# Monetary Policy and Equity Valuation

Nicolas Mougeot*

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**Abstract**

I use a general form of the Taylor rule to show the effect of monetary policies on equity valuation. If equity investors infer their long-term discount rate based upon guidance from the Fed using the Taylor rule, I show that when the sensitivity of Fed funds rates to inflation is greater than one, then earnongs yield should also display a positive relationship with inflation. This would provide a rational explanation to the empirically observed relationship between earnings yield and inflation. Equity investors therefore discount nominal cash flows at nominal discount rate, accounting for the Fed's policy response to inflation changes, refuting the Money Illusion Hypothesis of Modigliani and Cohn. An empirical analysis on US data over the 1915-2017 period confirms the proposition.

**Keywords:** Money Illusion, Inflation, Taylor Rule, Earnings Yield

*Nicolas Mougeot is at John Molson School of Business, Concordia University (nicolas.mougeot@concordia.ca)

# 1 Introduction

While the effect of inflation on bond yield is consensual among academics and practitioners, its impact on equity valuation metrics such as the Price-Earnings Ratio (P/E ratio) is still an open debate. On the one hand, Asness (2003) and Campbell and Vuolteenaho (2004) among others advance that a rational investor should not account for changes in inflation expectations when valuing stocks. The dividend-discount model implies that the dividend-price ratio (or dividend yield) is a function of the spread $(K_e - G)$ between the nominal long-term discount rate, $K_e$, and the nominal growth rate of dividend, $G$. Subtracting inflation from both R and G implies that the dividend yield is a function of the real spread $(k_e - g)$ between the real long-term discount rate $k_e$ and the real growth rate of dividend, $g$. Changes in inflation expectations should therefore leave the dividend-price ratio unaffected.

Figure 1 however shows that earnings yield, bond yield and inflation have comoved together over the past 50 years. This empirical observation has led many practitioners to use the so-called "Fed Model" that relates bond yield to earnings yield as an approach to assess relative valuation of stocks over bonds. As inflation has historically been the main driver of interest rate, the Fed Model implies that earnings yield should also be highly correlated with inflation (See Campbell and Vuolteenaho (2004)). There is therefore a wide gap between academics and practitioners when it leads to understanding the effect of inflation on stocks. As discussed in Section 2, three explanations compete to solve the puzzling relation between earnings yield and inflation: the Money Illusion Hypothesis of Modigliani and Cohn (1979), the effect of inflation on the equity risk premium (e.g. Bekaert and Engstrom (2010)) and the asymmetric impact of inflation on earnings growth (See Thomas and Zhang (2009) or Bhamra et al (2017) for example).

In this paper, I offer a fourth explanation: The choice of monetary policy may affect the way investors discount future cash flows and this could provide a rational explanation to the observed empirical relation between inflation and earnings yield. One of the main objectives of central banks is usually to control for price stability and I show that depending on the policy response to change in inflation, earnings yield could rationally be a function of inflation. In the US for example, the Federal Reserve

(Fed) has a dual mandate consisting in stabilizing prices while maximizing employment. This has been well documented by Taylor (1993) who showed that the Fed funds rate can simply be described by:

$$r_t = 2\% + \pi_t + 0.5\,(\pi_t - 2\%) + 0.5\,(y_t - y^*) \tag{1.1}$$

Where $\pi_t$ is the current inflation calculated over the past four quarters, $y_t$ is the real GDP and $y^*$ is its potential. According to Equation 1.1, usually referred as the Taylor rule, The Fed will increase interest rate if the current inflation $\pi_t$ is above the Fed's target of 2% and if the output gap $(y_t - y*)$ is positive. Re-arranging the terms of Equation 1.1, the Taylor rule also implies that the Fed fund rate should have a beta of 1.5 with current inflation. Under such assumption, long-term bond yields should also have an inflation beta of 1.5 which in turn implies that the dividend yield should have a beta of 0.5. In such a case, a dividend payout ratio of 0.5 for example would imply an inflation beta of one for earnings yields.

A rational investor accounting for Fed's monetary policy should therefore expect the S&P 500's earnings yield to rise with inflation and its Price-Earnings ratio to fall accordingly. The Taylor rule could therefore partially explain the currently elevated level of S&P 500's price-earnings ratio since inflation has been low and contained as well as its low level in the 70ies when inflation was high. If the Taylor rule explains the relationship between inflation and earnings yield, one could also expect this relationship to be much weaker when the Fed's mandate was not explicitly to fight against inflation or when the Fed follows a highly accommodative monetary policy such as since the financial crisis of 2008. Indeed, in periods when the Fed reacts less to inflation, the earnings yield could display little to no sensitivity to inflation too.

This paper therefore refutes the Money Illusion of Modigliani and Cohn (1979): Equity investors are rational agents discounting nominal cash flows using nominal discount rates that are drawn from the Fed's policy response to inflation changes, which itself can change over time.

The rest of the paper is structured as follow. The next section relates why the potential effect of inflation on equity valuation is a central question for investors and provides a short literature review on the debate regarding the existence of a relationship between earnings yield and inflation. Section 3 assesses the the implication of the Taylor rule on bond yield and equity valuation. Section 4 introduces the ARDL methodology and describes the data used in the analysis. In session 5 the impact of inflation on bond yield and earnings yield is analyzed in the US during periods over different periods when the Taylor rule holds or not. Section 6 concludes.

# 2 The Historical Relationship between Earnings Yield and Inflation

## 2.1 Dividend Discount Model and Inflation

Following Bekaert and Engstrom (2010), Asness (2003) and many others, I start from the well-known constant-growth dividend discount model (DDM), also known as Gordon-Shapiro model. It expresses the value of a stock price $P_t$ at time t as the discounted value of its future dividend stream:

$$P_t = \frac{D_t * (1+G)}{K_e - G} \tag{2.1}$$

Where $D_t$ is the dividend at time t, G its nominal growth rate and $K_e$ the nominal discount rate, or cost of equity. Assuming a constant dividend payout ratio $pay$, Equation 2.1 can be rewritten as:

$$P_t = \frac{E_t * (1+G)}{K_e - G} * \frac{1}{pay} \tag{2.2}$$

The earnings-to-price ratio, or earnings yield, is therefore equal to:

$$EY_t = \frac{E_t}{P_t} = \frac{D_t}{P_t}\frac{E_t}{D_t} = (K_e - G) * \frac{pay}{(1+G)} \tag{2.3}$$

The transmission mechanism of inflation to earnings yield can therefore be through either the discount rate $K_e$, the earnings growth rate or a combination of both. Campbell and Vuolteenaho (2004) and Asness (2003) and others argue however that inflation should have little effect on the price-earnings ratio or its inverse, the earnings yield. The main argument is that Equation 2.3 can be rewritten in real terms, by subtracting inflation to both the discount rate and the earnings growth:

$$EY_t = (rr + ERP - g)\frac{pay}{(1+G)} \tag{2.4}$$

Where $rr$ is the real risk-free rate, $g$ the expected real growth rate of earnings and ERP the equity risk premium. Therefore, whenever inflation moves up or down, its effect on nominal cash flow should be offset by its effect on the discount rate and the earnings yield should be independent from inflation.

## 2.2 The Fed Model and the Empirical Relationship between Earnings Yield and Inflation

Proponents of the existence of a relationship between earnings yield and inflation usually start from empirical evidence. As shown by Figure 1, earnings yield, bond yield and inflation seem to have fluctuated together, advocating for the use of the Fed model. The Fed model is a simple framework used by some practitioners which compares earnings yield, $EY_t$ with bond yield $BY_t$. When the earnings yield is higher than the bond yield, some investors interpret it as a buy-signal for stocks. When bond yield is above earnings yield, bonds are more attractive and should be preferred. Despite the fact that the Fed does not officially embrace the so-called Fed model, its simplicity has made it very popular. According to the Fed model's followers, bond yield and earnings yield are driven by the same factor, inflation. The relationship between inflation and bond yield is usually not challenged as central banks use interest rate to control inflation. When inflation rose in the seventies, the Fed and other central banks quickly increased interest rates in order to tame inflation. Earnings yield however should be independent from inflation as discussed in the precedent section and therefore the rationale behind the Fed model has been questioned.

## 2.3 The Money Illusion Hypothesis and other Explanations to the Earnings Yield-Inflation Puzzle

The empirical observation is not questioned by academics. For example, Cohen, Polk and Vuolteenaho (2005), Sharpe (2002), and Asness (2003) confirm the existence of a strong correlation between earnings yield and bond yield. This is however considered as a puzzle given that it is not predicted by the dividend-discount model and the main explanation to that puzzle is the Money Illusion Hypothesis of Modigliani and Cohn (1979). Modigliani and Cohn (1979) argue that investors correctly assess the real growth rate of earnings, accounting for expected inflation. However, they fail to correctly adjust the discount rate for inflation and end up discounting real cash flows with a nominal discount rate. More recently, the Money Illusion Hypothesis was also put forward as an explanation of the link between earnings yield and inflation by Cohen, Polk and Vuolteenaho (2005), Campbell and Vuolteenaho (2004), Asness (2003) and Ritter and Warr (2002).

Given the behavioral nature of the money illusion argument, the relationship between earnings yield and inflation should have faded away since it was discovered as investors become aware of their valuation error. What is striking too is that investors seem to have suffered from money illusion in a on-and-off fashion: Estrada (2006) for example points out that the relationship between earnings yield and inflation is much weaker when the analysis is extended to 1871. Figure 1 seems to highlight that the relationship has also been weaker since the 2008 crisis. The Money Illusion Hypothesis may therefore not be the only explanation to the earnings yield-inflation puzzle and two strands of research have emerged to provide rational explanations to the time-varying relationship between earnings yield and inflation.

