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# U.S. STOCK MARKET P/E RATIOS, STRUCTURAL BREAKS, AND LONG-TERM STOCK RETURNS

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**Abstract.** Our study investigates structural changes in the market P/E ratio and shows how structural changes affect long-term stock market returns. Using the cumulative sum control chart and the Bai-Perron algorithm, we identify multiple structural breakpoints in the market P/E ratio and find that those structural changes are significantly perceived over the long run. Unlike previous studies that do not consider structural changes, our study is the first one that shows how structural changes asymmetrically influence long-term stock returns depending on the high or low P/E period. This implies that structural changes in the market P/E ratio play an important role in explaining long-term stock returns. We propose that structural changes should be taken into account in some manner to establish the relationship between P/E ratios and long-term stock returns.

**Keywords:** P/E ratio, mean-reversion, structural breakpoints, historical economic events, long-term stock returns, asymmetric returns.

**JEL Classification:** G10, G17.

## Introduction

Traditionally, it has been noted that the stock market P/E ratio tends to revert to its historical mean which is expected to stay constant over time. Based on this traditional view, many studies have focused on investigating the relationship between market P/E ratios and stock market returns. While most of them have found a meaningful relationship between P/E ratios and long-term market returns, they have identified a minor or trivial relationship between P/E ratios and short-term market returns. However, all those studies are based only on the traditional mean-reverting characteristic of P/E ratios without recognizing structural changes in the P/E ratio over time.

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The first paper (Carlson *et al.* 2002) that sheds light on structural breaks in the market P/E ratio shows that the market P/E ratio significantly moves upward at a structural breakpoint rather than reverts to its long-run historical mean. If, at a point in time, the long-run mean of the P/E ratio substantially moves to a higher or lower level than its historical mean, and the new level lasts for quite a long time, we can expect market investors to perceive the new level as a long-term structural change. For example, while a P/E ratio of 20 seems to be high relative to the historical mean of the stock market P/E ratio which is around 16, it would be considered relatively low if the long-run mean substantially moves up to a high level of 25 at a point in time and stays that high level for quite a long time. Then, this structural change is likely to affect long-term stock returns in some way as long as there exists a significant relationship between P/E ratios and long-term stock returns.

Basically, our study consists of two parts. First, we attempt to identify structural breakpoints in the time series of the market P/E ratio over the past 142-year time span. Second, we examine how structural changes influence future long-term stock returns. From our results, we identify multiple structural breaks in the market P/E ratio over the past 142-year time span and find that structural changes asymmetrically affect future long-term stock returns depending on the high or low P/E period. In fact, significant return premiums exist during high P/E periods. This implies that market investors properly perceive structural changes in the P/E ratios and recognize high P/E ratios less (more) significantly and low P/E ratios more (less) significantly during structurally high (low) P/E periods. Thus, structural changes in the market P/E ratio appear to play an important role in explaining long-term stock returns. Since few studies have delved into the effect of structural changes in the market P/E ratio and thus, most previous studies have shown the relationship between P/E ratios and long-term stock returns without allowing for structural changes, we argue that structural changes should be considered in some manner to establish the relationship between P/E ratios and long-term stock returns.

## 1. Literature review and hypotheses development

Many of previous studies have supported the inverse relationship between P/E ratios and long-term stock returns (Campbell, Shiller 1988; Lakonishok *et al.* 1994; Siegel 2000; Wu, Wang 2000; Malkiel 2004; Estrada 2006; Weigand, Irons 2007). However, one recent study (Jones 2008) finds that market P/E ratios have no impact on long-term market returns on the basis of a supply-side model. There are also studies on short-term predictability for stock returns and they show insignificant results. Some authors discover that P/E ratios play a minor role in forecasting stock returns in emerging markets (Aras, Yilmaz 2008) while P/E ratios have no relationship with stock returns in an emerging markets (Abrokwa, Nkansah 2015). Another study (Gupta, Modise 2012) finds that P/E ratios are uncorrelated with real stock returns in the South African stock market.

