Formally, $D/P > Y$, where Y is the bond yield.

Graham developed a concept known as the “fair” (or “intrinsic”) value of a stock and emphasized the fact that the value of a stock usually differs from its price. He promoted the idea that common stocks should be bought mainly during periods when they are undervalued. To determine whether the stock market is overvalued or undervalued, Graham suggested using the methodology previously employed by Roger Babson² (see Graham & Dodd, 1934, Chapter 50). This methodology consisted in using the stocks in the Dow Jones Industrial Average and “determine an indicated ‘normal’ value for this group by applying a suitable multiplier to average earnings” (Graham & Dodd, 1934, page 693). Put differently, Graham advocated that, under “normal” conditions, the relationship between the stock earnings yield (E/P) and the bond yield must be $E/P = M \times Y$.

According to Graham, in 1927 the interest in common stocks reached its height and the traditional theory was replaced by the modern-era theory:

“during the postwar period, and particularly during the latter stage of the bull market culminating in 1929, the public acquired a completely different attitude towards the investment merits of common stocks... The new theory or principle may be summed up in the sentence: *The value of a common stock depends entirely upon what it will earn in the future.*” (Graham & Dodd, 1934, page 355, our emphasis)

That is, whereas in the traditional theory, the approach to stock selection was “backward looking”, in the new era theory, the approach to stock selection was “forward looking”. Specifically, “the analyst sought to look into the future and to select the industries or the individual companies that were likely to show the most rapid growth” (Graham & Dodd, 1934), page 353). That is, the analysts turned their attention from the company’s dividends, earnings, and asset values to exclusively the earnings trend in the recent past; this earnings trend was then projected into the observable future.

Even though the idea that “the value of a common stock depends entirely upon what it will earn in the future” emerged in the late 1920s, the first stock valuation method based on this idea appeared a decade later in the book by Williams (1938). This valuation method was later called the dividend discount model (DDM). Under the assumption that the dividend growth is constant, Gordon and Shapiro (1956) showed that the current “intrinsic” stock price P is given by

$$P = \frac{D}{k - g}, \quad (3)$$

where D is the next period dividends, k is the required rate of return, and g is the dividend growth rate. This valuation formula is known as the Gordon growth model (GGM).

Since $D = b \times E$, where E is the next period earnings and b is the payout ratio ($0 \leq b \leq 1$), and the earnings growth rate g is computed as the retention rate ($1 - b$) times the return on new investment k^* , the stock valuation formula can be written as

$$P = \frac{b \times E}{k - (1 - b)k^*}. \quad (4)$$

In the case $k^* = k$, the firm’s dividend policy does not matter and the stock valuation formula reduces to $P = E/k$, which can be rewritten as

$$\frac{E}{P} = k. \quad (5)$$

As applied to the stock market as a whole, the formula above says that the stock market earnings yield should equal the required return on the market. However, there is no common agreement among financial analysts about how to determine the appropriate market return. Williams (1938) suggested that, in choosing the appropriate rate, the return on alternative and less risky assets such as Treasury bills and bonds must be taken into account, as well as the uncertainty inherent in the long-run estimate of future cash dividends. The idea was that the appropriate market return had to compensate investors for the risk taken; the market return should therefore exceed the rate on less risky assets. Since bonds are considered to be less risky than stocks, and denoting by RP the risk premium for holding stocks, Eq. (5) can be restated as

$$\frac{E}{P} = Y + RP = \left(1 + \frac{RP}{Y}\right) Y = M \times Y,$$

where $M = 1 + RP/Y$ denotes a multiplier on Y . Apparently, the valuation formula above is the same as that previously suggested by Graham and Dodd. In the Graham and Dodd model, $M > 1$ because the risk premium is strictly positive. On the other hand, in its most popular form, the Fed model states that in equilibrium, the stock market earnings yield should equal the long-term bond yield

$$\frac{E}{P} = Y.$$

Apparently, the Fed model is a special case of the GGM. The Fed model can be reconciled with the existing financial theory under very restrictive assumptions. Specifically, the Fed model is valid when either all earnings are paid out as dividends ($E = D$) or the return on new investment equals the required rate of return ($k^* = k$), there is no growth in dividends ($g = 0$), and the investors require no more return from stocks than from bonds ($RP = 0$). Additionally, the Fed model can be justified in a special case where $Y = k - g$, that is, when the bond yield equals the required rate of return less the growth rate of dividends.

In sum, most of the academics have noted that the Fed model is inconsistent with a rational valuation of the stock market (see, for instance, Ritter and Warr (2002), Asness (2003), Campbell and Vuolteenaho (2004), Estrada (2006), Estrada (2009), Sharpe (2002), and Feinman (2005)). From a theoretical point of view, the Fed model can be partially explained by the “money illusion” hypothesis (see Campbell and Vuolteenaho (2004), Cohen, Polk, and Vuolteenaho (2005), and Feinman (2005)). Money illusion is the tendency of investors to discount future cash flows using nominal, rather than real, interest rates. In our context, if investors project future dividends in real terms but discount them using nominal rates, they arrive at a lower estimate for the earnings yield. Bekaert

² Roger Babson was an American entrepreneur, economist, and business theorist in the first half of the 20th century. He is famous for predicting the stock market crash of 1929.

and Engstrom (2010) demonstrate that the Fed model can be reconciled with modern asset pricing theory under assumptions that the investors exhibit habit-based risk aversion and expect increased inflation during recessions. Finally, Asness (2000, 2003) presents a behavioral explanation for the Fed model. Specifically, Asness conjectures that the relation between stock earnings and bond yields is influenced by the experience of each generation of investors with each asset class. Asness shows that starting from the mid-1950s, the riskiness of stocks has been decreasing, while the riskiness of bonds has been increasing. As a result, starting from the 1960s, investors might have perceived stocks and bonds to be of similar riskiness.

Even though the Fed model has often been criticized on theoretical grounds, solid empirical support for this model is found in many academic studies (Berge, Consigli, & Ziemba, 2008; Koivu et al., 2005; Lander, Orphanides, & Douvogiannis, 1997; Lleo & Ziemba, 2015, 2017; Maio, 2013). However, several academic studies report that the Fed model is supported by data that start from around 1960 only (Asness, 2000, 2003; Estrada, 2006, 2009). Prior to this date, there is no empirical support for the Fed model.

3. Econometric methodology

3.1. Testing for structural breaks

Consider the standard linear regression model

$$y_t = \mathbf{x}'_t \boldsymbol{\beta}_t + u_t, \quad t = 1, \dots, T, \tag{6}$$

where at time t , y_t is the observation of the dependent variable, \mathbf{x}_t is the $k \times 1$ vector of observations of the independent variables, $\boldsymbol{\beta}_t$ is the $k \times 1$ vector of unknown regression coefficients, and u_t is an unobservable disturbance term. We are interested in the null hypothesis that $\boldsymbol{\beta}_t = \boldsymbol{\beta}_0$ for all t against the alternative that $\boldsymbol{\beta}_t$ varies over time. To test the null hypothesis, we employ the recursive CUSUM test (Brown, Durbin, & Evans, (1975), Kramer, Ploberger, and Alt (1988), Ploberger and Kramer (1992)).

The recursive CUSUM test starts with the recursive least-squares estimates of $\hat{\boldsymbol{\beta}}_n$ based on the first n observations, $n = k + 1, \dots, T$. This procedure gives $T - k$ estimates ($\hat{\boldsymbol{\beta}}_{k+1}, \dots, \hat{\boldsymbol{\beta}}_T$). Each of the estimates is obtained using

$$\hat{\boldsymbol{\beta}}_n = (\mathbf{X}'_n \mathbf{X}_n)^{-1} \mathbf{X}'_n \mathbf{y}_n, \quad n = k + 1, \dots, T,$$

where \mathbf{X}_n is the $n \times k$ matrix of observations of the independent variables up to time n and \mathbf{y}_n is the $n \times 1$ vector of observations of the dependent variable up to time n .

The recursive CUSUM test uses the standardized errors from the recursive one-step ahead forecast of y_t based on $\hat{\boldsymbol{\beta}}_{t-1}$

$$w_t = \frac{y_t - \mathbf{x}'_t \hat{\boldsymbol{\beta}}_{t-1}}{\sqrt{1 + \mathbf{x}'_t (\mathbf{X}'_{t-1} \mathbf{X}_{t-1})^{-1} \mathbf{x}_t}}.$$

The recursive CUSUM statistic is defined by

$$CUSUM_t = \frac{1}{\hat{\sigma}_w \sqrt{T-k}} \sum_{n=k+1}^t w_n, \quad t = k + 1, \dots, T,$$

where $\hat{\sigma}_w = \sqrt{\frac{1}{T-k} \sum_{n=k+1}^T (w_n - \bar{w})^2}$ is the estimated standard deviation of w_n and \bar{w} is the average value of w_n . When the number of observations increases, $CUSUM_t$ converges in distribution to the standard Wiener process (i.e., Brownian motion). Under the null hypothesis of no structural breaks, the mean value of $CUSUM_t$ is zero and the standard deviation is $\sqrt{T-k}$. Therefore, the p -value of the test is determined by the probability of a Wiener process crossing the standard pair of linear boundaries $b_t = \lambda(1 + 2t)$ or $b_t = -\lambda(1 + 2t)$, where λ depends on the significance level α of

the test (Brown et al., 1975). Visual examination of the graph of CUSUM can be useful in identifying the structural breaks. Specifically, straight lines in a graph correspond to periods of no structural change, whereas sustained changes in the CUSUM slope signify that a change has occurred. The slope inflection point indicates when the change happened (or became observable).

3.2. Detecting the breakpoints

The foundation for estimating a single break in time series regression models was given by Bai (1994) and was further extended to multiple breaks by Bai (1997), Bai and Perron (1998), and Bai and Perron (2003). We assume that there are m breakpoints in the standard linear regression model given by Eq. (6), where the coefficients shift from one stable regression relationship to a different one. Specifically, we assume that there are $m + 1$ segments in which the regression coefficients are constant, and model (6) can be rewritten as

$$y_t = \mathbf{x}'_t \boldsymbol{\beta}_j + u_t, \quad t = t_{j-1} + 1, \dots, t_j, \quad j = 1, \dots, m, \tag{7}$$

where j is the segment index and t_1, \dots, t_m denotes the set of the breakpoints (this set is also called m -partition). By convention, $t_0 = 0$ and $t_{m+1} = T$.