First, Bekaert and Engstrom (2010) suggest that the impact of inflation on earnings yield could potentially come from the equity risk premium itself. As high inflation is often related to high economic uncertainty, investors should require a high equity risk premium in an uncertain economic environment characterized by high inflation. Bekaert and Engstrom (2010) use a vector auto-regressive (VAR) framework to show that the covariance between dividend yield and expected inflation can be explained by the correlation between expected inflation and equity risk premium.

A second stream of research relates to the effect of inflation on earnings growth: The effect of inflation on the nominal growth rate of earnings is not necessarily one-to-one. According to Thomas and Zhang (2009), the "common wisdom" given by Equation 2.4 does not recognize that accounting rules include inflationary gains in reported earnings. When properly accounting for these inflationary gains, they postulate that earnings yield should vary with inflation while earnings growth need not vary with expected inflation. Bhamra et al. (2017) advance another argument. They show that the sensitivity of earnings growth to inflation can be affected by sticky leverage and profitability: In the short-run, leverage is sticky as nominal coupons are fixed. Profitability is sticky too in the short-run as earnings growth is less sensitive to variations in expected inflation than the nominal risk-free rate.

In the following section, I tackle the puzzle from the interest rate and discount rate angle: monetary policy itself could explain the sensitivity of earnings yield to inflation over the last 40 years as well as its absence of any relationship in the preceding 60 years.

# 3 Taylor Rule and Equity Valuation

## 3.1 The Taylor Rule

In a seminal paper, Taylor (1993) shows that, over the period 1987-1993, the Federal Reserve monetary policy can be approximated by the following rule:

$$r_t = rr^* + \pi_t + 0.5\left(\pi_t - \pi^*\right) + 0.5\left(y_t - y^*\right) \tag{3.1}$$

Where $r_t$ is the Fed funds rate, $rr^*$ is the long-run real interest rate, $\pi_t$ is the current period's inflation measured by the GDP deflator and $\pi^*$ is the Fed's inflation target. $(y_t - y^*)$ is referred as the "output gap" and measures the difference between the log of real GDP, $y_t$, and the log of the potential output, $y^*$. In other words, Equation 3.1 states that the Fed fixes its target rate as a function of:

- The deviation of current inflation from the central bank's inflation target
- The deviation of the real GDP from its potential output

This summarizes well the dual objective of the Fed to control inflation while seeking full employment (and hence real GDP reaching its potential output). Equation 3.1 can be rewritten as:

$$r_t = rr^* - 0.5\pi^* + 1.5\pi_t + 0.5\left(y_t - y^*\right) \tag{3.2}$$

Under the Taylor rule, the sensitivity of Fed funds rate to inflation is equal to 1.5. The Federal Reserve needs to increase rates at a faster pace than inflation to control it. As discussed in section 5.3, several authors (Taylor (1999), Clarida, Gali and Gertler (2000)) have shown that the policy response to inflation and output gap has evolved over time. According to Taylor (1999) for example, the coefficient associated to inflation and the output gap have more than doubled from the 1960ies to the 1987-1997 decade. More recently, the decade that has followed the mortgage debt crisis has experienced unconventional monetary policy with a Fed funds rate close zero despite positive inflation and a significant output gap. Investors should therefore first assess what the current policy rule is before they can form views on the discount rate they use to value other assets. They should use a general form of Equation 3.1 such that the Fed funds rate is given by:

$$r_t = rr* + (1 - \beta_{FF}^{\pi})\,\pi^* + \beta_{FF}^{\pi}\pi_t + \beta_{FF}^{y}\,(y_t - y*) \tag{3.3}$$

A $\beta_{FF}^{\pi}$ of 1.5 and $\beta_{FF}^{y}$ of 0.5 yields the original Taylor rule. As $\beta_{FF}^{\pi}$ is expected to be positive and greater than one, the Taylor rule could have a substantial effect on the pricing of bonds and equities if investors follow it to draw expectations on future short-term interest rates.

## 3.2 Taylor Rule and Long-term Bond Yield

First, let assess the effect on bond prices in a framework where for simplicity the Expectations Hypothesis is assumed to holds. Under such assumption, the yield of a nominal bond is the average of future Fed funds rates[1]. Investors form anticipations on short-term interest rates according to the Taylor rule such that Equation 3.3 holds not only at time t but also in expectations terms at any time t+1:

$$\bar{r}_{t+1} = r_t = rr* + (1 - \beta_{FF}^{\pi})\,\pi^* + \beta_{FF}^{\pi}\bar{\pi}_{t+1} + \beta_{FF}^{y}\,(\bar{y}_{t+1} - y*) \tag{3.4}$$

[1]One could relax this assumption and use an affine representation of interest rate following Duffie and Kan (1996) or Duffee (2002). However, as we are primarily interested in the effect of inflation in this article, I assume that the Expectations Hypothesis holds (or that there is no time-varying risk premia associated with inflation and output gap).

If $r_t$ is a continuously compounding interest rate, then the yield $R_{t,t+n}$ of a bond maturing at $t+n$ should be equal to:

$$R_{t,t+n} = \frac{1}{n}\sum_{j=0}^{n-1} \bar{r}_t = rr* + (1-\beta^{\pi}_{FF})\,\pi^* + \beta^{\pi}_{FF}\bar{\pi}_{t,t+n} + \beta^{y}_{FF}\,(\bar{y}_{t,t+n} - y*) \tag{3.5}$$

Where $\bar{\pi}_{t,t+n}$ and $\bar{y}_{t,t+n}$ represent the expected average inflation and the average real GDP over the period $[t, t+n]$ respectively. As the real GDP hovers around its potential output, the average output gap$(\bar{y}_{t.t+n} - y*)$ should converge towards zero as $n$ increases. Following Equation 3.5, long-term bond yields should equally have an inflation beta equal to $\beta^{\pi}_{FF}$.

One then can wonder whether the Taylor rule could also affect the way investors are valuing equity prices. The Fed communicates widely about its objective to keep price stable and several central bankers such as Yellen (2012) and Bernanke (2015) have mentioned that the Taylor rule should at minima be a strong guideline to the Fed's monetary policy. Investors should therefore account for the consequences that the use of the Taylor rule may entail when they form their expectations about the discount rate.

### 3.3 Earnings Yield and Monetary Policy

Let's consider a period during which the Federal Reserve's monetary policy can be described by the Taylor rule. Rational investors estimating a firm's value should account for monetary policy set by the Fed. If the Fed's fund rate effectively respects the Taylor rule, the long-term bond yield should follow Equation 3.5, implying an inflation beta of $\beta^{\pi}_{FF}$. Let assume that investors use the long-term bond yield $R_{t,t+n}$ plus a an equity risk premium (denoted $ERP$) to discount cash flows, where $n$ could be 10 years for example as the long-term risk-free rate is often proxied by investors with the US 10-year treasury bond yield. This leads to a second proposition:

**Proposition 1.** *When the Taylor rule correctly describes the Fed's monetary policy and the Expectations Hypothesis holds, the cost of equity should have an inflation beta of* $\beta^{\pi}_{FF}$.

$$K_e = R_{t,t+n} + ERP = rr* + (1 - \beta_{FF}^{\pi})\,\pi^* + \beta_{FF}^{\pi}\bar{\pi}_{t,t+n} + ERP \tag{3.6}$$

Let assume that the real earnings growth is given by a constant $g$. The nominal dividend growth $G_{t,t+n}$ is thus given by $g + \pi_{t,t+n}$ , assuming that there is a one-for-one relation between earnings growth and inflation. If the dividend payout ratio is constant and inflation expectations are correct on average, then $\pi_{t,t+n} = \bar{\pi}_{t,t+n}$ and dividend yield $EY_t$ should follow:

$$EY_t = \frac{E_t}{P_t} = \frac{D_t}{P_t}\frac{E_t}{D_t} = \frac{(rr* + (\beta_{FF}^{\pi} - 1)\,(\bar{\pi}_{t,t+n} - \pi^*) + ERP - g_{t,t+n})}{1 + G_{t,t+n}}\frac{1}{pay} \tag{3.7}$$

Equation 3.7 has several implications. First, it provides us with a potential rational explanation to the observed relationship between earnings yield and bond yield. In a "Taylor rule" environment, investors correctly anticipate that bond yields should change by more than one-for-one to any change in inflation, which implies a positive inflation beta for the earnings yield. Therefore, the observed relationship between earnings yield and inflation may not come from money illusion but from rational expectation of the Fed's reaction to changes in inflation. If firms implement a dividend payout policy independent from inflation and if we assume that the dividend payout ratio lies around 0.5, then the original Taylor rule would imply that the earnings yield should have an inflation beta around 1 (=(1.5-1)/0.5). Second, Equation 3.7 only holds true when the Fed's monetary policy can be correctly described by the Taylor rule. The sensitivity of earnings yield to inflation should reflect the way the Fed reacts to changes in inflation and how it adjusts its target rate accordingly. If in a given period the monetary policy can be characterized by $\beta_{FF}^{\pi} = 1$, then the earnings yield should be independent from inflation. If the Fed has modified the way it responds to change in inflation, then the sensitivity of earnings yield to inflation should reflect it too and could vary over time. I therefore investigate in the next section to which extent the Fed's mandate has evolved since it was created in 1914 and whether the Taylor rule has always correctly reflected the Fed's monetary policy.