On the other hand, one interesting study (Carlson *et al.* 2002) identifies a structural breakpoint in the time series of the market P/E ratio and shows that the market P/E ratio significantly moves upward at the structural breakpoint instead of reverting to its historical mean. As a result, their argument is that the long-run mean of the market P/E ratio is not constant over time, which means that the market P/E ratio is non-stationary. Although their data are relatively limited and they do not analyze or discuss any effect that the structural change may have on stock market returns, they provide a new insight on studying the structural change in the market P/E ratio. A few more studies also consider structural changes in the market P/E ratio against the traditional mean-reversion theory. They mention the possibility of a structural change in the market P/E ratio (Haubrich *et al.* 2015), test the P/E mean-reversion using Fourier approximation (Moghaddam, Li 2017) and confirm that the market P/E ratio can become stationary after controlling for structural changes (Becker *et al.* 2012). However, they focus on methodologies to test the mean reversion of the market P/E ratio rather than discussing the effect of structural changes on stock market returns and lack any further discussion about the relationship between structural changes and long-term stock returns. Actually, the most recent study (Moghaddam, Li 2017) concludes that the market P/E ratio is mean-averting rather than mean-reverting and it seems to be difficult to catch empirical evidence for the mean-reversion of the P/E ratio. From these studies, we are highly motivated to study structural changes in the market P/E ratio and their impact on long-term stock returns and develop two hypotheses.

First, it seems that there exists some point in time at which the market P/E ratio significantly changes (Carlson *et al.* 2002) and that structural change lasts for quite a long time. Since we analyze monthly P/E data over the 142-year time span, we expect that there exist multiple structural breakpoints in the market P/E ratio.

*Hypothesis 1:* Over the past 142-year time span, there exists multiple breakpoints in time at which the market P/E ratio significantly changes and the structural change at each breakpoint is expected to last for quite a long time.

Second, previous studies support the inverse relationship between P/E ratios and long-term stock returns based on the traditional view (Campbell, Shiller 1988; Lakonishok *et al.* 1994; Siegel 2000; Wu, Wang 2000; Malkiel 2004; Estrada 2006; Weigand, Irons 2007). If there exist structural changes in the market P/E ratio, those changes are expected to have an impact on long-term stock returns in some predictable way because market investors are likely to perceive high P/E ratios less (more) significantly and low P/E ratios more (less) significantly during structurally high (low) P/E periods. Given the inverse relationship between P/E ratios and long-term stock returns, we expect long-term stock returns to less (more) decrease with high P/E ratios and more (less) increase with low P/E ratios during structurally high (low) P/E periods. In other words, the effect of structural changes on long-term stock returns is expected to differ depending on structurally high or low P/E periods.

*Hypothesis 2:* If there exist structural changes in the market P/E ratio, given the inverse relationship between P/E ratios and long-term stock returns, we expect that those structural changes asymmetrically affect long-term stock returns depending on structurally high or low P/E periods.

## 2. Data

We use 142 years of monthly stock market data downloadable from Shiller's website. The data consist of stock market (S&P Composite Stock Price Index) real prices, the consumer price index (CPI), real earnings, real dividends, 10-year government security (Treasury note) yields, and P/E ratios from 1871 through 2012. We analyze two different types of P/E ratio. One is the P/E1 ratio calculated using the past 12-month moving average of earnings, and the other is the P/E10 ratio calculated using the past 120-month (10-year) moving average of earnings. The latter is known as the price-smoothed-earnings ratio (Campbell, Shiller 2001). Table 1 shows the basic statistics of historical P/E1 and P/E10 ratios.

Table 1. Summary statistics

| Basic statistics | PE1 | PE10 |
|---|---|---|
| Mean | 15.43 | 16.44 |
| Median | 14.48 | 15.84 |
| Standard deviation | 6.62 | 6.56 |
| Maximum | 86.84 | 44.20 |
| Minimum | 4.41 | 4.78 |

*Notes*: The basic statistics are calculated using monthly data from 1871 to 2012.

We truncate the data at the beginning or end of the entire data period if necessary for short- or long-term calculations. Since all data are real values, the results are comparable over the whole period regardless of inflation.

## 3. Structural breakpoints and historical economic events

We attempt to identify structural breakpoints in the market P/E ratio using 142 years of monthly stock market P/E data. To find structural breaks, we adopt purely empirical approaches relying on data. First, we employ the cumulative sum (CUSUM) control chart and the unit root test with a structural break. The CUSUM control chart is used to see systematic movements of time series data. The cumulative sum is calculated as follows.

$$SUM_t = SUM_{t-1} + \left(PE_t - \overline{PE}\right) \text{ for } t = 1, 2, \ldots, n, \quad (1)$$

where $PE_t$ is the P/E ratio at time $t$ and $\overline{PE}$ is the historical mean of the P/E ratio. The cumulative sum ends at zero with a starting value of zero.