The dating of structural changes is performed as follows. Given an m -partition t_1, \dots, t_m , the least-squares estimates for the $\boldsymbol{\beta}_j$ can easily be obtained. The resulting total residual sum of squares is given by

$$RSS(t_1, \dots, t_m) = \sum_{j=1}^{m+1} rss(t_{j-1} + 1, t_j),$$

where $rss(t_{j-1} + 1, t_j)$ is the residual sum of squares in the j th segment. The problem of dating structural changes is to find the breakpoints $\hat{t}_1, \dots, \hat{t}_m$ that minimize the following objective function

$$(\hat{t}_1, \dots, \hat{t}_m) = \operatorname{argmin}_{t_1, \dots, t_m} RSS(t_1, \dots, t_m)$$

over all feasible partitions (t_1, \dots, t_m) . To find the global minimum of the objective function, we employ the dynamic programming approach suggested by Bai and Perron (2003).

3.2.1. Vector error correction model

Two nonstationary data series x_t and y_t are said to be cointegrated if their linear combination is stationary. In our context, the evidence of cointegration is established if the disturbance term, u_t , in the linear regression

$$y_t = \beta x_t + u_t, \tag{8}$$

is stationary. If we find this to be the case, the condition $y_t = \beta x_t$ is interpreted as the long-run equilibrium relationship between the two data series, whereas the disturbance term u_t is interpreted as the deviation from the long-run equilibrium.

Engle and Granger (1987) provide a representation theorem stating that if two data series are cointegrated, then there exists a vector error correction representation taking the following form:

$$\begin{aligned} \Delta x_t &= c_1 + \text{lagged}(\Delta x_t, \Delta y_t) + \gamma_1 u_{t-1} + \varepsilon_{1,t}, \\ \Delta y_t &= c_2 + \text{lagged}(\Delta x_t, \Delta y_t) + \gamma_2 u_{t-1} + \varepsilon_{2,t}, \end{aligned} \tag{9}$$

where either $\gamma_1 \neq 0$ or $\gamma_2 \neq 0$ or both. The vector error correction model (VECM) given by (9) is the vector autoregressive model (VAR) in the first differences with one lagged error correction term. In the VECM above, the changes in Δx_t and Δy_t are caused by the previous changes in these variables and the changes in u_{t-1} . The γ_i coefficients are the error correction coefficients. They measure

the response of each variable to the degree of deviation from the long-run equilibrium in the previous period. We expect that $\gamma_i < 0$ because if, for example, y_{t-1} is above its long-run value in relation to x_{t-1} , then the error correction term is positive, which should lead, other things being constant, to downward movement in y_t .

In a VECM, there are two possible sources of causality (Granger, 1988). For example, the change in Δy_t may be caused by the changes in the lagged values of Δx_t and/or by the changes in u_{t-1} if $\gamma_2 \neq 0$. The first source of causality is often interpreted as a “short-run” causality in the sense that the dependent variable responds to the short-term shocks in the independent variable. The second source of causality is often interpreted as a “long-run” causality in the sense that the dependent variable responds to the deviations from the long-run equilibrium.

4. Empirical study of the relationship between stock earnings and bond yields

4.1. Data and preliminary analysis

The data for the study in this paper are the quarterly prices of Standard and Poor's Composite stock price index, earnings on this index, and the long-term government bond yield. The data span the long-run historical period from the first quarter of 1871 through the fourth quarter of 2017. The data on the earnings from the S&P Composite index and the long-term government bond yield are provided by Robert Shiller.³ The data on the S&P Composite index come from two sources.⁴ The price index for the period from 1926 to 2017 is from the Center for Research in Security Prices (CRSP); these data are provided by Amit Goyal.⁵ The price index for the period from 1871 to 1925 is provided by Goetzmann, Ibbotson, and Peng (2001).⁶ Using the earnings and prices, we compute the earnings-to-price ratio (E/P). Fig. 1 plots the original data series.

Our hypothesis is that there exists a long-run equilibrium relationship between the stock earnings and bond yields. We analyze this relationship using the following linear regression model

$$\ln(E_t/P_t) = \beta \ln(Y_t) + u_t. \quad (10)$$

The basic definition of cointegration is laid out in Engle and Granger (1987): If there exists a stationary linear combination of nonstationary random variables, the variables combined are said to be cointegrated. We expect variables $\ln(E_t/P_t)$ and $\ln(Y_t)$ to be nonstationary but the residuals u_t to be stationary. Therefore, the first step in our analysis is to examine the time series properties of our data by testing for a unit root over the full sample.

Since our data represent very long time series that cover different historical stages and policy regimes, the equilibrium relationship can be subject to discontinuities. As a consequence, the assumption of stability in the long-run relationship between the stock earnings and bond yields would be too restrictive. The relationship between stock earnings and bond yields has likely changed over time due to variations in macroeconomic forces, changes in the economy, and regulatory reforms. Since we suspect structural

Table 1

The results of the unit root tests over the full sample. Here, u_t are the residuals from the linear relationship between $\ln(E_t/P_t)$ and $\ln(Y_t)$.

Variable	Test statistic	Potential breakdate(s)
<i>Conventional ADF test by Dickey and Fuller (1979)</i>		
$\ln(E_t/P_t)$	-1.141	
$\ln(Y_t)$	-0.971	
$\Delta \ln(E_t/P_t)$	-15.271***	
$\Delta \ln(Y_t)$	-20.117***	
u_t	-3.182***	
<i>One-break ADF test by Zivot and Andrews (2002)</i>		
$\ln(E_t/P_t)$	-6.333***	1990 Q3
$\ln(Y_t)$	-3.930	1967 Q1
u_t	-5.192**	1957 Q4
<i>One-break LM test by Lee and Strazicich (2013)</i>		
$\ln(E_t/P_t)$	-6.050**	1985 Q1
$\ln(Y_t)$	-2.936	1968 Q3
u_t	-4.751**	1958 Q1
<i>Two-break ADF test by Narayan and Popp (2010)</i>		
$\ln(E_t/P_t)$	-6.648***	1972 Q3, 1984 Q3
$\ln(Y_t)$	-3.531	1905 Q2, 1958 Q1
u_t	-5.660***	1933 Q2, 1957 Q4
<i>Two-break LM test by Lee and Strazicich (2003)</i>		
$\ln(E_t/P_t)$	-7.197**	1973 Q4, 2002 Q1
$\ln(Y_t)$	-5.166	1955 Q3, 1984 Q3
u_t	-5.978**	1958 Q1, 2002 Q2

*Denotes statistical significance at the 10% levels.

** Denotes statistical significance at the 5% levels.

*** Denotes statistical significance at the 1% levels.

breaks in our time series, unit root tests need to make allowance for the presence of breaks. Otherwise, as demonstrated by Perron (1989), the standard unit root tests are biased towards the non-rejection of the null hypothesis.

Another motivation for conducting unit root tests that allow for structural breaks is to ensure that the assumptions behind the recursive CUSUM test and the breakpoint detection methodology by Bai and Perron (1998) are fully satisfied. Specifically, the CUSUM test assumes the stationarity of the residuals (see, for example, Ploberger and Kramer (1992)). Prodan (2008) points to the limitations of the Bai and Perron methodology in the presence of persistent series. In particular, Prodan (2008) shows that, when data are highly persistent, the Bai and Perron methodology has low power and tends to reject the no-structural-change hypothesis too often when it is true. Consequently, since we expect variables $\ln(E_t/P_t)$ and $\ln(Y_t)$ to be nonstationary, the Bai and Perron methodology can be used on only residuals u_t that are supposed to be stationary. Alternatively to the Bai and Perron methodology to detect multiple breaks, modern unit root tests that allow structural breaks can be used to detect up to two structural breaks in a time series.

Table 1 reports the results from a number of unit root tests. We begin with the conventional augmented Dickey-Fuller (ADF) test (Dickey & Fuller, 1979). The conventional ADF test rejects the unit root null hypothesis only for the residuals implying that both $\ln(E_t/P_t)$ and $\ln(Y_t)$ are nonstationary time series. However, these two time series become stationary after differencing. We then proceed with the unit root tests that allow for one structural break. These tests are the one break ADF test by Zivot and Andrews (2002) and one break minimum Lagrange multiplier (LM) test by Lee and Strazicich (2013). These tests reject the unit root hypothesis for both the residuals and the log of the stock market earnings yield. Finally, we apply the unit root tests that allow for two structural breaks. These tests are the two-break ADF test by Narayan and Popp (2010) and two-break LM test by Lee and Strazicich (2003). These tests also reject the unit root hypothesis for both the residu-

³ See <http://www.econ.yale.edu/~shiller/data.htm>.

⁴ Although Robert Shiller also provides data on the S&P Composite stock price index, these data cannot be used in our analysis because Robert Shiller constructs the price index using the average of high and low monthly prices. Averaging high and low prices introduces a large first-order serial correlation problem for stock returns, see Working (1960).

⁵ Downloaded from <http://www.hec.unil.ch/agoyal/>. These data were used in the widely cited paper by Goyal and Welch (2008).

⁶ See <https://som.yale.edu/faculty-research/our-centers-initiatives/international-center-finance/data/historical-newyork>. To check the robustness of our findings, we also used the price data for the period from 1871 to 1925 provided by Schwert (1990). We found that regardless of the choice of the price index for the period 1871 to 1925, our empirical results remain intact.