Equation 3.7 assumes that there is a one-for-one relationship between earnings nominal growth and inflation. However, several studies (See Sharpe (2002) for example) show that this latter assumption is not always verified, either because the real earnings growth may be affected by inflation or because firms are not able to fully pass on inflation to end-customers. This hypothesis can be further relaxed by assuming that the nominal earnings growth has an inflation beta $\beta_G^\pi$, which may differ from one, such that it is given by:

$$G_{t,t+n} = \beta_G^\pi \bar{\pi}_{t,t+n} + g_{t,t+n} \tag{3.8}$$

$g_{t,t+n}$ can be interpreted either as the real earnings growth or its constant term. The earnings yield can therefore be obtained by combining Equations 2.3, 3.6 and 3.8, to obtain:

$$EY_t = \frac{\left(rr^* + \left(1 - \beta_{FF}^\pi\right)\pi^* + \left(\beta_{FF}^\pi - \beta_G^\pi\right)\bar{\pi}_{t,t+n} + ERP - g_{t,t+n}\right)}{1 + G_{t,t+n}} \frac{1}{pay} \tag{3.9}$$

This yields a second proposition as follow:

**Proposition 2.** *When the Taylor rule correctly describes the Fed's monetary policy and the Expectations Hypothesis holds, if earnings nominal growth has an inflation beta equal to* $\beta_G^\pi$*, then the earnings yield has approximately an inflation beta equal to* $\left(\beta_{FF}^\pi - \beta_G^\pi\right)/pay$ *. If the inflation beta of nominal growth is equal to one, then the sensitivity of earnings yield to inflation is reduced to* $\left(\beta_{FF}^\pi - 1\right)/pay$*.*

*Alternatively, when the Fed funds rate does not provide any guideline on the long-run relationship between rates and inflation, earnings yield should be independent from inflation .*

Proposition 2 offers an alternative solution to the empirical observed sensitivity of earnings yield to inflation. Under the Money Illusion Hypothesis, the strong correlation between earnings yield and bond yield is explained by the following. Investors correctly assess the real growth rate of earnings, accounting for inflation but they fail to correctly adjust the discount rate for inflation. Investors are assumed to incorrectly discount real cash flows with a nominal discount rate, leading to an inflation beta of earnings yield, $\beta_{EY}^{\pi}$ , equal to one.

Instead, if Proposition 2 holds, $\beta_{EY}^{\pi}$ could well be explained by the policy response to inflation as it is given by $(\beta_{FF}^{\pi} - \beta_{G}^{\pi})/pay$. As monetary policies evolve over time, investors should take it into account and adjust the way they discount future earnings. Therefore, changes in monetary policies over time should yield different inflation betas of earnings yield.

In a "Fisherian" world where interest rate would have a one-to-one relationship with inflation, the earnings yield should have an inflation beta equal to zero as long as earnings growth is also reacting on a one-to-one basis to inflation. In a "Taylorian" world, investors should draw their expectations about future interest rates upon what the Taylor rule assumes for short-term rate, implying a sensitivity of the discount rate to inflation greater than zero. $\beta_{EY}^{\pi}$ could well be different from zero as $\beta_{FF}^{\pi}$ is expected to be greater than one.

Proposition 2 stands on the assumption that the monetary policy can provide information on long-term rates through the fixing of short-term rates. However, there have been periods where Fed funds rates have not been influenced by inflation, for various reasons. As later discussed in Section 3.5, the Fed did not have inflation as an explicit factor to target prior to the WWII. More recently, in the aftermath of the 2008 crisis, the Fed did not only use its target rate to bolster the economy but started large-scale asset purchases (QE1, QE2 and QE3) as well as other forms of unconventional monetary actions such as the Operation Twist. In fact, the very low inflation environment combined with a sluggish economic environment could have driven the Fed to impose negative rates if it had continued to follow the Taylor rule.

Therefore, Fed funds rates are likely to be largely independent from inflation over these periods and equity investors can not base their long-term discount rate expectations on the Fed's reaction to inflation. Instead, the best they can do is to assume that, in the long-run, long-term nominal rates are equal to long-term real rate plus inflation. It implies that during these two periods, Pre-WWII and Post-2008 Crisis, earnings yield should be independent from inflation as $(K_e - G)$ should be equal to $(k_e - g)$.

## 3.4 An Alternative Specification of the Taylor Rule and its Implications on Asset Valuation

While Taylor (1993) suggests that such a policy rule could resemble Equation 1.1, he reckons that many variants could exist. He suggests for example that there could be "a policy rule where the growth rate of real GDP rather than its level appears". Using the real GDP growth rate instead of its level could solve one of the issues that lies with the Taylor rule: it relies on the potential GDP which is an unobservable variable. Therefore, How can FOMC members decide if the current real GDP is above or below its potential? An alternative Taylor rule could therefore specify the Fed funds rate as a function of inflation and real GDP growth rate, such that it would be given by:

$$r_t = rr^* + (1 - \beta_{FF}^{\pi})\,\pi^* + \beta_{FF}^{\pi}\pi_t + \beta_{FF}^{gdp}\,(gdp_t - gdp^*) \tag{3.10}$$

Where $gdp_t$ stands for the real GDP growth rate over the past quarters, $gdp^*$ is the real GDP growth rate targeted by the Fed and $\beta_{FF}^{gdp}$ the sensitivity of the Fed funds rate to the deviation of the real GDP growth from the target. When the economy is overheating and the real GDP growth rate is above a given level $gdp^*$, the Fed is likely to increase its target rate to cool down the economic activity before it creates unsustainable inflation. While the Fed objective is to seek maximum employment, real GDP growth is a key factor to reach that goal. As an example, the May 2018 Minutes of the Federal Open Market Committee states that "Beyond 2018, the projection for GDP growth was essentially unrevised. With real GDP rising a little less, on balance, over the forecast period, the projected decline in the unemployment rate over the next few years was also a touch smaller than in the previous forecast". While the "optimal" response of the Fed to real GDP growth is left to further research, one would expect $\beta_{FF}^{gdp}$ to be positive and significant.

Equation 3.10 would imply the following dynamic for long-term bond yields:

$$R_{t,t+n} = \frac{1}{n}\sum_{j=0}^{n-1} r_t = rr* + (1 - \beta_{FF}^{\pi})\,\pi^* + \beta_{FF}^{\pi}\bar{\pi}_{t,t+n} + \beta_{Fed,gdp}\left(\overline{gdp}_{t,t+n} - gdp^*\right) \tag{3.11}$$

Where $\overline{gdp}_{t,t+n}$ represents the expected average real GDP growth rate over the period $[t, t+n]$. The assumption regarding the sensitivity of nominal earnings growth to real GDP growth can be further relaxed by postulating that investors draw long-term expectations on nominal earnings growth from economic growth such that:

$$G_{t,t+n} = \beta_G^{\pi} \bar{\pi}_{t,t+n} + \beta_G^{gdp} \overline{gdp}_{t,t+n} \tag{3.12}$$

Depending on the magnitude of $\beta_G^{\pi}$ and $\beta_G^{gdp}$, the nominal growth rate of equity earnings may not equal the nominal growth rate of the economy. This paper is not drawing any assumption on these two parameters but instead aims at assessing their implied values from historical equity valuation and policy rules. Combining Equations 3.11 and 3.12 provides the following form for the earnings yield:

$$EY_t = \frac{\left(rr* + \left(1 - \beta_{FF}^{\pi}\right) \pi^* + \left(\beta_{FF}^{\pi} - \beta_G^{\pi}\right) \bar{\pi}_{t,t+n} + ERP + \left(\beta_{Fed,gdp} - \beta_G^{gdp}\right) \overline{gdp}_{t,t+n}\right)}{1 + G_{t,t+n}} \frac{1}{pay} \tag{3.13}$$

According to this alternative form of the Taylor rule, the earnings yield may not only have a positive and significant beta to inflation but earnings growth may not affect it one-for-one either. While this specification is very close to the precedent one, it allows to assess the potential effect of monetary policy rules on the sensitivity of earnings yield on both inflation and earnings growth.

**Proposition 3.** *When the alternative Taylor rule given by Equation 3.10 correctly describes the Fed's monetary policy and the Expectations Hypothesis holds, if the earnings nominal growth has an inflation beta equal to $\beta_G^{\pi}$ and a real economic growth beta equal to $\beta_G^{gdp}$, then the earnings yield has approximately an inflation beta, denoted $\beta_{EY}^{\pi}$, equal to $\left(\beta_{FF}^{\pi} - \beta_G^{\pi}\right)/pay$ and a real economic growth beta, denoted $\beta_{EY}^{gdp}$ equal to $\left(\beta_{Fed,gdp} - \beta_G^{gdp}\right)/pay$.*

*Alternatively, the implied sensitivities of the nominal earnings growth rate to inflation and real GDP growth are given by $\left(\beta_{FF}^{\pi} - pay * \beta_{EY}^{\pi}\right)$ and $\left(\beta_{FF}^{gdp} - pay\beta_{EY}^{gdp}\right)$ respectively.*

Proposition 3 allows to further test whether investors are affected by money illusion or whether they build expectations on inflation and real GDP growth upon information drawn from monetary policy. If Equation 3.10 correctly describes policy response to inflation and real GDP growth, then rational investors should take it into account when valuing equities. Therefore, the sensitivity of earnings yield to inflation ($\beta_{EY}^{\pi}$ ) and to real GDP growth ($\beta_{EY}^{gdp}$) may not be equal to zero and one respectively.