The CUSUM control chart displays the cumulative sum of differences between P/E ratios and the historical mean over the 142-year time span. We use an average of historical monthly P/E ratios as the historical mean of each type of P/E ratio: 15.43 for P/E1 and 16.44 for P/E10.

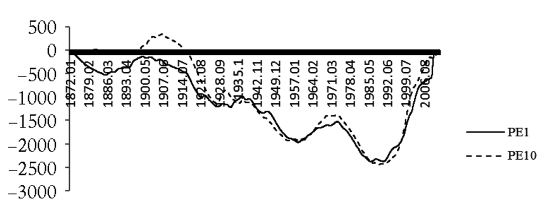

Figure 1. CUSUM control chart

Figure 1 shows the CUSUM control chart for both P/E1 and P/E10. The CUSUM control chart clearly shows that P/E ratios systematically move up and down relative to their historical mean. An upward (downward) slope indicates a time period during which P/E ratios stay above (below) their historical mean. In fact, the points that have maximum and minimum values in peaks and troughs of the CUSUM control chart are considered structural breakpoints because the systematic upward or downward trend goes into reverse at those points. We conduct the unit root test with two adjacent sub-periods at each breakpoint and we expect the P/E ratios to be non-stationary over two adjacent sub-periods. Even when a break has a temporary effect rather than a long-term effect, the Augmented Dickey-Fuller (ADF) unit root test often tends to fail to reject the null hypothesis of a unit root (Perron 1988). With the modified unit root test (Perron 1988; Glynn *et al.* 2007), we add two break dummies, $D_1$ (P/E level dummy) and $D_2$ (P/E crash dummy), to the Dickey-Fuller unit root test.

$$\Delta PE_t = \beta_0 + \beta_1 D_1 + \beta_2 D_2 + \beta_3 t + \rho PE_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta PE_{t-i} + \varepsilon_t, \qquad (2)$$

where $D_1$ equals 1 if $t >$ breakpoint and 0 otherwise and $D_2$ equals 1 if $t =$ breakpoint + 1 and 0 otherwise. Lag terms are also added to allow for serial correlation.

Table 2. Modified unit root test for structural breaks identified by the CUSUM method

| Panel A: P/E1 | | | | | |
|---|---|---|---|---|---|
| | First period | Break-point | Second period | λ | $t$-statistic for the null hypothesis of a unit root (ρ = 0) |
| 1st Test Period | 1/1872–7/1885 | 7/1885 | 8/1885–8/1899 | 0.5 | –3.68 |
| 2nd Test Period | 8/1885–8/1899 | 8/1899 | 9/1899–9/1958 | 0.2 | –3.85 |
| 3rd Test Period | 9/1899–9/1958 | 9/1958 | 10/1958–7/1973 | 0.8 | –3.81 |
| 4th Test Period | 10/1958–7/1973 | 7/1973 | 8/1973–3/1986 | 0.5 | –3.37 |
| 5th Test Period | 8/1973–3/1986 | 3/1986 | 4/1986–6/2012 | 0.3 | –3.99 |
| Panel B: P/E10 | | | | | |
| | First period | Break-point | Second period | λ | $t$-statistic for the null hypothesis of a unit root (ρ = 0) |
| 1st Test Period | 1/1881–1/1907 | 1/1907 | 2/1907–3/1955 | 0.4 | –3.70 |
| 2nd Test Period | 2/1907–3/1955 | 3/1955 | 4/1955–4/1973 | 0.7 | –3.65 |
| 3rd Test Period | 4/1955–4/1973 | 4/1973 | 5/1973–5/1989 | 0.5 | –2.65 |
| 4th Test Period | 5/1973–5/1989 | 5/1989 | 6/1989–6/2012 | 0.3 | –2.38 |

*Notes*: **, * indicate statistical significance at the 0.01 and 0.05 level respectively based on the asymptotic $t$-distribution developed by Perron (1988).

In Table 2, based on the asymptotic t-distribution with time of break relative to total sample size, λ (Perron 1988), we fail to reject the null hypothesis of a unit root (ρ = 0) for all test periods at both the 1% and 5% significance levels. This means that the P/E1 and P/E10 ratios with structural breaks turn out to be non-stationary, with long-term effects in each test period. As a result, we identify five structural breakpoints in the time series of the P/E1 and four structural breakpoints in the time series of the P/E10.