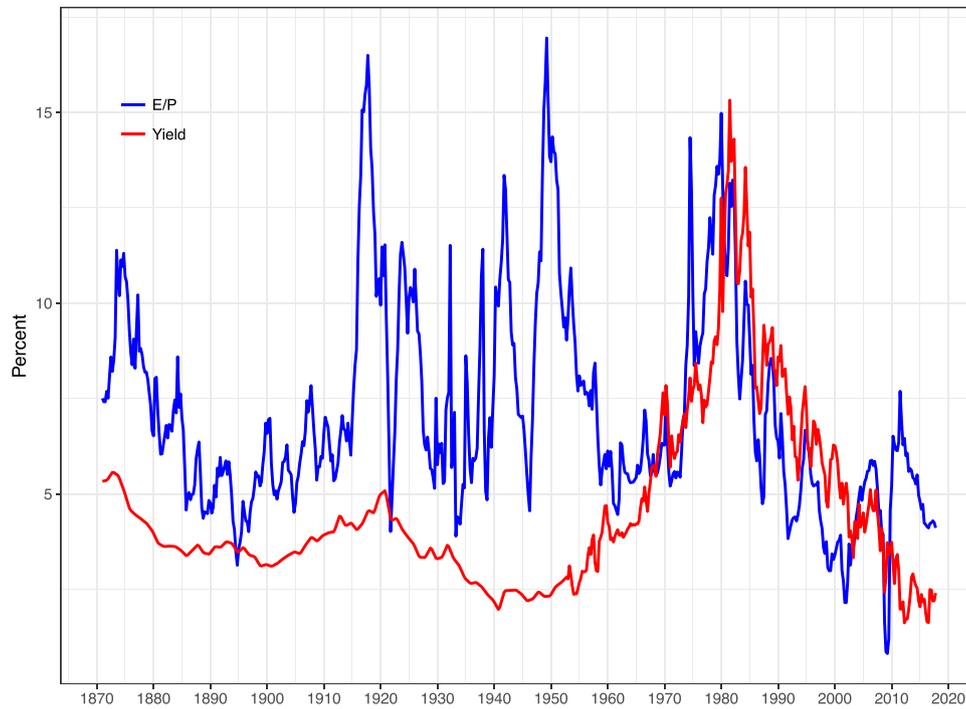


Fig. 1. The original data series: quarterly earnings-to-price ratio (E/P) and the long-term government bond yield (Yield).

als and the log of the stock market earnings yield. Consequently, we conclude that the residuals from the cointegration relationship are stationary but subject to structural breaks. The log of the bond yield series, $\ln(Y_t)$, are $I(1)$ with trend breaks, while the log of the stock earnings yield series, $\ln(E_t/P_t)$, could be $I(1)$ with trend breaks or stationary around a broken trend.

4.2. Structural breaks in the relationship and breakpoints detection

The results reported in the previous section suggest the existence of a long-run equilibrium relationship between the stock earnings and bond yields, but this relationship is subject to structural breaks. These results also suggest that the residuals from the cointegration relationship are stationary; hence, the assumption behind the recursive CUSUM test is satisfied. However, the results further reveal that both $\ln(E_t/P_t)$ and $\ln(Y_t)$ are highly persistent series and, as a consequence, the Bai and Perron methodology to detect the breaks may have low power.

The breaks in the cointegration relationship can alternatively be detected by the examination of the residuals using unit root tests that allow for breaks. The results of both the one-break ADF test by Zivot and Andrews (2002) and one-break LM test by Lee and Strazicich (2013) are fairly unanimous and suggest that a major break in the residuals occurred around 1957–1958. However, regarding the date of the second break, the two-break unit root tests disagree. Whereas the two-break ADF test by Narayan and Popp (2010) identifies the second break date in 1933, the two-break LM test by Lee and Strazicich (2003) finds the second break in 2002.

To summarize, the results of the two-break unit root tests are inconclusive with respect to the date of the second break in the residuals. In addition, a major disadvantage of these tests is that they allow for a maximum of two breaks. Therefore, to further study the structural breaks in the cointegration relationship and identify the break dates, we rely on the examination of the residuals. For this purpose, we study the following linear regression model for the residuals

Table 2

Results of detecting multiple breakpoints. m denotes the number of breakpoints. BIC denotes the Bayesian information criterion. RSS denotes the total residual sum of squares.

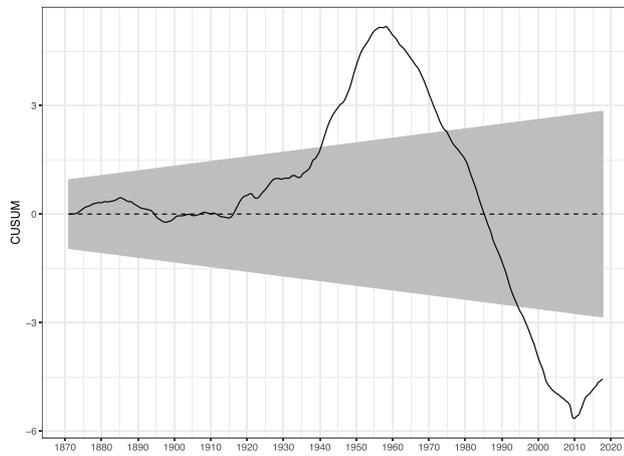
m	Breakdates	BIC	RSS
0		1105.04	220.63
1	1958 Q2	808.46	130.37
2	1932 Q1 1958 Q3	643.53	96.37
3	1898 Q2 1932 Q1 1958 Q3	644.25	94.42
4	1898 Q2 1932 Q1 1958 Q3 1991 Q3	646.90	92.81

$$u_t = \alpha + \epsilon_t. \tag{11}$$

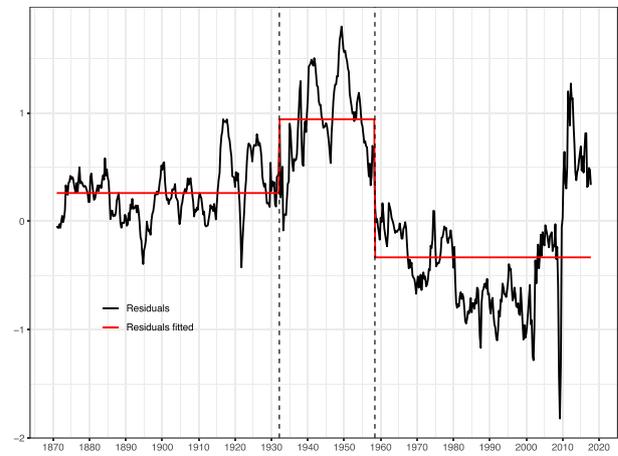
We test the null hypothesis that the intercept is constant through time $\alpha = \alpha_0$ versus the alternative that α varies over time. That is, the alternative hypothesis is that there are structural breaks in level of the residuals.

We compute the recursive CUSUM process and plot it with the boundaries of the 5% significance level in Fig. 2, Panel A. The recursive CUSUM process exceeds its boundary. Hence, there is evidence for a structural change (this evidence becomes apparent around the year 1940). Furthermore, the process seems to indicate three major changes: the first in the mid-1930s, the second in the late 1950s, and the third at the sample end around the year 2010.

Given the evidence supporting the presence of structural breaks in the residuals from the equilibrium relationship, we implement the Bai and Perron procedure of detecting the breakpoints for $m = 0, \dots, 4$. Table 2 reports the breakpoints for m -segmented models as well as the associated total residual sum of squares (RSS) and the Bayesian information criterion (BIC). In principle, both RSS and BIC can be used as a model selection criterion. However, Bai and Perron (2003) advocate for employing BIC as the most suitable model selection criterion. The results of the breakpoint detection procedure can be summarized as follows. The most important breakpoint (when $m = 1$) is detected in the year 1958. The date of this breakpoint agrees very well with the results of the unit root tests that allow for breaks and the results of the recursive CUSUM test. The BIC selects a model with $m = 2$ breakpoints where the breakpoint



Panel A



Panel B

Fig. 2. Panel A plots the recursive CUSUM process for $u_t = \alpha + \epsilon_t$. The shaded area highlights the boundaries of the 5% significance level. Panel B plots the residuals u_t and fitted model for $u_t = \alpha + \epsilon_t$ with 2 breakpoints.

Table 3
Results of the estimation of $\ln(E_t/P_t) = \beta \ln(Y_t) + u_t$ over 3 historical segments associated with 2 breakpoints. For all historical segments, β is statistically significantly different from zero at the 1% level.

Historical segment	β
1871 Q1–1932 Q1	1.42
1932 Q2–1958 Q3	2.14
1958 Q4–2017 Q4	0.99

of secondary importance is identified in the year 1932. This breakpoint date is fairly consistent with the results of the two-break ADF test by Narayan and Popp (2010) and the results of the recursive CUSUM test.

To summarize, our analysis identifies 2 major breakpoints in the residuals from the cointegration relationship between the price-to-earnings ratio and the bond yield. These 2 breakpoints divide the total historical period into 3 segments. Panel B in Fig. 2 plots the residuals and fitted model for $u_t = \alpha + \epsilon_t$ with 2 breakpoints. Table 3 reports the estimated value of β for each segment of the model $\ln(E_t/P_t) = \beta \ln(Y_t) + u_t$ with $m = 2$ breakpoints. Fig. 3 plots the original data series and the fitted model for each segment.

4.3. Causality relationship between the stock’s earnings and bond yields

The results reported in the previous sections provide evidence of existence of the equilibrium relationship between the stock’s earnings and bond yields and the occurrence of two major breaks in this relationship. By using a VECM, the goal of this section is to investigate the direction of causality in the relationship. We estimate the VECM using the data for the total sample as well as the data for each of the 3 historical segments associated with 2 breakpoints.⁷

The first step in the estimating VECM is to study the stationarity properties of our variables: $\ln(E_t/P_t)$, $\ln(Y_t)$, u_t , $\Delta \ln(E_t/P_t)$, and $\Delta \ln(Y_t)$. This is done by performing the standard ADF unit root test, the results of which are reported in Table 4. The results of the unit

⁷ A similar approach to examining the equilibrium relationship in the presence of structural breaks has previously been used by Bekaert, Harvey, and Lumsdaine (2002), Herrera and Pesavento (2009), Pala (2013), Razmi, Azali, Chin, and Habibullah (2016), Diaz, Molero, and de Gracia (2016), and Bataa, Vivian, and Wohar (2019), among others.

Table 4
Results of the ADF unit root test for the total sample and 3 historical segments associated with 2 breakpoints. Critical values of the test statistics are -2.58 , -1.95 , and -1.62 at the 1%, 5%, and 10% significance level, respectively.