Equally, changes over time in policy responses to inflation and real GDP growth should affect $\beta_{EY}^{\pi}$ and $\beta_{EY}^{gdp}$. Proposition 3 allows to infer the sensitivity of nominal earnings growth to inflation from the inflation beta of earnings yield and the Fed funds rate as well as the implied relationship between nominal earnings growth and real GDP growth as $\beta_{G}^{gdp}$ is given by $\left(\beta_{FF}^{gdp} - pay * \beta_{EY}^{gdp}\right)$.

## 3.5 The Evolving Mandate of the Fed and the Taylor Rule

Following Taylor (1999), Clarida, Gali and Gertler (2000) and Orphanides (2003) among others, it is well known that central banks in general and the Fed in particular have seen their mandate evolving over time. One could wonder whether Propositions 1 and 2 always hold. First, while Taylor related Fed's funds rate to inflation and output gap in 1993, alternative "Taylor rules" have been proposed to better fit more current data, summarized by Taylor (1999). In particular, recent data seems to indicate that the Fed puts more emphasis towards the output gap than originally described by Taylor (1993). The "1999 Taylor rule" suggests to leave the inflation beta unchanged but to increase the response to output gap from 0.5 to 1. Many economists and central bankers still believe that the Taylor rule should hold. Bernanke (2015) for example advocates that the Taylor rule is still well and alive but should be used 1) with core PCE inflation instead of the GDP deflator to better reflect the prices of domestically produced consumer goods and 2) with a coefficient of 1 on the output gap instead of 0.5 as suggested by the "1999 Taylor rule". Yellen (2012) further states that a monetary policy should first and foremost be systematic and predictable and that the Federal Open Meeting Committee (FOMC) should " at minimum, routinely monitor the recommendation of Taylor-type policy rules as a check on its judgmental decision".

As Yellen mentions too, one of the key principles of the Taylor rule is that the nominal interest rate must rise or fall by more than one-for-one with a change inflation, as described by Equation 3.3. She stresses the fact that the Taylor rule is a necessary condition to "avoid potentially catastrophic outcomes". I therefore assume that Taylor rule has been effective for at least thirty years and should remain at minima a strong guideline to the Fed's decisions.

Clarida, Gali and Gertler (2000) however advocate that interest rates in the Volcker-Greenspan period appears to have been more sensitive to inflation than during the pre-Volcker period. Earnings yield could therefore have experienced a lower inflation beta prior to Volcker's chairmanship. For less recent monetary policy, the historical analysis of the Taylor rule from Orphanides (2003) provides great insights on changes in the Fed's mandate and a few dates are worth highlighting. It's only since 1977 that the Fed has the statutory objective to seek "maximum employment, stable prices, and moderate long-term interest rates" as stated by the amendment of Section 2A of the Federal Reserve Act of 16 November 1977. Orphanides (2003) also mentions that during the post World War II the Fed's mandate was to seek "sustainable growth together with stability of the value of the dollar" (1957 Congressional Hearing). Pre-WWII though, while the mandate of the Fed was potentially implicitly to stabilize prices while seeking full employment, it was not an explicit mandate.

To test the assumption that monetary policies explain the sensitivity of inflation on earnings, I split the past 100 years into three distinctive periods:

1. Pre-WWII: 1915-1955
2. Bretton Woods era: 1955-1977
3. Modern era: 1978-2017

The first period covers from 1915 to 1955. The starting date, 1915, coincides indeed with the year that showed the end of the gold standard and the beginning of the Federal Reserve's operations. This first period encompasses mainly the Pre-WWII II period during which the Fed did not have an explicit mandate to seek maximum employment and stable prices. The Taylor rule should not be expected to hold during that period in its purest form and earnings yield could have a null or even negative inflation beta, depending on how the Fed reacted to inflation and deflation.

The "Modern Era" period starts in 1978 after the Federal Reserve Act was amended in 1977 to put maximum employment, stable prices and moderate long-term interest rates as objectives for the Fed. During that period, the Taylor rule should be broadly respected, leading to a positive and significant sensitivity of earnings yield to inflation.

The "Bretton Woods Era" can be characterized as an intermediate period during which economists and central bankers improved their understanding of the role interest rate and inflation on the economy. While the Employment act of 1944 added the goal of seeking maximum employment to Fed, it's only in 1977 that the Fed received the explicit role of stabilizing prices. The sensitivity of earnings yield to inflation during the Bretton Wood era could therefore very much depend on the exact period considered as the Fed transitioned from an implicit mandate to an explicit one to stabilize prices. The inflation beta of earnings yield should therefore lie between zero and one during the Bretton Woods Era.

The following section will therefore assess whether these propositions about the effect of inflation on Fed funds rate, bond yield and earnings yield are empirically observed using an error correction framework.

# 4 An Error Correction Framework

## 4.1 Data

The data set is quarterly as economic data is usually available every three months and spans the period between Q1 1915 and Q4 2017. The earnings yield, earnings growth, inflation and bond yield are obtained from Pr. Shiller's website [2]. Following on Graham and Dodd (1934) or Campbell and Shiller (1988), I assume that equity

[2] http://www.econ.yale.edu/~shiller/data.htm

valuation is best measured by taking a long-term average of earnings instead of the most recent earnings data. The earnings yield is therefore measured as the inverse of the Cyclically-Adjusted Price-Earnings ratio which is computed as the last index prices divided by the inflation-adjusted average earnings over the past ten years. While the inverse of the trailing price-earnings ratio could be used too, it is well-known that it does not always represent a good proxy for equity valuation. In 2009 for example, the earnings of S&P 500 stocks almost reached zero due to large write downs by some of the major US banks, leading to extremely high price-earnings ratio at a time when the the equity market was potentially relatively attractive. The sensitivity to short-term movements in earnings is thus removed when using the CAPE ratio as it takes an average of earnings over the past 10 years. While the Taylor rule was initially based on the GDP deflator, I calculate inflation using the last four quarters of the Consumer Price Index (CPI). This choice is not only motivated by the data availability over a long period but also by the fact that the Federal Open Market Committee targets an inflation of 2% as measured by personal consumer expenditure[3]. Therefore, the CPI should be a closer proxy of the inflation targeted by the FOMC than the GDP deflator[4]. The long-term bond yield is the yield on US 10-year Treasury bonds which is one of the most commonly used proxy for long-term risk-free rates by market participants. The output gap is calculated as the log difference between the real GDP and the real potential GDP. Both are obtained from the Federal Reserve of St-Louis's website (Fred, https://fred.stlouisfed.org/). The real potential GDP is calculated by the US congressional Budget Office and the real GDP growth is measured as the return over the past four quarters.. When testing for the relationship between earnings yield and inflation, the equity risk premium (ERP) is assumed to be a function of the S&P 500's 1-year variance, which is calculated using daily prices of the S&P 500 from Worldscope database.

## 4.2 Unit Root Testing

One of the standard issues in studying the dynamics of interest rates or inflation

[3]See for example the 25th January 2012 press release from FOMC, available at https://www.federalreserve.gov/newsevents/pressreleases/monetary20120125c.htm.

[4]For the two periods 1955-1977 and 1977-2018, results for the Taylor rule estimations using the GDP deflator are available upon request.

is their stationarity. The problem may even be magnified here as the analysis is split in three shorter periods, 1915-1954, 1955-1977 and 1977-2018. The first step therefore consists in testing for unit root using the Augmented Dickey-Fuller test. Table 1 reports the test results for the exogenous and endogenous variables necessary to estimate the Taylor rule and test Propositions 2 and 3.

First, the three endogenous variables, i.e. the Fed funds rate, the bond yield and the earnings yield, are integrated of order one (I(1)) at the 1% confidence level in each sub-periods and none of them seems stationary in level as expected. The 1-year inflation is integrated of order one at the 1% confidence level during the 1978-2017 and 1915-1954 periods while only at the 5% confidence level over the 1955-1977 period. Second, the output gap, the real GDP growth rate and the S&P 500 1-year volatility are however level stationary (I(0)) at the 1% or 5% confidence level according to the Augmented Dickey-Fuller tests. Given the necessity to opt for a model that can combine variables that are I(0) and I(1), the ARDL methodology developed by Pesaran and Shin (1998) and Pesaran, Shin and Smith (2001) is retained to estimate the Taylor rule and assess the effect of inflation on bond yield and earnings yield.

### 4.3 The ARDL Methodology

The Error-Correction Model (ECM) provides a popular methodology to estimate both the short-term and the long-term effects of one variable on another when variable are I(1) (See Sargan (1964), Engle and Granger (1987)). Such specification seems well suited in the context of this paper as inflation is likely to affect Fed funds rate, bond yield and earnings yield in the long-run as well as in the short-run. The approach has been significantly improved over the years including the introduction of the Vector-based Error-Correction Model (VECM). The VECM removed the restriction of a single equation with one variable designated as the dependent variable and all the others as exogenous variables. The VECM however suffers from its own weaknesses too. It requires that all variables are integrated of order one (I(1)) and therefore does not allow for any variable to be I(0). This pre-testing for the presence of unit roots can be sometime problematic as unit root test may suffer size and power issues (See Perron and Ng (1996)).

To avoid these issues, an Auto-Regressive-Distributed Lag (ARDL) model is chosen to estimate the short- and long-run dynamics of the Fed funds rate, the earnings yield and the bond yield. This choice is driven by the works of Pesaran and Shin (PS, 1998) and Pesaran, Shin and Smith (PSS, 2001) who show that an ARDL model is a flexible and robust approach to test for cointegration.