We also employ the Bai-Perron algorithm run in the *R Package Strucchange* with the same 142 years of monthly data and a break fraction of 10%. Figure 2 and Figure 3 show breakpoints in the P/E1 and P/E10 respectively with the Bai-Perron algorithm. These breakpoints are slightly different from those identified by the CUSUM method. With structural breakpoints, the whole period can be divided into six different sub-periods for the P/E1 and five different sub-periods for the P/E10.

In summary, both CUSUM and Bai-Perron methods identify similar breakpoints. Unlike the previous study (Carlson *et al.* 2002) that finds one breakpoint (fourth quarter of 1992) with limited quarterly data from 1945 to 2000, our tests show multiple structural breakpoints in the P/E1 and P/E10. These results are aligned with our Hypothesis 1.

Table 3 summarizes the basic statistics for these sub-periods identified by the CUSUM method and the Bai-Perron algorithm. We categorize all sub-periods into two structurally different periods on the basis of their means and medians: High P/E period (H) and Low P/E period (L).

We use the median as the long-run mean of each sub-period instead of the mean because the median is more representative of the central tendency of the sample data. However, as shown in Table 3, the mean and median of each sub-period are very close to each other.For sub-periods of the P/E1 with the CUSUM method in Panel A, low P/E periods have relatively low medians, which range from 9.61 to 12.80 whereas high P/E periods have relatively high medians, which range from 17.70 to 19.96. The sub-periods of the P/E10 in Panel B have parallel ranges as well.

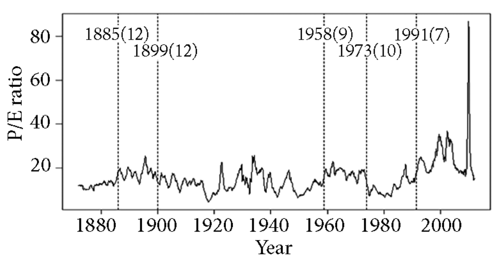


Figure 2. Structural breakpoints of PE1 – Bai-Perron algorithm

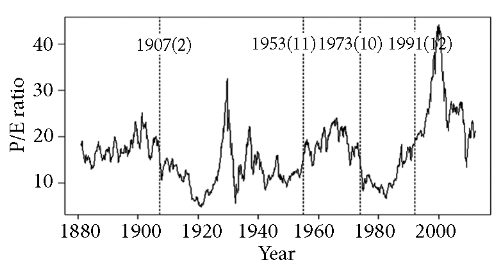


Figure 3. Structural breakpoints of PE10 – Bai-Perron algorithm

The duration of each sub-period extends from a minimum of 13 years to a maximum of 59 years. The starting date of the P/E10 is 9 years later than that of the P/E1 because the P/E10 is based on 10 years of past earnings. When we take into account all of these factors, the structural breakpoints in both the P/E1 and P/E10 do not seem to be very different. Both Panel C and Panel D with the Bai-Perron algorithm also show similar statistics.

In summary, since sub-periods have a minimum duration of 13 years (15 years with the Bai-Perron algorithm) which is quite a long time, it seems to make more sense to analyze the relationship between P/E ratios and stock market returns with structural breaks. This is different from the traditional standpoint which does not consider any structural change in the market P/E ratio.