Historical segment	ADF test statistics				
	$\ln(E_t/P_t)$	$\ln(Y_t)$	u_t	$\Delta \ln(E_t/P_t)$	$\Delta \ln(Y_t)$
1871 Q1–2017 Q4	-1.14	-0.97	-3.18***	-15.27***	-20.12***
1871 Q1–1932 Q1	-0.51	-0.95	-3.46***	-9.04***	-7.30***
1932 Q2–1958 Q3	-0.26	0.11	-1.57	-6.76***	-6.38***
1958 Q4–2017 Q4	-0.95	-0.62	-3.58***	-9.35***	-12.55***

*Denotes statistical significance at the 10% levels.
**Denotes statistical significance at the 5% levels.
*** Denotes statistical significance at the 1% levels.

Table 5
Results of Johansen’s test for cointegration. Critical values of the trace statistic are 23.52, 17.95, and 15.66 at the 1%, 5%, and 10% significance level, respectively.

Historical segment	Trace statistic
1871 Q1–2017 Q4	29.88***
1871 Q1–1932 Q1	20.73**
1932 Q2–1958 Q3	13.97
1958 Q4–2017 Q4	22.29**

*Denotes statistical significance at the 10% levels.
** Denotes statistical significance at the 5% levels.
*** Denotes statistical significance at the 1% levels.

root tests are very similar for the total sample and for the 1st and 3rd historical segments. Specifically, over the total sample and on each of these two segments, the log of the E/P ratio and the log of the bond yield are nonstationary, whereas their first differences are stationary. We can reject the null hypothesis of unit root in the error correction term at the 1% significance level. With regard to the 2nd segment of data, we cannot reject the null hypothesis of unit root in the error correction term. Consequently, the unit root test suggests that there is an equilibrium relationship between the stock market E/P ratio and the bond yield on the 1st and 3rd segments of data, but there is no equilibrium relationship on the 2nd segment of data.

To further confirm the presence of the equilibrium relationship between the stock’s earnings and bond yields, we run the Johansen (1991) trace test where the null hypothesis is the absence of cointegration. The results of the Johansen’s trace test for cointegration are reported in Table 5. In sum, the null hypothesis of no cointegration between the two yields is rejected for all historical periods

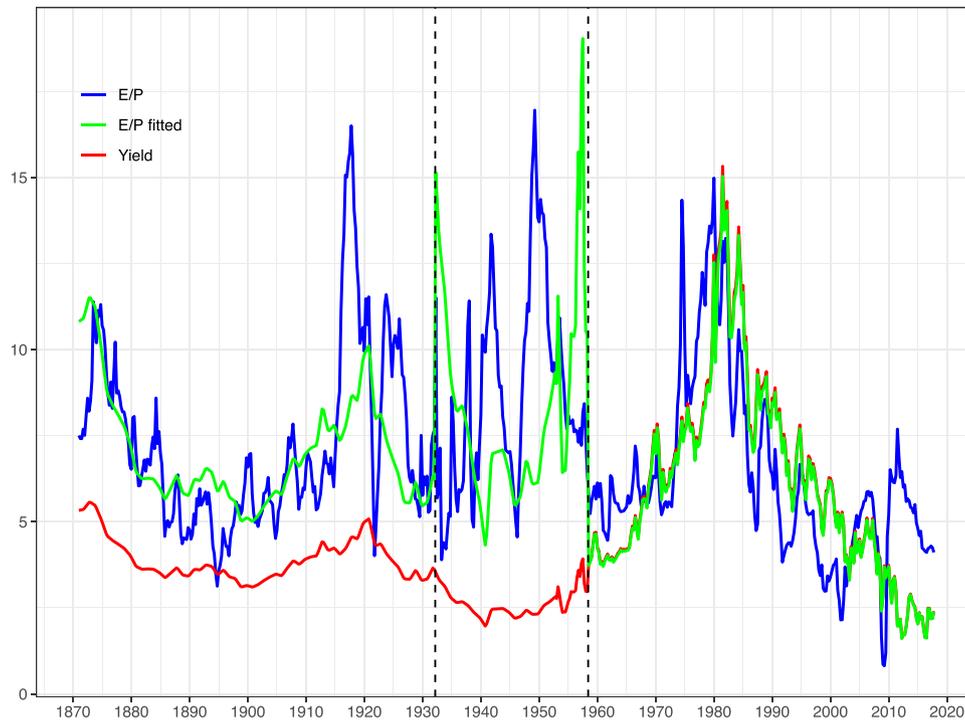


Fig. 3. Original data series and fitted model for $\ln(E_t/P_t) = \beta \ln(Y_t) + u_t$ with 2 breakpoints. Vertical dashed lines show the location of the breakpoints.

except the 2nd segment of data from 1932 to 1958. Consequently, the results of the Johansen’s test agree with those of the unit root test.

We determine the number of lags in the VECM given by Eq. (9) using BIC as the selection criterion and setting the maximum lag length of 5. Over the total sample and on each historical segment, BIC selects 1 lag. As a result, our VECM is given by

$$\begin{aligned} \Delta \ln(E_t/P_t) &= c_1 + \alpha_1 \Delta \ln(E_{t-1}/P_{t-1}) + \theta_1 \Delta \ln(Y_{t-1}) + \gamma_1 u_{t-1} + \varepsilon_{1,t}, \\ \Delta \ln(Y_t) &= c_2 + \alpha_2 \Delta \ln(E_{t-1}/P_{t-1}) + \theta_2 \Delta \ln(Y_{t-1}) + \gamma_2 u_{t-1} + \varepsilon_{2,t}. \end{aligned} \quad (12)$$

Table 6 presents the results of the estimation of the VECM given by (12) using the data for the total sample and for each of the three historical segments. In particular, this table reports parameter estimates and p -values (in parenthesis) from the VECM for each historical period. As summary statistics, the table reports R -squared (R^2) and p -values of the F -statistic for testing the joint significance of the regressors (Prob(F -statistics)). The R^2 statistic measures the success of the regression in predicting the values of the dependent variable and may be interpreted as the fraction of the variance of the dependent variable explained by the regressors. The reported F -statistic p -values are from a test of the hypothesis that all the coefficients (excluding the intercept) in a regression are zero. If the p -value is less than a specified significance level, say 5%, the null hypothesis that all equation coefficients are equal to zero is rejected.

The results of the estimation of the VECM indicate the presence of persistence in the changes of $\Delta \ln(Y_t)$ on the 1st and 2nd historical segments, and in the changes of $\Delta \ln(E_t/P_t)$ over the total sample and on the 1st and 3rd segments. Specifically, the autoregressive term in the equation for $\Delta \ln(Y_t)$ is positive and statistically significant at the 1% level on the 1st and 2nd segments. In addition, the autoregressive term in the equation for $\Delta \ln(E_t/P_t)$ is positive and statistically significant at the 1% level on the total sample and the 1st and 3rd segments. Therefore, on the 1st and 2nd segments, the changes in the bond yield can be partially explained by its lagged

Table 7

Results of the Granger causality test. The null hypothesis is the absence of Granger causality. “Yes” denotes the rejection of the null hypothesis, whereas “No” denotes that we cannot reject the null hypothesis.

Historical segment	Granger causality	
	Short-run	Long-run
<i>Panel A: Dependent variable $\Delta \ln(E_t/P_t)$</i>		
1871 Q1–2017 Q4	Yes	Yes
1871 Q1–1932 Q1	Yes	Yes
1932 Q2–1958 Q3	No	No
1958 Q4–2017 Q4	Yes	Yes
<i>Panel B: Dependent variable $\Delta \ln(Y_t)$</i>		
1871 Q1–2017 Q4	No	No
1871 Q1–1932 Q1	No	No
1932 Q2–1958 Q3	No	No
1958 Q4–2017 Q4	No	No

values. Similarly, over the total sample and on the 1st and 3rd segments, the changes in the E/P ratio can be partially explained by its lagged values.

Our primary interest in using VECM is to determine whether there is evidence of Granger causality between the two variables and, if the answer is affirmative, to investigate the direction of causality. Since our VECM includes only one lag of each of the independent variables, the evidence of Granger causality can be established through the significance of the regression coefficients. For example, the evidence of short-run causality from the E/P ratio to the bond yield becomes apparent if the coefficient α_2 is statistically significantly different from zero. Similarly, the evidence of the long-run causality from the error correction term to the bond yield can be established if the coefficient γ_2 is statistically significantly different from zero.

Table 7 reports the results on the Granger causality between the two variables. These results can be summarized as follows. On the 2nd historical segment of data, there is neither short-run nor long-run causality between the stock market E/P ratio and the bond yield. Over the total historical sample and on the 1st and 3rd seg-

Table 6
The table reports parameter estimates and p -values (in parenthesis) from the VECM model for the total sample and three historical segments. As summary statistics, the table reports R -squared (R^2) and p -values of the F -statistic for testing the joint significance of the regressors (Prob(F -statistics)). Bold text indicates parameters that are statistically significant at the 5% level.

	1871 Q1–2017 Q4		1871 Q1–1932 Q1		1932 Q2–1958 Q3		1958 Q4–2017 Q4	
	$\Delta \ln(E_t/P_t)$	$\Delta \ln(Y_t)$	$\Delta \ln(E_t/P_t)$	$\Delta \ln(Y_t)$	$\Delta \ln(E_t/P_t)$	$\Delta \ln(Y_t)$	$\Delta \ln(E_t/P_t)$	$\Delta \ln(Y_t)$
Intercept	0.003 (0.571)	−0.002 (0.417)	0.002 (0.679)	−0.000 (0.541)	0.004 (0.761)	0.000 (0.939)	0.004 (0.642)	−0.003 (0.609)
$\Delta \ln(E_{t-1}/P_{t-1})$	0.196 (0.000)	−0.039 (0.066)	0.127 (0.050)	−0.005 (0.359)	0.121 (0.183)	−0.029 (0.319)	0.339 (0.000)	−0.075 (0.096)
$\Delta \ln(Y_{t-1})$	0.306 (0.000)	0.028 (0.509)	1.382 (0.004)	0.848 (0.000)	0.457 (0.188)	0.320 (0.005)	0.239 (0.008)	0.002 (0.978)
u_{t-1}	− 0.024 (0.005)	0.007 (0.141)	− 0.081 (0.001)	−0.001 (0.427)	−0.035 (0.203)	0.012 (0.176)	− 0.067 (0.001)	0.017 (0.260)
R^2	0.080	0.009	0.102	0.705	0.044	0.099	0.184	0.016
Prob(F -statistics)	0.000	0.158	0.000	0.000	0.215	0.015	0.000	0.302

ments of data, both the changes in the bond yield and the error correction term Granger cause the changes in the stock market E/P ratio. Specifically, in the short run, there is Granger causality running from the bond yield to the E/P ratio, and in the long run, there is Granger causality running from the error correction term to the E/P ratio. The regression coefficients have the correct signs: $\theta_1 > 0$ and $\gamma_1 < 0$. This fact tells us that the changes in the bond yield cause the adjustments in the P/E ratio both in the short run and the long run. In particular, an increase in the bond yield in period $t - 1$ tends to cause an increase in the E/P ratio through itself and through the error correction term.