Without loss of generality, let's introduce an ARDL(p,q) model relating a dependent variable $y_t$ that is related to its lagged values as well as to contemporaneous and lagged values of a single dependent variables $x_t$. An ARDL(p,q) with p and q lags is given by:

$$y_t + \varphi_1 y_{t-1} + \varphi_2 y_{t-2} + ... + \varphi_p y_{t-p} = a_0 + \beta_0 x_t + \beta_1 x_{t-1} + ... + \beta_q x_{t-q} + u_t \quad (4.1)$$

Where $u_t$ is an iid $(0, \sigma_u^2)$ error term. Let's denote the lag operator by $L$ and define the lag polynomials $\varphi(L)$ and $\beta'(L)$ such that $\varphi(L) = 1 + \sum_{i=1}^{p} \varphi_i L^i$ and $\beta(L) = \sum_{i=0}^{q} \beta_i L^i$ . The ARDL(p,q) model can be rewritten as:

$$\varphi(L) y_t = a_0 + \beta(L) x_t + u_t \quad (4.2)$$

$y_{t-j}$ can be rewritten as $y_{t-j} = y_{t-1} - (\Delta y_{t-1} + \Delta y_{t-2} + ... + \Delta y_{t-j+1})$ and $y_t = \Delta y_{t-1} + y_{t-1}$. Substituting these into Equation 4.1 we obtain[5] :

$$\Delta y_{t-1} = a_0 - \varphi(1) y_{t-1} + \beta(1) x_{t-1} + \sum_{i=1}^{p-1} \varphi_i^* \Delta y_{t-i} + \sum_{i=0}^{q-1} \beta_i^* \Delta x_{t-i} + u_t \quad (4.3)$$

Where $\varphi(1) = 1 + \varphi_1 + ... + \varphi_p$, $\beta(1) = \beta_0 + \beta_1 + ... + \beta_q$ , $\varphi_i^* = \sum_{j=i+1}^{p} \varphi_j$ and $\beta_i^* = -\sum_{j=i+1}^{q} \beta_j$

Equation 4.3 can be rewritten as a standard error-correction model:

$$\Delta y_{t-1} = -\varphi(1) \left( y_{t-1} - \frac{a_0}{\varphi(1)} - \frac{\beta(1)}{\varphi(1)} x_{t-1} \right) + \sum_{i=1}^{p-1} \varphi_i^* \Delta y_{t-i} + \sum_{i=0}^{q-1} \beta_i^* \Delta x_{t-i} + u_t \quad (4.4)$$

According to Equation 4.4, the changes in $y_t$ are due to short-term variations

[5] See Pesaran (2015) p. 124-125 for example

in $y_t$ and $x_t$ as well as the deviation of $y_t$ from its long-term dynamic given by $\left(\frac{a_0}{\varphi(1)} + \frac{\beta(1)}{\varphi(1)} x_{t-1}\right)$. $\varphi(1)$ can be interpreted as the convergence speed at which $y_t$ is reverting back towards its long-term equilibrium.

Based on the ARDL representation, PSS (2001) further propose a cointegration test that presents three advantages over other cointegrating techniques. First, it allows for variables to be a mixture of $I(0)$ and $I(1)$, removing the restrictions of standard VECM where all variables must be $I(1)$. Second, the model can be estimated using only one equation using least square regressions. Third, the model is flexible enough to allow variables to have different lag-lengths if necessary.

# 5 Monetary Policy and Asset Valuation

In this section, the ARDL methodology is applied to assess if the fact that the Fed follows the Taylor rule could offer a rational explanation to the sensitivity of earnings yield to inflation. The first step therefore consists in assessing whether the Taylor rule holds as expected during the "Modern Era" but not necessarily over the two preceding periods or at least with different betas to inflation and output gap/real GDP growth.

## 5.1 Estimating the Taylor Rule

Table 2 reports the analysis for the three sub-periods 1915-1954, 1955-1977 and 1978-2017. During the "Modern Era" spanning 1978-2017, the long-term equation for the Fed funds rate is given by:

$$r_t = 0.23\% + 1.862\bar{\pi}_t + 1.487\,(y_t - y^*) \tag{5.1}$$

The Fed funds rate has an inflation beta of 1.862, above the 1.5 suggested by the Taylor rule. The coefficient associated to the output gap is 1.487, also above the 0.5 suggested by Taylor in 1993. However, the coefficients are close to those suggested by Taylor (1999) who showed that the FOMC members should potentially put a greater weight on the output gap, suggesting a weight of 1. Bernanke also advocated for a higher sensitivity of the output gap to inflation, in line with the results found for the period 1978-2017.

Following on the Taylor rule, the constant term, 0.23%, must be equal to $rr^* +$

$(1-\beta_{FF}^{\pi})\,\pi^*$. If the Fed targets an inflation of 2%, Equation 5.1 implies a real rate of 1.96% over that period. However, the implied the real rate would be 1.72% if the constant is assumed to be equal to zero as it is not statistically different from zero .

Equation 5.2 reports the estimation of the long-term equation for the Fed funds rate using the alternative Taylor rule, accounting for the real GDP growth rate instead of the output gap:

$$r_t = -4.90\% + 1.414\bar{\pi}_t + 1.700\,(gdp_t - gdp^*) \tag{5.2}$$

Equation 5.2 gives a slightly lower weight to inflation and a slightly bigger weight to the real economy variable. What is important to notice however is that irrespective of the chosen variables, Fed funds rates have a greater than one sensitivity to inflation. Equation 5.2 can also provide some insights on the real GDP growth that FOMC members are implicitly or explicitly targeting. According to the alternative Taylor rule as given by Equation 3.10, the constant coefficient should be equal to $rr^* + (1-\beta_{FF}^{\pi})\,\pi^* - \beta_{FF}^{gdp} gdp^*$. Assuming again that the targeted inflation is equal to 2% and that the real rate is equal to the 1.72% as estimated previously, then the implied real GDP growth rate is equal to 2.88%. This implied real GDP growth rate can be interpreted as the real GDP level above which the Fed is likely to raise rate, even if inflation is at 2%. This means that the Fed would consider the U.S. economy to be overheating whenever the real GDP growth is above 2.88%. Indeed, the opposite is true too: FOMC members may decide not to raise the Fed funds rate when inflation is above target if the U.S. economy is depressed and its real growth falls below 2.88%.

Table 2 provides some insights on policy responses to inflation and economic growth during the Bretton-Woods era. First, it seems that during that period the Fed was much less reactive to inflation as the inflation beta is well below one, irrespective of the economic variables used to estimate the ARDL model (.72 with the output gap and 0.75 with the real GDP growth) . Further, the F-test is only significant at the 1% level when the real GDP growth is added to the equation. The lower significance of the output gap may simply be due to the fact that the concept of the output gap itself was not widespread among economists and policy makers during that period.

During the Pre-WWII period, the Fed funds rate does not seem to show any sensitivity to inflation or the real GDP growth rate, highlighting that the Fed was still at an early stage in understanding the effect of policy rules on the economy.

Estimations of the Taylor rule over these three different periods could have material implications on the pricing of other assets such as bonds and equities if investors infer future interest rate using the same framework as the Fed. In particular, as the inflation beta of the Fed funds rate is greater than zero during the Modern Era, one would expect the pricing of bonds and equities to reflect it, which what will be tested in the next two sections.

## 5.2 Bond Yield and Inflation

The second step of the analysis consists in testing whether bond yields have an inflation beta close to what the estimation of the Taylor rule would infer. Table 3 reports the results of the ARDL model for the three periods. Let's first analyze the effect of inflation on bond yield during the "Modern Era". Accounting for the output gap, the relationship between bond yield and inflation is given by:

$$BY_t = 0.12\% + 1.869\pi_t + 0.809\,(y_t - y^*) \tag{5.3}$$

While accounting for the real GDP growth, we get:

$$BY_t = -2.20\% + 1.544\pi_t + 0.907\,(y_t - y^*) \tag{5.4}$$

The inflation beta of bond yields equal 1.54 and 1.86, depending on whether the output gap or the real GDP growth are included in the specification or not. This is in line with the inflation beta found previously for the Fed funds rate. The sensitivity of bond yield to inflation is therefore relatively close to the value described by Equation 3.5 and this confirms that bond investors draw long-term interest rate expectations based upon the Fed monetary policy.

Equation 3.5 suggests that bond yield and Fed funds rate should have a similar sensitivity to inflation, and this irrespective of whether Fed funds rate can effectively be described by the Taylor rule. During the Bretton-Woods period, Fed funds rate showed an inflation lying between 0.72 and 0.75 as shown in Table 2 which is relatively close to what is reported in Table 3 in the case of bond yield. During that period, bond yields displayed an inflation beta lying around 0.67 and 0.71, confirming that Equation 3.5 also held true during that period.

For the 1915-1954 period, there was no significant relationship between bond yields and inflation, in line with the absence of relationship between the Fed funds rate and inflation over the same period. Therefore, Equation 3.5 was confirmed over the three distinctive periods, indicating that bond investors consistently draw expectations on bond yield on the basis of the Fed's monetary policy.

### 5.3 The Taylor Rule and Equity Valuation

Bondholders seems to be rational agent as their long-term interest rate expectations follow the Fed's reaction to inflation and growth. This section aims to assess if equity investors follow the same path by testing whether Propositions 2 and 3 hold.