Table 3. Summary statistics for structurally different sub-periods

| Panel A: P/E1 – CUSUM | | | | | | |
|---|---|---|---|---|---|---|
| Sub-period | Year range | Duration | P/E range | Mean | Median | Standard deviation |
| 1 (L) | 1/1872–7/1885 | 13 years | 9.61–14.91 | 12.17 | 12.22 | 1.23 |
| 2 (H) | 8/1885–8/1899 | 14 years | 12.45–25.61 | 17.79 | 17.70 | 2.41 |
| 3 (L) | 9/1899–9/1958 | 59 years | 4.41–25.71 | 12.85 | 12.80 | 3.87 |
| 4 (H) | 10/1958–7/1973 | 15 years | 12.71–23.02 | 17.92 | 18.13 | 1.93 |
| 5 (L) | 8/1973–3/1986 | 13 years | 6.57–15.19 | 9.84 | 9.61 | 2.02 |
| 6 (H) | 4/1986–6/2012 | 26 years | 12.85–86.84 | 22.99 | 19.96 | 9.68 |
| Panel B: P/E10 – CUSUM | | | | | | |
| 1 (H) | 1/1881–1/1907 | 26 years | 12.91–25.24 | 17.54 | 17.22 | 2.36 |
| 2 (L) | 2/1907–3/1955 | 48 years | 4.78–32.56 | 12.50 | 11.96 | 4.37 |
| 3 (H) | 4/1955–4/1973 | 18 years | 13.67–24.06 | 18.98 | 18.59 | 2.59 |
| 4 (L) | 5/1973–5/1989 | 16 years | 6.64–18.33 | 10.97 | 10.67 | 2.62 |
| 5 (H) | 6/1989–6/2012 | 23 years | 13.32–44.20 | 25.25 | 23.69 | 7.19 |
| Panel C: P/E1 – Bai-Perron | | | | | | |
| 1 (L) | 1/1872–12/1885 | 15 years | 9.61–18.05 | 12.31 | 12.24 | 1.47 |
| 2 (H) | 1/1886–12/1899 | 15 years | 12.45–25.61 | 17.74 | 17.69 | 2.46 |
| 3 (L) | 1/1900–9/1958 | 58 years | 4.41–25.71 | 12.84 | 12.78 | 3.88 |
| 4 (H) | 10/1958–10/1973 | 15 years | 12.71–23.02 | 17.88 | 18.13 | 1.95 |
| 5 (L) | 11/1973–7/1991 | 18 years | 6.57–21.78 | 11.51 | 11.07 | 3.36 |
| 6 (H) | 8/1991–6/2012 | 21 years | 14.42–86.84 | 24.87 | 22.58 | 9.95 |
| Panel D: P/E10 – Bai-Perron | | | | | | |
| 1 (H) | 1/1881–2/1907 | 26 years | 12.91–25.24 | 17.54 | 17.22 | 2.36 |
| 2 (L) | 3/1907–11/1953 | 46 years | 4.78–32.56 | 12.45 | 11.87 | 4.42 |
| 3 (H) | 12/1953–10/1973 | 20 years | 11.75–24.06 | 18.57 | 18.34 | 2.83 |
| 4 (L) | 11/1973–12/1991 | 18 years | 6.64–18.51 | 11.73 | 10.51 | 3.26 |
| 5 (H) | 1/1992–6/2012 | 20 years | 13.32–44.20 | 26.26 | 25.20 | 7.00 |

*Notes*: (L) – The P/E period that has relatively low mean and median. (H) – The P/E period that has relatively high mean and median.

There may be several possible explanations about structural changes in the P/E ratio but it is not easy to get a clear-cut answer. First, we consider the Gordon model (Constant growth model) which attempts to explain stock price movements (Balke, Wohar 2001). According to the Gordon model, the P/E ratio can be determined by three factors: dividend payout, dividend growth, and required rate of return. It can be expressed as follows:

$$P / E = \left(D/E\right) / \left(r - g\right), \tag{3}$$

where *P* and *E* are the price and earnings, *D* is the dividend, *r* is the required rate of return, and *g* is the dividend growth. Figure 4 and Figure 5 show growth (change) in the dividend payout ratio and growth (change) in real dividends respectively. Their averages are close to zero.

We expect their growth rates to consistently stay positive or negative during each high or low P/E period. Loosely speaking, we expect to observe approximately similar patterns during high P/E or low P/E periods. However, as we see in Figure 4 and Figure 5, it is hard to find any similar pattern for high or low P/E periods. Even when we examine the time trend of these two factors for each sub-period by conducting a simple linear time trend regression, we do not find a consistent pattern for high or low P/E periods.

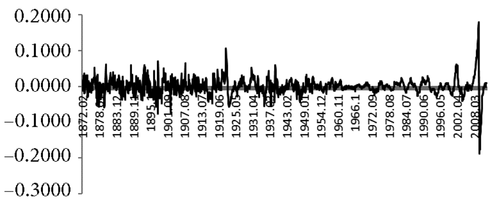


Figure 4. Growth in dividend payout ratio

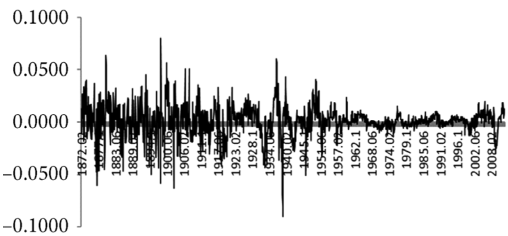


Figure 5. Growth in real dividends

While dividend payout and dividend growth are expected to be affected by firms' policies, the required rate of return would be determined by market participants' expectations. Basically, the required rate of return is composed of the risk-free rate of return and the risk premium. Considering that dividend payout and dividend growth do not show a consistent pattern for high or low P/E periods, we naturally expect the required rate of return to be low during high P/E periods and high during low P/E periods. However, there are several different arguments about change in the required rate of return and it is hard to find statistical evidence for stock market movements based on fundamental factors such as dividends, earnings, and interest rates (Balke, Wohar 2001).