In contrast, our results suggest that there is no Granger causality running from the stock market E/P ratio to the bond yield. The coefficient of the error correction term, γ_2 , is never statistically significantly different from zero. Thus, there is no long-run causality running from the error correction term to the bond yield. Similarly, the coefficient α_2 is never statistically significantly different from zero. Consequently, there is no short-run causality running from the P/E ratio to the bond yield. Therefore, the bond yield can be considered an exogenous variable.

Overall, using the data for the total sample, our results advocate for the existence of the equilibrium relationship between the stock market E/P ratio and the bond yield and a unidirectional short- and long-run Granger causality running from the bond yield to the E/P ratio. In other words, over the total historical sample, the E/P ratio followed the bond yield in both the short run and the long run, but not vice versa. However, our results for each particular segment suggest that on the second segment of data, there was no relationship between the stock market E/P ratio and the bond yield. That is, the relationship broke down in 1932 and re-emerged again in 1958.

5. Key forces behind the breaks in the relationship between earnings and bond yields

This is the first of two sections devoted to explaining what caused the breaks in the relationship between earnings and bond yields. We start in this section with investigating (1) the monetary policy and historical evolution of interest rates, and (2) the evolution of income tax rates and corporate dividend policy. The results from these two investigations are used and further analyzed, together with the “paradigm shift” in stock valuation theory, in our narrative discussion in subsequent Section 6.

Throughout this section, we investigate structural breaks in a number of relationships. To conduct tests for structural breaks, we implement a procedure that is similar to that used to detect the breakpoints in the relationship between the stock earnings and bond yields. To save space, we only indicate the main results of

these tests. The detailed results are available from the authors upon request.

5.1. Monetary policy and the evolution of interest rates

In addition to the long-term bond yield, in this section, we consider the short-term interest rate. The data on the short-term interest rate are provided by Amit Goyal.⁸ The short-term interest rate for the period from 1920 to 2017 is the yield on the T-bills with time to maturity of approximately 1 month. Because there was no risk-free short-term debt prior to the 1920s, Goyal and Welch (2008) estimate it using the data for the Commercial Paper rates for New York.

In the context of our study, the short-term interest rate is highly relevant since in modern finance theory, this rate serves as a proxy for the risk-free rate of return. This is because short-term government-issued securities have virtually zero risk of default and the return from these securities is known in advance with high precision. In contrast, the return from the long-term bonds is risk-free only when the investor holds them until maturity. If the investor sells long-term bonds before maturity, their (holding period) return is unknown in advance. Moreover, this return can be negative. This is why in modern finance, the bonds with time to maturity longer than 3 months are considered risky.

Fig. 4 plots the evolution of both the long-term bond yields and the short-term interest rates over the period from 1871 to 2017. The following observations can be made regarding the relationship between the short-term interest rate and the long-term bond yield/rate. First, both the interest rates tend to move in tandem. However, the relationship between the rates is not stable over time. Over the period from 1871 to approximately 1930, both interest rates moved largely together; the short-term interest rate was much more volatile than the long-term interest rate. Over the period from approximately 1930 to the end of the 1940s, the short-term interest rate was much lower than the long-term bond yield. Starting from the early 1950s, both interest rates have again moved in tandem, but this time, the short-term interest rate tended to lie below the long-term bond yield.

To summarize, our visual observation of the co-movements between the long-term bond yield and the short-term interest rate suggests that they tend to move in tandem, but the relationship is not stable over time. Therefore, it is interesting to analyze the breakpoints in the relationship

$$R_t = \beta Y_t + u_t,$$

⁸ Downloaded from <http://www.hec.unil.ch/agoyal/>. These data were used in the widely cited paper by Goyal and Welch (2008).

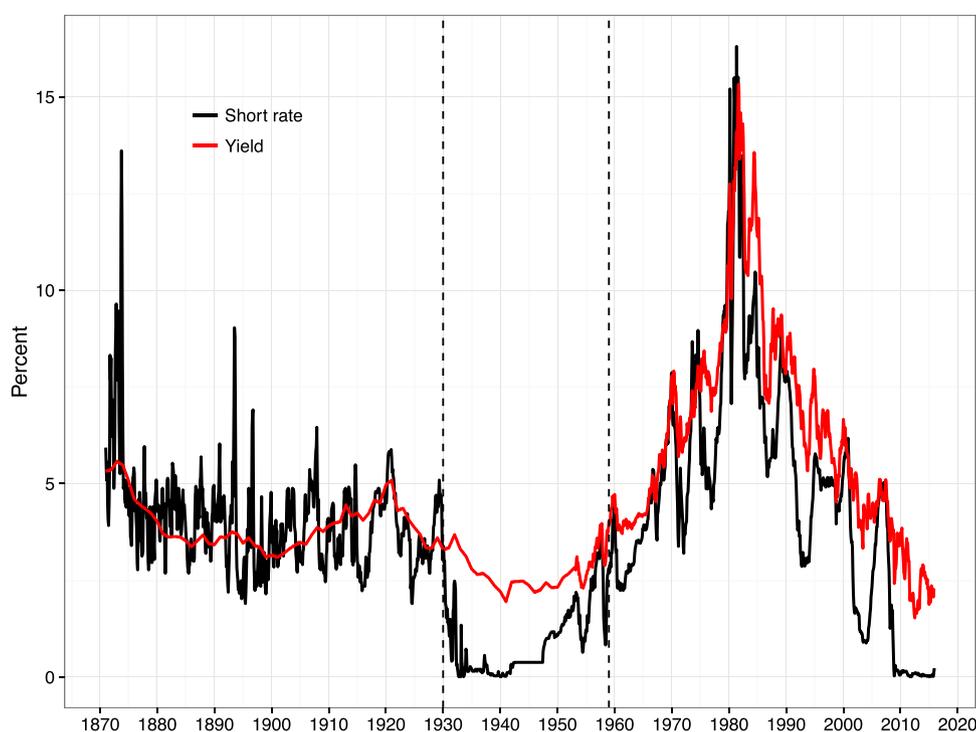


Fig. 4. The long-term bond yields versus the short-term interest rates. Vertical dashed lines show the location of the two major breakpoints in the relationship between the short-term and long-term interest rates ($R_t = \beta Y_t + u_t$).

where R_t and Y_t denote the time- t short-term interest rate and long-term bond yield, respectively. The structural break analysis detects two major breakpoints that occurred in 1930 Q1 and 1959 Q1; these breakpoints largely coincide with the two major breakpoints in the relationship between the stock earnings and bond yields. The vertical dashed lines in Fig. 4 show the location of the two major breakpoints in the relationship between the long-term bond yield and the short-term interest rate. Judging by the goodness of fit (the value of R -squared statistics), the relationship between the short-term interest rate and the long-term bond yield was very strong before 1930 and after 1959. Conversely, the relationship was much weaker during the period from 1930 to 1959.

To understand the historical evolution of interest rates, we need to learn who determines them. Over the period from 1871 to 1914, the level of interest rates was determined chiefly by market forces of supply and demand. The level of interest rates was rather stable mainly due to the existence of the gold standard. Since 1914, however, the level of interest rates has been determined by the Fed, which represents the central banking system.

As specified by the US Congress in the Federal Reserve Act (from December 23, 1913), the Fed should conduct appropriate monetary policy in order to achieve maximum employment, stable prices, and moderate long-term interest rates. In particular, when an economy is in a recession, the Fed conducts an expansionary policy by lowering the short-term interest rate and increasing the money supply. In contrast, when an economy is in a state of excessive growth, the Fed conducts a contractionary policy by increasing the short-term interest rate and reducing the money supply. The Fed is also able to influence the level of long-term interest rates by buying or selling long-term government bonds.

In the aftermath of the stock market crash of 1929 and the beginning of the Great Depression, the Fed started to decrease the short-term interest rate. Specifically, the short-term interest rate fell from approximately 5% in the late 1920s to less than 1% in the early 1930s. The long-term bond yield was also reduced by half (from approximately 5% to approximately 2.5%) over the

same period. In April 1942, approximately five months after the US entered WWII, the Department of Treasury requested that the Fed commit to (pegging) an interest rate of 3/8% on Treasury bills. The rate on long-term bonds was capped at 2.5% (Hetzel & Leach, 2001). This low interest rate was requested to accommodate the war financing. After the war, the authorities were afraid of a new severe depression and, therefore, the Fed continued to keep the interest rates at very low levels. The fixed-income market in the US was deregulated only in 1951 (Treasury-Fed Accord of 1951).

In sum, the Fed's monetary policy is responsible for the break in the relationship in 1930 and the establishment of the new weaker relationship between the short-term and long-term interest rates. After the deregulation of the market in the early 1950s, both the short-term and long-term interest rates started to increase. However, according to our structural break analysis, the re-establishment of the modern strong relationship occurred only by the end of the 1950s.

5.2. Evolution of income tax rates and corporate dividend policy

In the US, the modern individual tax era was born in 1913 when the states ratified the 16th Amendment to the Constitution that authorized Congress to “collect taxes on incomes, from whatever source derived, without apportionment among the several states, and without regard to any census or enumeration.” Since that time, the income tax in the US has been determined by applying a tax rate, which increases as income increases. For example, in 1913, the individuals with the lowest income had to pay 1% income tax (lowest bracket), whereas the individuals with the highest income were bound to pay 7% income tax (highest bracket or top rate). Fig. 5 plots the evolution of the top individual income tax rates⁹ on

⁹ Data sources are: <https://fred.stlouisfed.org/>, <http://www.worldtaxdatabase.org/>, and <http://www.insidegov.com/>.