Table 4 reports the results of the ARDL model for the S&P 500 earnings yields for the 1978-2016 "Modern Era" while Table 5 shows the results for the other two periods. Five alternative models are tested to assess the impact of inflation on earnings yield, starting with Model #1 which simply relates the inflation to the earnings yield. Following Merton (1980) among others, it is well known that in theory the equity risk premium should be a function of the equity risk. Model #2 therefore accounts for the S&P 500 3-month variance as a proxy for equity risk. Model #3 adds a dummy variable, $Dum_{1996-2000}$, equal to one for the period 1996-2000 and zero otherwise. This period is well-known for its "irrational exuberance" period. Shiller (2000) popularized the expression to emphasize the fact that these years were marked by irrational equity valuation levels. Therefore, earnings yield may not have been solely driven by rational expectations of the Fed reaction to change in inflation during that period and the introduction of a dummy variable may ensure that the results of the ARDL estimations are not skewed by this irrational period. Model #4 and #5 check whether the results are robust to the introduction of the output gap or the real GDP growth.

Let's assess first the sensitivity of earnings yield to the five variables over the recent 1978-2017 period. First, the S&P 500 3-month variance is found to significantly affect the earnings yield during the 1978-2017 period with a coefficient of 0.463. Equity investors want to be compensated for the risk they take and will require a higher earnings yield when volatility is high. Second, the 1996-2000 dummy is significant and equal to -2.7%. This means that the earnings yield was on average 2.7% lower during these years compared to the rest of the sample. While the output gap does not affect earnings yield significantly, the real GDP growth does. This can be explained as follow: The earnings yield is the return equity investors expect in the long-run to be compensated for the risk they take. In the long-run, the output gap should be on average equal to zero, which explains why equity investors do not account for it. Real GDP growth however directly impact equity valuation as long as it relates to earnings growth. Therefore, this is not surprising to find that real GDP growth significantly affects S&P 500's earnings yield.

Irrespective of the model, the estimates of the earnings yield's inflation beta are all strongly significant and vary from 1.085 and 1.308. As the output gap is found to be non significant, I focus on Model #5 that accounts for inflation, the 1996-2000 dummy, the S&P 500's 3-month variance, noted $\sigma_t^2$, and the 1-year real GDP growth as well as Model #3 that excludes any GDP-related variable:

$$\text{Model \#3: } EY_t = -0.18\% + 1.241\pi_t - 0.027Dum_{1996-2000} + 0.443\sigma_t^2 \quad (5.5)$$

$$\text{Model \#5: } EY_t = -0.91\% + 1.160\pi_t - 0.030Dum_{1996-2000} + 0.445\sigma_t^2 + 0.492gdp_t \quad (5.6)$$

According to Proposition 2, if equity investors account for the policy response of the Fed to changes in inflation, then the implied sensitivity of earnings growth to inflation, $\beta_G^\pi$, is equal to $(\beta_{FF}^\pi - pay * \beta_{EY}^\pi)$. I assume that the payout ratio is unrelated to inflation over the 1977-2018 period and equal to its historical average of 48.58%. Combining the estimated Taylor rule with Model #3 gives an inflation beta of S&P 5000's earnings equal to 1.26 (=1.862-0.4858*1.241). The alternative Taylor rule and Model #5 can also be combined as they both account for real GDP growth. In this case, the implied sensitivity of earnings growth to inflation is equal to 0.85 (=1.544-0.4858*1.16). An alternative would be to assume that equity investors assess the proper discount rate using bond yield instead of Fed funds rate. In such a case, the implied inflation beta of earnings growth is equal to 0.98 (=1.544-0.4858*1.16).

Therefore, over the 1978-2017 period, the implied sensitivity of earnings growth lies between 0.85 and 1.26, depending on the specification retained for the Fed funds rates and earnings yields. The sensitivity is even closer to one, 0.98, if we assume that equity investors rationally follow what bondholders expects in terms of relationship between long-term interest rates and inflation. This is a substantial result as it shows that equity investors may not have suffered from money illusion over that period as suggested by several studies. Instead, equity investors simply account for the fact that the Fed is likely to adjust its target rate to changes in inflation by more than one-for-one, as suggested by the Taylor rule. I therefore reject the Money Illusion Hypothesis of Modigliani and Cohn (1979) over that period.

During the Bretton-Woods period, equity investors are often assumed to be rational as the relationship between earnings yield and inflation or bond yield is much weaker (See Estrada (2006) for example). This is confirmed by the estimation of the sensitivity of earnings yield to inflation as reported in Table 5. Over the 1955-1977 period, I do not find any conclusive long-term relationship between S&P 500's earnings yield and inflation. First, the none of the estimated parameters associated with the 1-year inflation are significant, even at the 10% level. Second, the F-test rejects the assumption of a long-term relationship between earnings yield and inflation.

If Proposition 2 holds over that period, the implied sensitivity of earnings growth to inflation $\beta^{\pi}_{G}$ can be calculated the same way as before, i.e. using $(\beta^{\pi}_{FF} - pay * \beta^{\pi}_{EY})$. As $\beta^{\pi}_{EY}$ is estimated to be equal to zero, the implied inflation beta of earnings growth is equal to the inflation beta of Fed funds rates. Depending on whether it is assumed that equity investors follow the bond markets or the Fed, $\beta^{\pi}_{G}$ lies between 0.667 and 0.751.

This confirms previous works highlighting that investors anticipate that firms may not be able to fully pass on the inflation to their end-customers and that the inflation beta of earnings growth should be below one. Sharpe (2002) for example shows that high inflation may negatively impact real earnings growth. As Sharpe specifies real earnings growth as nominal earnings growth - inflation, it is equivalent to assuming a constant real growth but a inflation beta lower than one.

Over the Pre-WWII period, S&P 500's earnings yields were also found independent from inflation, irrespective of the retained specification (adding variance and real GDP growth variables). This confirms Proposition 2 suggesting that when Fed funds rates are independent from inflation, the best equity investors can do is to expect long-term discount rate to have a one-for-one relationship with inflation. A proper conclusion is difficult for that period though. The effect of inflation on asset prices may have been little understood by the market and therefore not accounted for, be it by bond investors and equity investors alike. It seems a reasonable assumption as Fisher's work on inflation dates back from the 1930ies and many macro-economic theories related to inflation only emerged after 1950 with the works of Philips, Friedman and Lucas among others.

### 5.4 Unconventional Monetary Policy and the Fed Model

Before the 2008 global financial crisis, target rates were the main tool central banks were using to control for inflation and spur economic growth. Since then, they have used what is often called unconventional monetary policy. In Europe and Japan, central banks allowed for negative interest rates. In the U.S., the Fed started an expansionary monetary policy based on the purchase of government bonds and later on riskier assets. These quantitative easing measures were aimed at stimulating the economy and keep inflation in positive territory at a time where Fed funds rates became ineffective to do so.

In such environment, equity investors can not use Fed funds rate to draw very long-term expectations of discount rates. At best, they can assess that interest rates over the next few years should not be a function of inflation, implying that 10-year bond yields should therefore have a low or insignificant sensitivity to inflation. The earnings yields however is a function of a perpetual discount rate. This rate should incorporate short-term expectations, marked by little to no sensitivity to inflation, and a return to normal conditions in the long-run, where rates would be driven by the Taylor rule again. Equity investors could therefore expect their cost of equity, or discount rate, to have a one-for-one sensitivity to inflation, accounting for the dichotomy between the short-term and long-term effect inflation should have on interest rates. Further, between 2009 and 2016, valuations of equities and corporate bonds were probably supported by the successive rounds of quantitative easing initiated by the Fed to the extent that they became unrelated from fundamentals. All these reasons imply earnings yield should be independent from inflation as predicted by Proposition 2.

Table 6 reports the ARDL estimates for the Fed funds rate, the U.S. 10-Yr bond yield and the S&P 500's earnings yield over the period 2008:Q4 to 2016:Q4. This period was characterized by Fed funds rates below 1% and by three successive rounds of quantitative easing by the Fed in November 2008, November 2010 and September 2012, dubbed QE1, QE2 and QE3 respectively. As expected, Fed funds rates were not significantly sensitive to inflation during that periods where they remained stuck close to zero. Bond yields did not show any sensitivity to inflation either, highlighting that bond investors expected the unconventional monetary policy to hold on for a while.

As expected, the S&P 500's earnings yield hasn't been sensitive to inflation over the 2008-2016 period, as the very low F-test rejects the hypothesis of a long-term relationship between earnings yield and inflation. During periods of unconventional and expansionary monetary policy, earnings yield may therefore not be positively affected by inflation. While the precedent section was providing a rational explanation to the supposedly Money Illusion Hypothesis of Modigliani and Cohn (1979), proponents of the Fed model should therefore account for the fact that the relationship between earnings yield and bond yield may break down when such unconventional monetary policies are in place.

When assessing the drivers of equity valuation's multiple such as the Price-Earnings ratio, investors should therefore follow what the Fed says and implement in terms of monetary policy. It may not, however, always follow the Fed Model given that the relationships between earnings yield, bond yield and inflation are a function of the Fed's monetary policy which may evolve over time.

## 6 Conclusion

I have shown that equity valuation metrics such as the Price-Earnings ratio or its inverse the earnings yield may significantly be affected by the monetary policy set up by a central bank. In the U.S., the empirically strong correlation between earnings yield and inflation has been a puzzle and led several authors to advance the hypothesis that equity investors may suffer from money illusion, potentially intermittently. The Fed however has evolved over time in the way it answers to inflation and deflation.

Since the late seventies, its monetary policy is well described by the Taylor rule which implies that the Fed will change its target rate by more than one-for-one in response to changes in inflation. Rational investors should therefore take this into account when they form expectations about long-term discount rate.