As a result, it does not seem to be an easy task to explain why these structural changes have occurred with fundamental variables. As we mentioned in the introduction, the main purpose of our study is to identify statistically significant structural breaks and examine how these structural changes affect long-term stock market returns. Thus, we believe that further research is needed to study causes of structural breakpoints in depth. Instead, we broadly review historically influential economic events around structural breakpoints: 1872 – Long Depression (deflation and low growth); 1885 – Second Industrial Revolution; 1899 (or 1907 in the P/E10) – Economic Depression; 1958 (or 1955 in the P/E10 or 1953 in the P/E10 with the Bai-Perron algorithm) – Postwar Era (baby & housing boom and sharp increase in mortgage lending); 1973 – Stock Market Crash and Oil Crisis; and 1986 (or 1989 in the P/E10 or 1991 in the P/E1 and the P/E10 with the Bai-Perron algorithm) – Changes in the Corporate World (leveraged buyouts, mergers and hostile takeovers, and information technology). The Long Depression (1872), Economic Depression (1899), and Stock Market Crash and Oil Crisis (1973) might generate persistently negative prospects about the stock market and cause the required rate of return to increase. This is what we expect for these low P/E periods. In the same way, persistently positive prospects from the Second Industrial Revolution (1885), Postwar Era (1958), and Changes in the Corporate World (1986) might cause the required rate of return to decrease. This is also what we expect for these high P/E periods. Consequently, these historical economic events appear to provide at least partial clues about high or low P/E periods.

## 4. Structural changes, real stock market returns, and asymmetric response

In this section, we re-investigate the inverse relationship between market P/E ratios and subsequent long-term market returns. Then, we examine how structural changes in the P/E ratio affect long-term market returns. We calculate subsequent 10-year real market returns at the beginning of each month. We construct the following regression that includes the asymmetric dummy proposed in the previous study (Koutmos, Martin 2003).

$$Y_t = \beta_0 + (\beta_1 + \mu D_t) X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \beta_4 X_{4t} + \beta_5 X_{5t} + \varepsilon_t, \quad (4)$$

where:

$Y_t$: Subsequent 10-year real market return at time *t*,

$X_{1t}$: P/E1 or P/E10 at time *t*,

$X_{2t}$: Change in the consumer price index (CPI) at time t over the prior 10 years,

$X_{3t}$: Change in real earnings at time *t* over the prior 10 years,

$X_{4t}$: Bond market volatility at time *t* over the prior 10 years,

$X_{5t}$: Equity market volatility at time *t* over the prior 10 years,

$D_t$: Asymmetric dummy variable at time *t*,

where $D_t = 1$ if $X_{1t}$ happens during a high P/E period and $D_t = 0$ if $X_{1t}$ happens during a low P/E period.

The dummy variable, $D_t$, is included to determine if there exists an asymmetric response depending on a high or low P/E period. The regression includes two key variables change in the consumer price index (CPI) and change in real earnings from the supply side which the previous study (Ibbotson, Chen 2003) proposes for decomposing equity returns. We also include the bond volatility and the equity volatility employed by some studies (Asness 2000; Weigand, Irons 2007). To avoid a serial correlation problem and obtain robust results, we use the Newey-West HAC (Heteroskedasticity and Autocorrelation Consistent) method as well as the OLS method.

If subsequent long-term returns are inversely related to P/E ratios, and market participants properly perceive structural changes, we expect the asymmetric dummy variable to have a positive coefficient because market participants are likely to perceive high P/E ratios less significantly and low P/E ratios more significantly during high P/E periods than low P/E periods.

For instance, while a P/E ratio of 25 is likely to be considered less significantly high during high P/E periods than low P/E periods, a P/E ratio of 10 is likely to be considered more significantly low during high P/E periods than low P/E periods.