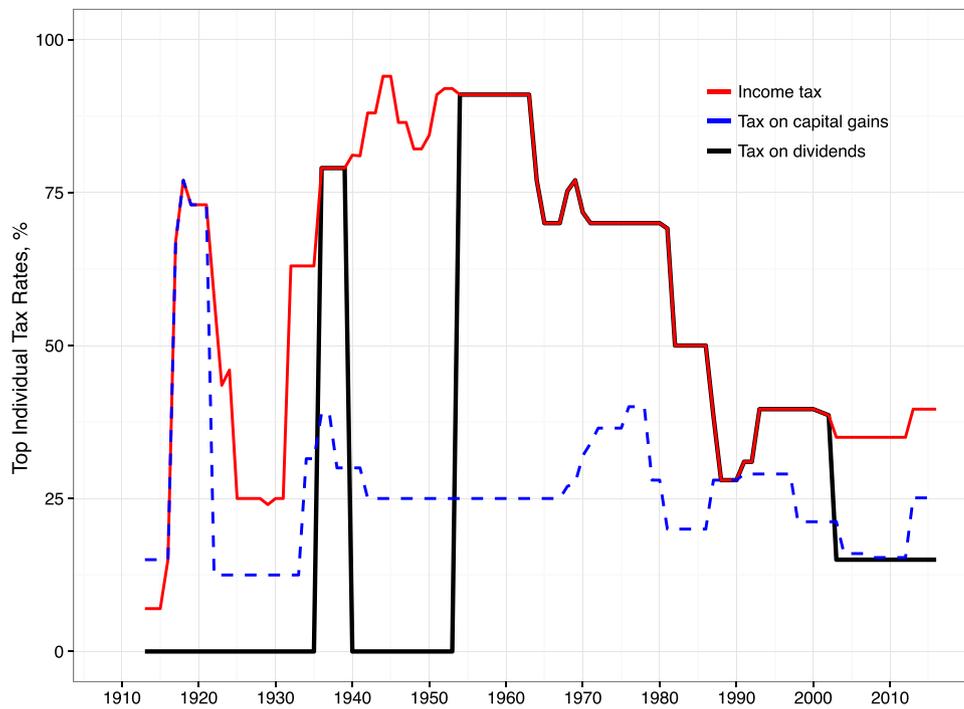


Fig. 5. Top individual income tax rates on dividends, long-term capital gains, and all other income.

dividends, long-term capital gains, and all other income in the US from 1913 to 2017.

First, consider the evolution of the top individual income tax rate on interest on bonds and stock dividends. In the beginning of the modern individual tax era, interest on bonds and dividends paid to shareholders was exempt from taxation until 1953, except for a four-year period from 1936 to 1939, where dividends were taxed at an individual's income tax rate. Beginning in 1954, dividends were fully taxed at an individual's income tax rate. In 2003, the dividend tax rate was lowered to 15%.

Second, examine the evolution of the top individual tax rate on long-term capital gains from financial securities (bonds and stocks held for more than a year). Whereas any profits recognized from short-term gains are taxed as ordinary income, long-term gains are taxed at a much lower rate. Only in the beginning of the modern individual tax era were the capital gains taxed at a rate greater or equal to that for interest and dividends. From 1954 to 2003, long-term capital gains were taxed at a maximum of one-half the rate applicable to interest and dividends. Over the period from 1954 to 1969, the interest and dividends were taxed at a rate that was at least three times as high as that for the long-term capital gains.

In the rest of this section, we argue that the key event that significantly altered the corporate dividend policy in the US was the sudden introduction of extremely large income taxes on stock dividends in 1954. In particular, beginning in 1954, the income on stock dividends was taxed at an individual's income tax rate; from 1954 to 1963 the top marginal tax rate was 91%. In contrast, the tax rate on long-term capital gains was only 25%. "Hence, tax considerations introduced a bias in favour of price appreciation and against current dividend income" (Vatter, 1963), page 200). Buying high-paying dividend common stocks no longer made sense for wealthy investors. In response to the high income taxes on dividends, the firms took action to protect their shareholders' income first by reducing the dividends and then by replacing dividends by share repurchase.

Specifically, to protect their shareholders' income, the firms' goal was to increase capital gains (that is, share price growth) at the expense of reducing dividends. The valuation formula given by Eq.

(4) suggests that as long as the return on new investment is greater than the required rate of return, $k_* > k$, decreasing the payout ratio increases the stock price.¹⁰ Put differently, by retaining more of its earnings, the firm can increase its growth rate and, hence, increase the share price. Even if the return on new investment is lower than the required rate of return, the firm can increase share price by share repurchase.¹¹ In the seminal paper by Miller and Modigliani (1961), the authors showed that the firm's dividend policy is irrelevant as long as the firm holds a fixed investment policy. Therefore, the stock valuation formula given by Eq. (4) remains valid when the firm uses the amount of $D = b \times E$ for share repurchase instead of paying this amount as dividends.

In sum, to increase capital gains at the expense of reducing dividends, the firms had two policies at their disposal: either to invest more in new projects or undertake share repurchase. However, although share repurchase programs have never been explicitly prohibited in the US, firms were reluctant to repurchase shares because of the potential risk of being charged with illegal market manipulation.¹² "Only in 1982 the SEC adopted Rule 10b-18, which provides a safe harbor for repurchasing firms against the anti-manipulative provisions of the Securities Exchange Act (SEA) of 1934" (Grullon & Michaely, 2002). A study from Straehl and Ibbotson (2017) showed that this rule really "opened up the floodgates for firms to start repurchasing their stock en masse."

The introduction of high income taxes on dividends in 1954 and the adoption of Rule 10b-18 in 1982 had critical spillover effects. In particular, these two events exerted a significant impact on the

¹⁰ In particular, the sign of the first-order derivative of P with respect to b is determined by $k - k_*$. If $k_* > k$, then the sign is negative. This means that increasing the payout ratio decreases the stock price. Conversely, decreasing the payout ratio increases the stock price.

¹¹ Share repurchase increases the price of the remaining shares. The investors can subsequently sell shares to create a "homemade dividend". The homemade dividend is then taxed according to the capital gains tax rate.

¹² In accordance with the anti-manipulative provisions of the Securities Exchange Act of 1934, the SEC has occasionally charged companies with illegally manipulating their stock prices during share repurchase programs.

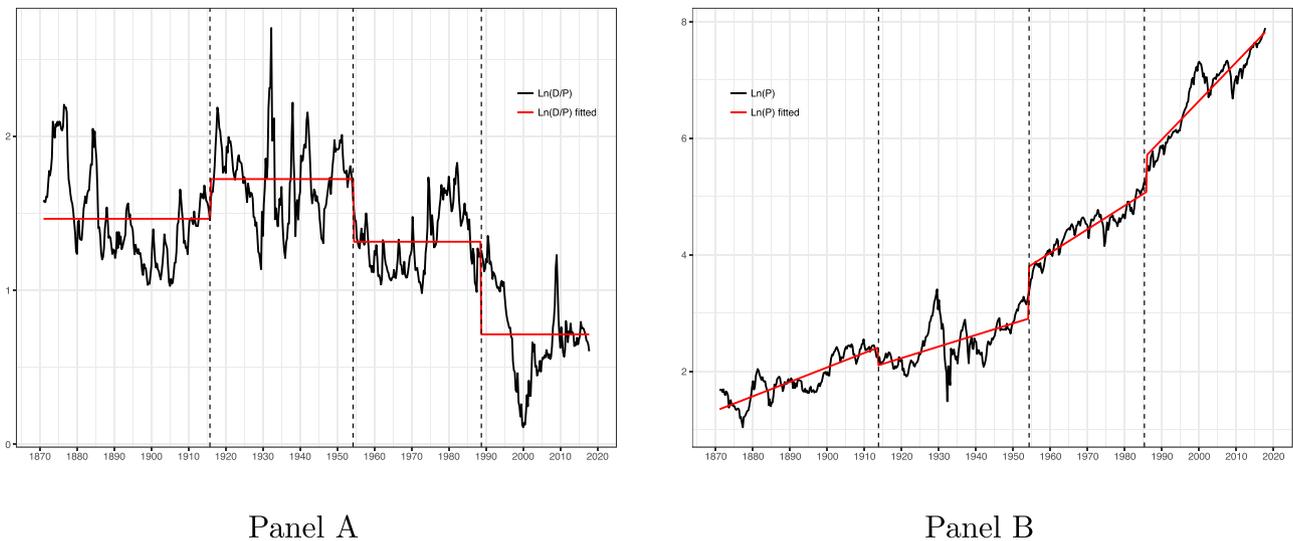


Fig. 6. Panel A plots the original data series and fitted model for $\ln(D_t/P_t) = \alpha + u_t$ with 3 breakpoints. Panel B plots the original data series and fitted model for $\ln(P_t) = \delta + \gamma t + u_t$ with 3 breakpoints. Vertical dashed lines show the location of the breakpoints.

dynamics of several relationships and caused structural breaks in these relationships. In this section below, we apply the econometric methodology of detecting structural breaks to demonstrate the spillover effects of these two events.

Lettau and Nieuwerburgh (2008) and Favero, Gozluklu, and Tamoni (2011) find that there are two statistically significant structural breaks in the mean of the log D/P ratio over the period from 1920 to 2008. We replicate their studies using a longer historical sample that spans the period from 1871 to 2017. Our linear regression model is given by

$$\ln(D_t/P_t) = \alpha + u_t. \tag{13}$$

We test the null hypothesis that the log of the dividend yield is constant over time $\alpha = \alpha_0$ versus the alternative that α varies over time. The structural break analysis detects three major breakpoints that occurred in 1915 Q4, 1954 Q2, and 1988 Q3. Fig. 6, Panel A, plots the original data series and the fitted model for each segment.

The most relevant results of this breakpoint detection procedure are as follows. One major breakpoint in the constant log dividend yield model is 1954 Q2, which coincides with the introduction of the large taxes on dividends. Compared to observations from the period prior to 1954 Q2, the dividend yield decreased notably. Another major breakpoint in the model is 1988 Q3. After this date, the dividend yield decreased almost by half. It is natural to attribute this decrease to massive share repurchase programs implemented after the adoption of Rule 10b-18 in 1982.