Over the period 1978-2017, Fed funds rates had an inflation beta lying between 1.55 and 1.85 depending on whether the output gap or the 1-year real GDP growth are accounted for. I show that these betas imply that the sensitivity of nominal earnings growth to inflation should be around one. Therefore, equity investors rationally discount nominal cash flows using nominal discount rates, refuting the Money Illusion Hypothesis of Modigliani and Cohn (1979). They simply base their expected nominal discount rates on the effect that inflation should have on long-term rates given the monetary policy implemented by the Fed.

Indeed, the Fed's response to inflation has evolved over time and this has led to changes in the sensitivity of earnings yield to inflation accordingly. In the 1955-1977 period, the Fed used to increase its target rate less than over the past 40 years, yielding a lower inflation beta of earnings yield. Since the financial crisis of 2008, the Fed has followed an unconventional monetary policy characterized by a very low and stable Fed funds rate. As expected, equity investors have accounted for the fact that in the short to medium-term, the Taylor rule should not be respected. The rate at which equity investors discount their long-term cash flow should therefore have a lower sensitivity to inflation, which implies that the earnings yield should be unaffected by inflation over that period.

These results may have substantial implications for central banks and investors alike. First, this is indeed a confirmation that the Fed's actions can materially affect the valuations of risky assets, including equities. Second, the Price-Earnings ratio should be affected by inflation when the Fed funds rate can be correctly described by the Taylor rule. This does not however provide a blank check to equity investors for using the Fed model in order to allocate among equities and bonds. During periods where the Taylor rule does not correctly described Fed funds rates (such as over the 1915-1954 and 2008-2016 periods), the relationship between earnings yield on the one hand and bond yield and inflation on the other may be much weaker.

In conclusion, follow what the Fed implements but do not necessarily implement the Fed model.

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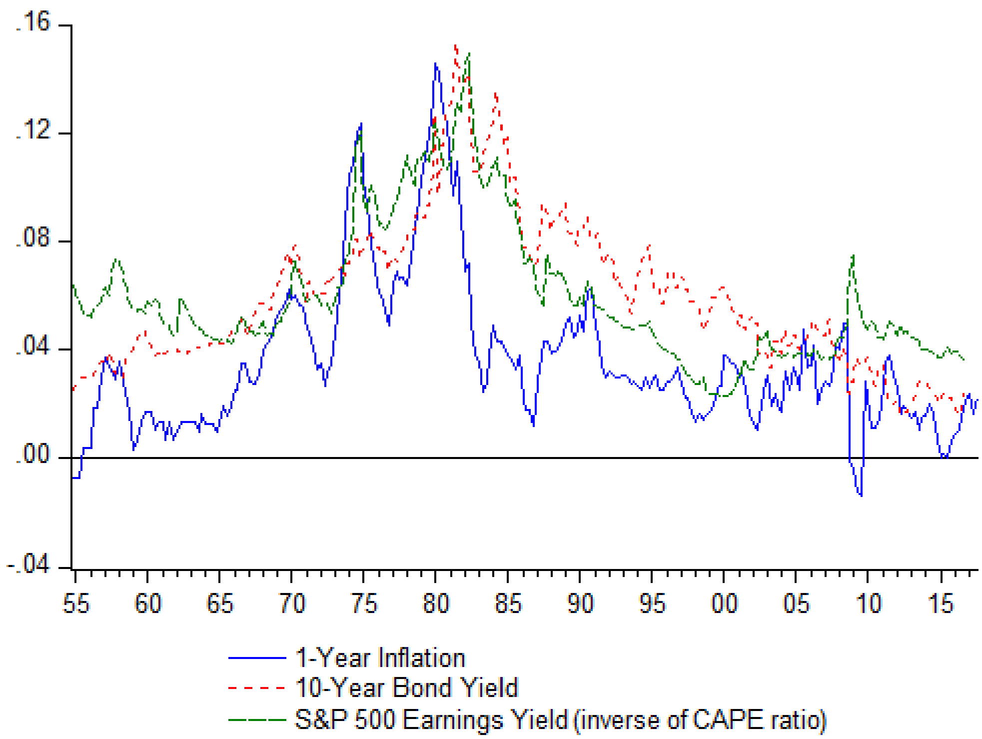
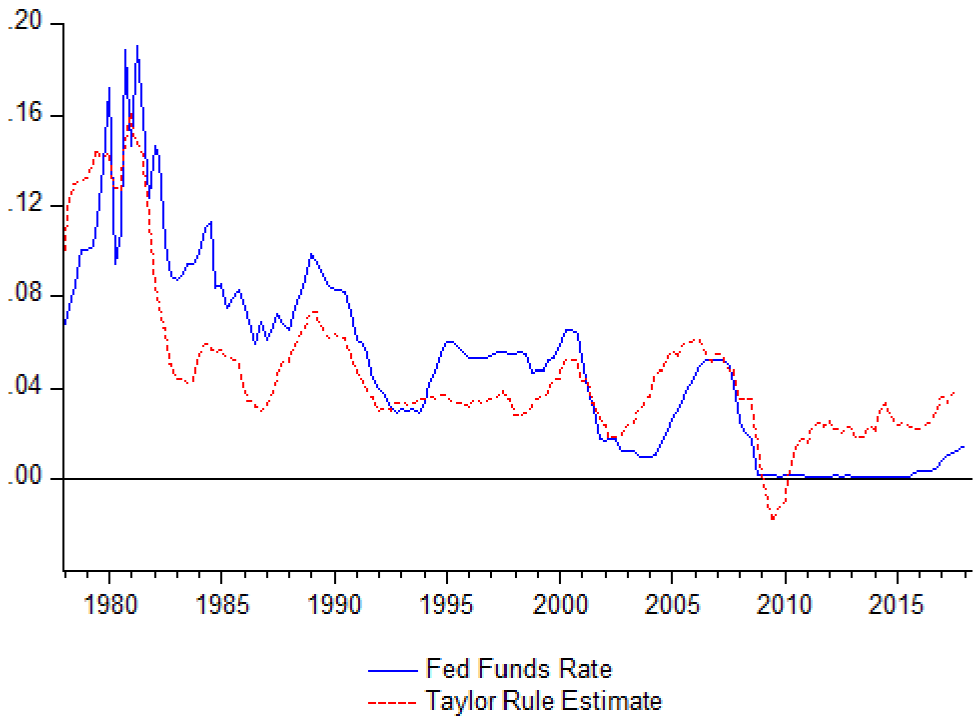
# A Figures and Tables

Figure 1: US Earnings Yield, Bond Yield and Inflation (1955 to 2017)



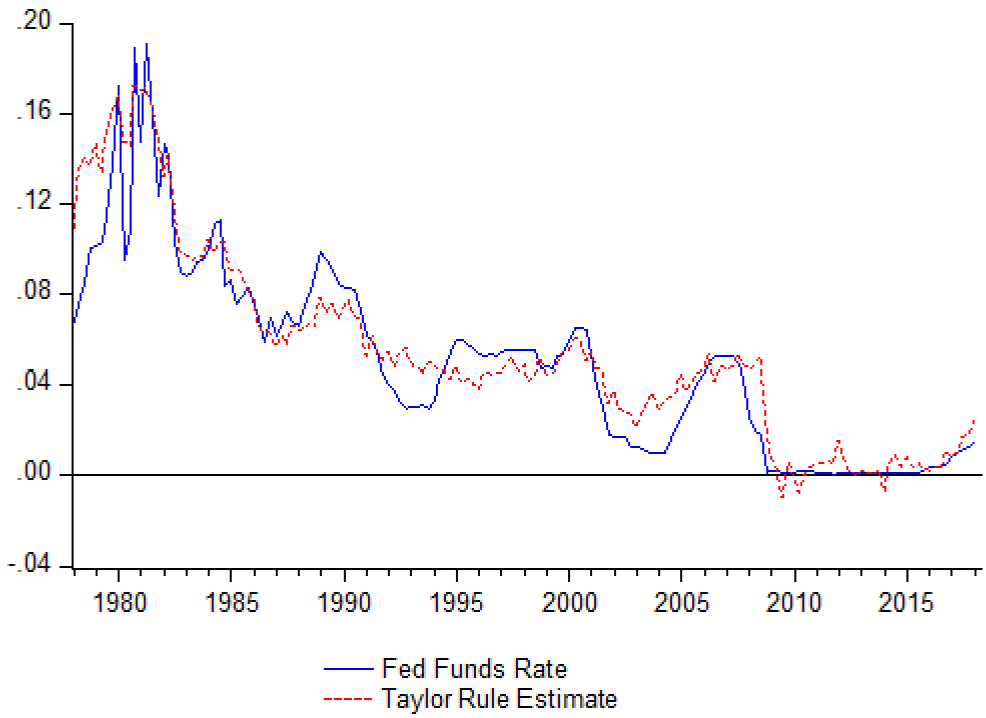

**Note:** Earnings yield is calculated as the inverse of CAPE ratio. Inflation is measured as the annualized return of the CPI index overs its past eight quarters. Bond yield is the US 10-year bond yield. Data from Shiller's database (See: http://www.econ.yale.edu/~shiller/data.htm)