Thus, if there exists an inverse relationship between P/E ratios and subsequent long-term returns, given a high P/E ratio, we expect subsequent long-term returns to decrease less during high P/E periods than low P/E periods or given a low P/E ratio, we expect subsequent long-term returns to increase more during high P/E periods than low P/E periods. In other words, there may exist an asymmetric response during high P/E periods in the form of an extra positive return. Table 4 shows the regression results with structural changes identified from the CUSUM method and the Bai-Perron algorithm. The first *t*-ratio in each parenthesis is calculated with the OLS method and the second one is calculated with the Newey-West estimator. As a whole, the statistical significance (*t*-ratio) with the Newey-West estimator tends to become relatively weak.

We confirm the inverse relationship between P/E ratios and subsequent long-term returns over the 142-year time span because $\beta_1$ is significantly negative. This finding is consistent with that of previous studies. On the other hand, the asymmetric dummy variable coefficient, $\mu$, is significantly positive in P/E1 and P/E10 regressions with both OLS and Newey-West methods.

This means that there exists an asymmetric response during the high P/E period and thus, market participants properly perceive structural changes in the market P/E ratio by responding asymmetrically. This result is consistent with our Hypothesis 2 and shows that there exist some extra return premiums during the high P/E period.

It seems to be quite predictable because given the inverse relationship between P/E ratios and long-term stock returns, market investors are likely to perceive high P/E ratios less (more) significantly and low P/E ratios more (less) significantly during structurally high (low) P/E periods. Accordingly, it may result in an incomplete model specification to establish the inverse relationship between P/E ratios and future long-term market returns without considering structural changes in the market P/E ratio.

In P/E1 and P/E10 regressions with the OLS method, while the changes in the CPI (inflation) and the equity volatility are significantly positive except for $\beta_5$ in the Bai-Perron P/E1 regression, the changes in real earnings and the bond volatility show mixed results. The change in real earnings, $\beta_3$, has a negative sign and that is consistent with the result of the previous study (Weigand, Irons 2007). On the other hand, with the Newey-West method, we obtain similar results.

Table 4. Regression results

| Coefficient | CUSUM | | | Bai-Perron | |
|---|---|---|---|---|---|
| | P/E1 ($X_{1t}$) | P/E10 ($X_{1t}$) | | P/E1 ($X_{1t}$) | P/E10 ($X_{1t}$) |
| $\beta_0$ | 0.0410<br>(7.99**, 4.75**) | 0.0498<br>(9.38**, 8.99**) | | 0.0369<br>(7.03**, 4.39**) | 0.0500<br>(9.21**, 8.71**) |
| $\beta_1$ | −0.0042<br>(−13.71**, −7.90**) | −0.0053<br>(−17.79**, −15.81**) | | −0.0028<br>(−9.10**, −5.38**) | −0.0046<br>(−15.06**, −13.65**) |
| $\mu$ | 0.0019<br>(9.56**, 7.33**) | 0.0023<br>(11.47**, 8.03**) | | 0.0008<br>(3.89**, 2.84**) | 0.0016<br>(8.02**, 5.50**) |
| $\beta_2$ | 0.6206<br>(13.12**, 9.23**) | 0.5892<br>(12.09**, 10.31**) | | 0.5447<br>(11.40**, 8.26**) | 0.5108<br>(10.46**, 8.71**) |
| $\beta_3$ | −0.2206<br>(−7.61**, −6.28**) | −0.0261<br>(−0.87, −0.71) | | −0.2232<br>(−7.50**, −6.18**) | −0.0372<br>(−1.22, −1.02) |
| $\beta_4$ | 0.0024<br>(1.07, 0.80) | 0.0106<br>(5.02**, 3.52**) | | 0.0094<br>(4.34**, 2.91**) | 0.0146<br>(6.86**, 4.46**) |
| $\beta_5$ | 0.1085<br>(4.23**, 3.72**) | 0.0998<br>(3.85**, 3.65**) | | 0.0343<br>(1.34, 1.21) | 0.0537<br>(2.04*, 1.90) |
| Adjusted $R^2$ | 0.3195 | 0.3663 | | 0.2866 | 0.3401 |

*Notes*: The parenthesis shows two *t*-ratios. The first one is calculated with the OLS method and the second one is calculated with the Newey-West method.
**, * indicate statistical significance at the 1% and 5% level respectively.

The semi-partial $R^2$ can be used to see how much each explanatory variable contributes to the regression. We calculate the semi-partial $R^2$ of each explanatory variable in order to show its unique contribution as a percentage rate of total contributions. In Table 5, as a whole, the asymmetric dummy variable appears to make substantial contributions to the regression. In particular, on average, the asymmetric dummy makes more contributions than real earnings and market volatilities.