Finally, in this section, we want to demonstrate that since the introduction of high taxes on dividends in 1954, the changes in corporate dividend policy successfully increased share price growth. For this purpose we consider the following linear growth model for the log of the stock price

$$\ln(P_t) = \delta + \gamma t + u_t. \tag{14}$$

The null hypothesis is that the log of the price grows at a constant rate $\gamma = \gamma_0$ versus the alternative that γ varies over time.

Fig. 6, Panel B, plots the original data series and the fitted model for each segment. In addition to a break in 1913 Q3, our breakpoint detection procedure identifies two major breaks in 1954 Q1 and 1985 Q4. The estimated coefficient γ over the second, third, and fourth historical segments is 0.05, 0.10, and 0.17, respectively. Note that, compared to observations over the second historical segment, the share price growth and, hence, the capital gain return,

doubled after the break in 1954 Q1. This break date coincides with the introduction of the large taxes on dividends. After the subsequent break in 1985 Q4, the share price growth further increased by more than 60%. It is natural to attribute this additional increase in the share price growth to massive share repurchase programs that implemented after 1982.

In sum, the introduction of high taxes on dividends in 1954 created a substantial bias in favor of price appreciation and against dividend income. This bias induced firms to change their corporate dividend policy. Since the introduction of taxes on dividends happened during the postwar economic boom (the period 1945–1970 is often called the “Golden Age of Capitalism”), the growth potential was substantial. After 1954, corporations started to retain more of their earnings that were invested in new projects. This policy decreased the dividend yield but increased the share prices. In the absence of growth potential, the firms could increase the share price by share repurchase programs. However, until 1982, the firms that were repurchasing shares could be accused of price manipulation. The adoption of the new rule in 1982 provided a safe harbor for repurchasing firms. Since that time, many firms have started repurchasing their own shares. These repurchase programs additionally decreased the dividend yield and increased the price growth.

6. Discussion

The aim of this section is to suggest answers to the following two major questions. The first major question is the following: Why was there no relationship between the stock market E/P ratio and the bond yield over the period from 1932 to 1958? Answering this question also requires answering the following two subquestions: Why did the break in the relationship occur in 1932? Why was the relationship re-established in 1958? The second major question is the following: Why has the multiplier in the relationship¹³ $E/P = M \times Y$ changed from $M \approx 2$ over the period from 1871 to 1932 to $M \approx 1$ over the period from 1958 to 2017?

The first subquestion, “Why did the break in the relationship between the earnings and bond yields occur in 1932?”, is easy to

¹³ Note that in our empirical study, we examine the relationship between the logs of variables E/P and Y. That is, we examine the following relationship $\ln(E/P) = \beta \ln(Y)$. For the sake of convenience, in this section, we write the relationship without logs: $E/P = M \times Y$, where M denotes the multiplier factor.

answer. After the stock market crash in 1929 and the onset of the Great Depression, the Fed started to conduct an expansionary monetary policy by lowering the short-term interest rate to nearly zero and substantially decreasing the long-term interest rate. Due to the government's need to finance WWII and the subsequent recession that ended in 1949, the interest rates were deregulated only in 1951. After the de-regulation, both short- and long-term rates started to increase.

To summarize, during the period from 1930 to 1951, the Fed held all interest rates at historically low and stable levels. This Fed policy explains the absence of the relationship between the earnings and bond yields over the aforementioned period. The second subquestion, "Why was the relationship between the earnings and bond yields re-established in 1958?", is more difficult to answer given the fact that the interest rates were deregulated earlier, in 1951. One possible answer is provided by our structural break analysis in the relationship between the short-term interest rate and the long-term bond yield. In particular, this structural break analysis revealed that, after the break in 1930, the relationship between the short-term interest rate and the long-term bond yield was fully re-established only in 1959. Both the breakpoints (1930 and 1959) largely coincide with those in the relationship between the earnings and bond yields. Therefore, one plausible explanation for the absence of the relationship between the earnings and bond yields over the period from 1932 to 1958 is the abnormal behavior of the short- and long-term interest rates that was caused by the Fed's monetary policy.

However, in our opinion, the re-establishment of the relationship between the short-term interest rate and the long-term bond yield is not the only key reason for the re-establishment of the relationship between the stock earnings and bond yields. The problem with this explanation is that the re-establishment of the relationship between the short-term interest rate and the long-term bond yield in 1959 seemingly has nothing to do with the re-appearance of the completely new relationship between the earnings and bond yields. Put differently, we believe that the answer to the question, "Why did the relationship re-emerge in 1958", should help us in answering the second major question "Why has the multiplier in the relationship $E/P = M \times Y$ changed from $M \approx 2$ over the period from 1871 to 1932 to $M \approx 1$ over the period from 1958 to 2017?"

We argue that the dividend yield had been an important equity valuation benchmark for investors until 1958. However, in response to the introduction of high income taxes on dividends in 1954, the firms took action to protect their shareholders' income first by reducing the dividends and then by replacing dividends with share repurchase. A dramatic reduction in stock dividend yield made use of the traditional equity valuation benchmark impossible at a point in time when such a benchmark was greatly needed: near the end of the post-WWII economic boom that was characterized by a speculative bubble. During a speculative bubble, stock prices increase rapidly and substantially, and subsequently, investors start to question whether the high prices can be justified by economic fundamentals. By the end of the 1950s, because the old valuation standards could no longer be used, a new valuation benchmark emerged. In the rest of this section, we present our story in full detail.

Our argument starts with the observation that prior to the mid-1950s, the earnings and dividends were highly correlated and cointegrated. As a result, before 1930, there was a causal relationship both between the earnings yield and the bond yield, as well as between the dividend yield and the bond yield. Fig. 7 plots the dividend-to-price ratio (dividend yield, D/P) versus the long-term government bond yield. Over the period from 1871 to 1930, the estimated relationship between the dividend and bond yields was $D/P = 1.35 \times Y$. In other words, this relationship suggests that prior to 1930, the investors required the stock dividend yield to be

35% higher on average than the bond yield. In periods of economic expansions and bull markets, the stock prices increased and, consequently, the dividend yield decreased. However, a visual inspection of the relationship between the dividend and bond yields reveals that, over the period from 1871 to 1958, the dividend yield was virtually always above the bond yield.

The rationale for the inequality $\frac{D}{P} \geq Y$ is that stocks are riskier than bonds and that the dividend yield should therefore be greater than the bond yield. There were many bull markets in stocks prior to 1930, but there was almost always a major market correction after the dividend yield decreased to the bond yield. Before 1958, the dividend yield was below the bond yield only once: over a rather short period right before the stock market crash of 1929.

In the US, the post-WWII historical period was a period of accelerated economic growth. As a result, as is typical during a prolonged period of economic boom, both the stock prices and investor optimism on the economy had been rising. It is worth noting that the end of an economic boom is usually characterized by a speculative bubble. This phenomenon is termed "speculative mania" (a.k.a. "speculative orgy" or "irrational exuberance"). According to Shiller (2005):

"A speculative bubble is a situation in which news of price increases spurs investor enthusiasm, which spreads by psychological contagion from person to person, and, in the process, amplifies stories that might justify the price increase and brings in a larger and larger class of investors, who despite doubts about the real value of the investment, are drawn to it partly through envy of others' successes and partly through a gambler's excitement." (Shiller, 2005)

Due to the rapid economic growth during the decades of the 1940s and 1950s, starting from approximately the mid-1950s, the investors became "obsessed with growth". According to the GGM, the stock price depends heavily on the growth rate of dividends. The majority of financial analysts valued stocks on the basis of naive extrapolation of recent dividend growth into the indefinite future. Such an approach to stock valuation pushed the stock prices continuously higher during the decade of the 1950s. However, as long as the dividend yield was larger than the bond yield, there was a general feeling that the stock market was not overvalued.

In 1954, the US government suddenly imposed high income taxes on stock dividends. Income on stock dividends was taxed at an individual's income tax rate; from 1954 to 1963 the top marginal tax rate was 91%. In contrast, the tax rate on long-term capital gains was only 25%. Buying high paying dividend common stocks no longer made sense for wealthy investors. Therefore, high paying dividend stocks went out of favor, and stayed out of favor, beginning from the mid-1950s. As a consequence, from 1955, firms sharply reduced the amount of dividends.

In 1958, the stock dividend yield decreased below the bond yield. Since that time, the dividend yield has remained below the bond yield. The new relationship between the dividend and bond yields puzzled financial analysts. At the same time, as is typical in periods where investors are obsessed with growth, some academics warned about the possibility that the stock prices were unreasonably high. For example, Durand (1957) expressed concerns that the GGM does not provide reliable evaluations of stock prices and, in the case of growth stocks, can justify any price no matter how high. According to Graham (1960), the stock market was highly overvalued by the end of the 1950s.

Therefore, at the end of the 1950s the investors and financial analysts were in a state that is known in the field of psychology as "cognitive dissonance" (see Festinger (1957)). In our context, a cognitive dissonance is the mental discomfort that occurs when a person is confronted with new information that contradicts prior

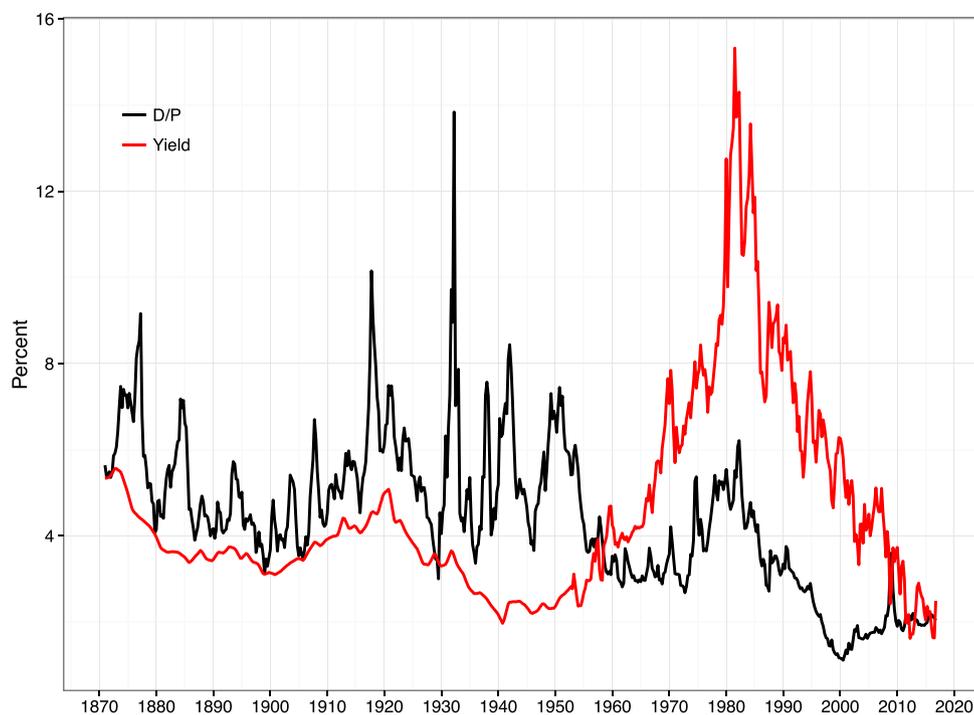


Fig. 7. Dividend-to-price ratio (D/P) versus the long-term government bond yield.

beliefs. On the one hand, the investors saw the strong economic growth that was supposed to continue in the observable future. The stock earnings grew rapidly, and this growth justified high stock prices. On the other hand, the stock dividend yield was notably below the long-term bond yield, and therefore, according to the traditional valuation benchmark, the stock market was substantially overvalued.

Cognitive dissonance theory suggests that people seek psychological consistency between their prior beliefs and the new information that contradicts these beliefs. That is, to function normally, people tend to reduce their cognitive dissonance. One possible way to reduce the cognitive dissonance experienced by the investors in the late 1950s was to find a new valuation benchmark that could justify high stock prices. One problem that had to be urgently resolved was to determine how to value stocks in situations where firms do not pay dividends. The ingenious solution was presented in the seminal paper by Miller and Modigliani (1961). In this paper, the authors showed that, in perfect capital markets, the firm's dividend policy is irrelevant as long as the firm holds a fixed investment policy. When the stock dividend yield decreased dramatically by the end of the 1950s, the investors gradually switched their attention from dividends to earnings: earnings growth and earnings yield.

All in all, our explanation for the establishment of the new relationship between earnings and bond yields is based on the idea that before the mid-1950s, the investors used the dividend yield as the ultimate benchmark to judge whether the stock market was overvalued or not. Specifically, the stock market had been considered highly overvalued when the dividend yield decreased to the bond yield. The introduction of high income taxes on dividends forced firms to reduce the amount of dividends paid out. When the dividend yield fell below the bond yield, the investors could no longer use the dividend yield as a valuation benchmark and they switched their attention to the earnings yield instead.

Finally, in this section, we offer our explanation for why the multiplier in the relationship $E/P = M \times Y$ has changed from $M \approx 2$ over the period from 1871 to 1932 to $M \approx 1$ over the period from 1958 to 2017. The heart of our explanation lies in the idea that the percep-

tion of riskiness of bonds and stocks underwent a dramatic change from the early 1910s to the late 1950s. In addition, one needs to take into account different taxes on capital gains from stocks and income from bonds. The remainder of this section presents our explanation in detail.

Regarding the investment practice in the early 1910s, Graham (1949) writes that the investors regarded high-grade corporate bonds as almost riskless securities because the bond default rate was virtually zero, the interest rates were rather stable over time, and the inflation rates were small and often negative. However, by the late 1950s, the investors began to treat bonds as rather risky securities because the bond yields over the period from 1930 to the late 1950s were unusually low (see Fig. 7). Moreover, starting from 1915, there have been many periods of high inflation. Specifically, the inflation increased dramatically because of deficit financing during WWI and WWII. In particular, from 1913 to 1920, the average annualized inflation rate was 11%, whereas from 1941 to 1948, the average annualized inflation rate was 7%.¹⁴ During these periods, the bond yields were substantially lower than the inflation rates. As a result, the investors realized that bonds often fail to protect investors from loss of purchasing power.

Therefore, starting from the early 1910s, bonds often provided a low return that was below the inflation rate over prolonged periods of time. This perception, that bonds are risky assets, was reflected in the fact that in the original modern portfolio theory developed by Harry Markowitz during 1950s (see Markowitz (1952, 1959)), there was no such thing as a risk-free asset. In addition, Asness (2000, 2003) convincingly demonstrates that starting from the early 1950s, the stock volatility has been decreasing while the bond volatility has been increasing. Consequently, the riskiness of stocks (bonds) has been decreasing (increasing) from the early 1950s.

Taking all this into consideration, we believe that by the late 1950s, the investors perceived bonds as a quite risky asset class. On the other hand, the investors were also very familiar with stock investment and began to treat stocks as a less risky asset class (in

¹⁴ These data are available online, see <https://www.measuringworth.com/>.

contrast to their attitude to stocks before 1920s) because, starting from the early 1940s, the stock returns were high and showed much less volatility than they did the decade before. In addition, stocks seemed to be a natural hedge against inflation. In sum, by the end of 1950s, the attractiveness of stocks had increased considerably because of the changed riskiness of stocks versus bonds.

Last but not least, the stocks were considered a more attractive investment than bonds because of tax considerations. In particular, the income from bond investing was taxed at the individual income tax rate that was very high starting from the early 1930s. Even though the US government introduced high taxes on stock dividends in 1954, firms quickly adopted a new dividend policy: they decreased the dividends and increased the capital gain return that was taxed at a much lower rate than dividends.

The bottom line is that, in our opinion, the “new normal” relationship $E/P = Y$ is misleading because it is stated in nominal before-tax rates of returns. To correctly access the pros and cons of stocks versus bonds, one has to take into account taxes and inflation protection provided by each asset class. It is true that, stated in nominal terms, bond returns are less risky than stock returns. However, investors tend to believe that bonds are riskier than stocks in terms of the potential loss of purchasing power. Moreover, after taxes, for many investors, stock returns are higher than bond returns, and hence, higher stock risk is compensated by higher returns. To summarize, we conjecture that after-tax real rates of returns to bonds and stocks do satisfy the correct risk-return relationship.

7. Conclusions

Since stocks and bonds are two major competing assets, it seems reasonable to conjecture that there should be an equilibrium relationship between the stock's earnings and bond yields. Over a very long run, however, the dynamics of financial markets are subject to evolutionary changes. Therefore, the equilibrium relationship between the two yields can also be subject to evolutionary changes. These two considerations motivate the study presented in this paper. In particular, given the very long historical data for the US, the goal of this paper is to find the structural breaks in the relationship between the stock's earnings and bond yields, investigate the direction of causality in the relationship, and try to explain the causes of the breaks.

The main empirical findings in the paper can be summarized as follows. Over the period from 1871 to 2017, our structural break analysis finds the presence of two different equilibrium relationships between the stock's earnings and bond yields. The first long-run equilibrium relationship existed from 1871 (the start of our sample) and broke up in 1932. Afterward, the relationship between the two yields was absent during two and a half decades. Finally, a completely new long-run equilibrium relationship re-emerged in 1958. Specifically, our analysis reveals that, whereas over 1871–1932 the equilibrium relationship was $E/P \approx 2Y$, over 1958–2017 the equilibrium relationship has been $E/P \approx Y$. On both historical segments 1871–1932 and 1958–2017, our analysis finds a unidirectional short- and long-run Granger causality running from the bond yield to the stock's earnings yield. In other words, on both segments, the stock's earnings yield followed the bond yield in both the short run and the long run, but not the other way around.

A large part of the paper is devoted to providing answers to the following two major questions: “Why was there no relationship between the stock's earnings yield and the bond yield over the period from 1932 to 1958?” and “Why has the multiplier in the equilibrium relationship changed from $M \approx 2$ to $M \approx 1$?” In brief, our story goes as follows. The breakdown of the equilibrium relationship in 1932 is explained by the stock market crash in 1929 and the following severe depression that forced the Fed to start conducting an expansionary monetary policy by lower-

ing the short-term interest rate to nearly zero and substantially decreasing the long-term interest rate. The fixed-income markets in the US were deregulated only in the early 1950s. We demonstrate that the Fed monetary policy was responsible for the abnormal relationship between the short- and long-term interest rates over the period from 1930 to 1959. However, our main argument for the re-establishment of a completely new equilibrium relationship between the stock's earnings and bond yields is that a major “paradigm shift” in the stock valuation theory occurred in the late 1950s. To support our argument and explain the transition from the old to the new paradigm, we review a number of important changes taking place during 1910–1960 that potentially could have caused the paradigm shift.

Under the old paradigm, bonds were almost risk-free and provided a stable and relatively high return, the inflation rate was moderate, and income taxes were absent or very low. Stocks, on the other hand, were considered highly risky. As a consequence, to attract investors to stocks, their earnings yield had to be notably higher than the bond yield. Under the new paradigm, the bond return was low and risky and did not protect investors from inflation. In addition, the income on bonds was taxed at a high rate. All these considerations attracted investors to stocks that provided a higher return than bonds. Moreover, stocks were considered to be a natural hedge against inflation, and the capital gain stock return was taxed at a low rate. As a result, stated in nominal before-tax terms, the stock's earnings yield descended to a level comparable to that of the bond yield.

More specifically, we demonstrate that the decades of the 1950s and 1980s witnessed two critical events that dramatically changed the corporate dividend policy in the US. The first critical event was the introduction of high income taxes on dividends in 1954. The second critical event, taking place in 1982, was the adoption of SEC Rule 10b-18, which provided a safe harbor for companies buying back their own stock. In response to the high income taxes on dividends, the firms first reduced the dividends and subsequently replaced the dividends with share repurchases. A dramatic reduction in the stock dividend yield made it impossible to use the traditional equity valuation benchmark at a point in time when a benchmark was greatly needed: near the end of the post-WWII economic boom that was characterized by a developing speculative bubble. As a consequence, by the end of 1950s, because the old valuation standards could no longer be used, a new valuation benchmark emerged.

Conflict of interest

The authors declare no conflicts of interest.

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