Table 5. Semi-partial $R^2$ for each explanatory variable

| Coefficient | CUSUM | | | Bai-Perron | |
|---|---|---|---|---|---|
| | P/E1 (Semi-partial $R^2$) | P/E10 (Semi-partial $R^2$) | | P/E1 (Semi-partial $R^2$) | P/E10 (Semi-partial $R^2$) |
| $\beta_1$ | 35.57% | 49.86% | | 27.22% | 50.08% |
| $\mu$ | 17.31% | 20.72% | | 4.98% | 14.17% |
| $\beta_2$ | 32.56% | 23.02% | | 42.67% | 24.15% |
| $\beta_3$ | 10.94% | 0.12% | | 18.41% | 0.31% |
| $\beta_4$ | 0.22% | 3.94% | | 6.14% | 10.39% |
| $\beta_5$ | 3.40% | 2.34% | | 0.58% | 0.89% |

Also, it has more contributions with P/E10 than P/E1. Consequently, we confirm that structural changes in the market P/E ratio play a relatively important role in explaining long-term market returns.

## 5. Discussion

We briefly discuss the possibility that structural breaks will be used to actually predict future stock returns. Although we find that structural changes asymmetrically affect stock market returns over the long run, we should forecast structural changes first, in order to use them for the purpose of predicting future stock returns. One potential model that can be used to forecast structural changes would be the modified mean reverting process, based on the Ornstein-Uhlenbeck mean reverting process:

$$dp_t = \lambda\left(\mu_t - p_t\right)dt + \sigma dW_t\,, \tag{5}$$

where $p_t$ is a P/E ratio at time $t$, $\mu_t$ is the varying long-run mean, $\lambda$ is the speed adjustment, and $W_t$ is the standard Wiener process ~ $N(0, dt)$. When we consider that high and low P/E periods occur alternately over the long run with varying means, the modified mean-reverting process appears to be appropriate. Since the duration of each high or low P/E period in Table 3 turns out to be sufficiently long, the modified mean-reverting process enables us to determine whether a specific point in time belongs to a high P/E or low P/E period by predicting the duration of the next high or low P/E period. Of course, there may be more sophisticated models that can be used to estimate future structural break cycles. The key issue for these models is how to estimate model parameters and this is directly related to the limitation of our study. To do this, further discussion and research are needed, because there would be many different factors that influence structural break cycles.

## Conclusions

Although many studies have shown that P/E ratios and long-term stock returns are inversely related, most of them have not taken structural changes in the market P/E ratio into account and thus, few studies have examined the effect of structural changes on long-term stock returns.

Basically, we argue that structural changes should be considered in some manner to establish the theoretical link between P/E ratios and long-term stock returns. Our study investigates structural changes in the market P/E ratio and shows how these structural changes affect long-term stock returns. We find significant results by identifying multiple structural breakpoints in both P/E1 and P/E10 over the past 142-year time span.

First, we identify multiple structural break points in the historical market P/E ratio and find that P/E ratios substantially move upward or downward at each break point rather than revert to the historical mean. Also, the duration of each break cycle turns out to be long enouth. This means that stock market participants properly perceive structural changes in the market P/E ratio and respond to structurally high or low P/E periods over the long run. Second, we find that structural break cycles repeat the high and low P/E periods and each cycle lasts for quite a long time. In fact, this implies that the long-run mean of the market P/E ratio should be recognized as a varying mean over time instead of a constant mean supported by the traditional standpoint. Third, we confirm the inverse relationship between P/E ratios and long-term stock returns, which is consistent with previous studies. However, more interestingly, we find that structural changes in the market P/E ratio asymmetrically influence long-term stock returns depending on the high or low P/E period. Actually, some positive return premiums exist during high P/E periods. This implies that stock market participants consider high P/E ratios less (more) significantly and low P/E ratios more (less) significantly during high (low) P/E periods. The main contribution of our study is that structural changes in the market P/E ratio play an important role in explaining long-term stock returns.

However, our study has some limitation when we actually use structural changes in the P/E ratios in order to predict long-term stock market returns because the high or low P/E period should be determined first. As mentioned in the discussion section, it would be possible to predict the high or low P/E period based on several different models. Considering that the duration of each high or low P/E break cycle has been long enough over the past 142-year time span, we would be able to determine whether a specific point in time falls within a high P/E or low P/E period without difficulty if a forecasting model is properly chosen. Further research is needed for the model selection and estimation.

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