Figure 2: Fed Funds Rate and Original Taylor Rule



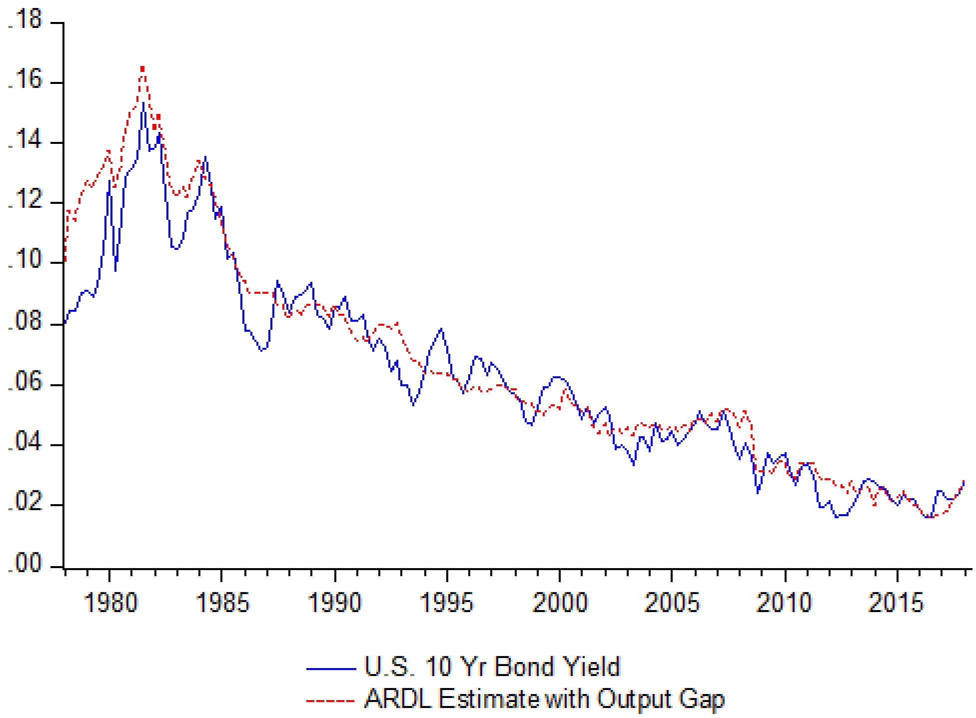

**Note:** The estimated Fed funds rates are calculated using the original Taylor equation (Equation 1.1) Inflation is calculated using the last four quarters of the GDP deflator. The output gap is calculated as the difference between the potential real output (log, as calculated by the Congressional Budget Office) and the real GDP (log). Following Taylor (1993), the long-run real interest rate and target inflation rate are both equal to 2%. Data obtained from FRED Economic Database.

Figure 3: Fed Funds Rate and Estimated Taylor Rule



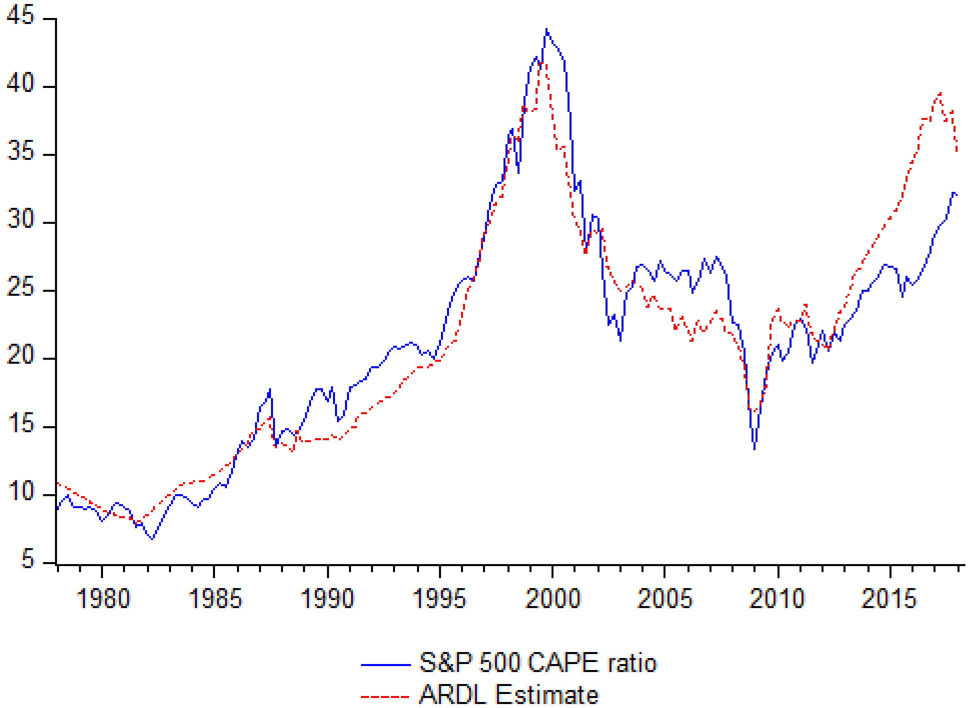

**Note:** The estimated Fed funds rates are calculated using the Taylor equation estimated over the 1978-2017 period using an ARDL model (Equation 5.1). Inflation is calculated using the last four quarters of the Consumer Price Index. The output gap is calculated as the difference between the potential real output (log, as calculated by the Congressional Budget Office) and the real GDP (log).

Figure 4: Bond Yield Estimation (1978-2017)




**Note:** U.S. bond yields' estimates are given by an ARDL model using data over the 1978-2017 period using an ARDL model (Equation 5.3). Inflation is calculated using the last four quarters of the Consumer Price Index. The output gap is calculated as the difference between the potential real output (log, as calculated by the Congressional Budget Office) and the real GDP (log).

Figure 5: S&P 500 Earnings Yield Estimates




**Note:** S&P 500' estimated are given by an ARDL model using data over the 1978-2017 period using an ARDL model (Equation 5.3). Inflation is calculated using the last four quarters of the Consumer Price Index. The output gap is calculated as the difference between the potential real output (log, as calculated by the Congressional Budget Office) and the real GDP (log).

*Table 1: Unit Root Tests (Augmented Dickey-Fuller Test)*

| | 1978-2017 | | 1955-1977 | | 1915-1954 | |
|---|---|---|---|---|---|---|
| | Level | 1st Difference | Level | 1st Difference | Level | 1st Difference |
| Fed Funds Rate | -1.90 | -4.56 | -2.07 | -7.39 | -1.96 | -11.02 |
| Bond Yield | -1.08 | -13.47 | -1.16 | -10.09 | -1.47 | -6.62 |
| Earnings Yield | -1.41 | -10.87 | -0.98 | -5.07 | -2.84 | -6.53 |
| 1-year inflation | -1.86 | -5.63 | -1.08 | -3.80 | -3.84 | -6.64 |
| Output Gap | -3.17 | -9.35 | -2.99 | -6.91 | | |
| 1-year Real GDP Growth Rate | -3.49 | -4.53 | -3.02 | -8.59 | -4.08 | -4.90 |
| S&P 500 3-Month Variance | -7.86 | -9.89 | -6.34 | -10.27 | -3.58 | -11.81 |
| Test Critical Values | | | | | | |
| 1% level | -3.47 | -3.48 | -3.50 | -3.50 | -3.48 | -3.48 |
| 5% level | -2.88 | -2.88 | -2.89 | -2.89 | -2.89 | -2.89 |
| 10% level | -2.58 | -2.58 | -2.58 | -2.58 | -2.58 | -2.58 |

***Note:*** *The output gap is calculated as the difference between the potential real output (log, as calculated by the Congressional Budget Office) and the real GDP (log). The output gap is calculated as the difference between the potential real output (log, as calculated by the Congressional Budget Office) and the real GDP (log). Inflation and bond yield data is obtained from Shiller's website. Output gap and real GDP growth are obtained from FRED Economic Database.*

*Table 2: Taylor Rule Estimation. Estimated Coefficients for the Long-Term Equation*

| | 1978-2017 | | 1955-1977 | | 1915-1954 |
|---|---|---|---|---|---|
| Constant | 0.002 (0.13) | −0.049*** (−3.81) | 0.019*** (6.03) | −0.013 (−0.83) | 0.010 (0.69) |
| 1-year Inflation | 1.862*** (5.13) | 1.414*** (5.82) | 0.725*** (7.03) | 0.751*** (4.73) | 0.725 (0.65) |
| Output Gap | 1.487*** (2.66) | | 0.383 *** (2.85) | | |
| 1-Year real GDP growth | | 1.70*** (5.10) | | 0.853** (2.23) | −0.393 (−0.64) |
| Cointegration coefficient | −0.106*** (−5.11) | −0.137*** (−5.74) | −0.284*** (−4.24) | −0.173*** (−5.60) | −0.019 (−3.48) |
| ARDL Specification | 10,0,9 | 12,0,7 | 5,0,2 | 3,2,0 | 8,0,0 |
| F-test | 6.40*** | 8.05*** | 4.32** | 8.06*** | 2.97 |
| Adjusted R-square | 50.91% | 55.26% | 48.08% | 46.58% | 19.50% |

***Note:*** *T-statistics are calculated using the Newey-West standard errors estimates and are reported in parentheses. ***, ** and * mean that the coefficients are significant at 1%, 5% and 10% respectively.The ARDL specification lists the lagged used for the Fed Funds rate, the 1-year inflation and the output gap (alternatively the 1-year real GDP growth) respectively. The output gap is calculated as the difference between the potential real output (log, as calculated by the Congressional Budget Office) and the real GDP (log). Earnings yield, inflation (CPI) and bond yield data is obtained from Shiller's website. Output gap and real GDP growth is obtained from FRED Economic Database.*

*Table 3: Estimated Coefficients for the Long-Term Equation of U.S. Bond Yields*

| | 1978-2017 | | 1955-1977 | | 1915-1954 |
|---|---|---|---|---|---|
| Constant | 0.001 (0.12) | −0.021** (−2.18) | 0.032*** (9.93) | 0.026*** (4.34) | 0.022** (2.18) |
| 1-year Inflation | 1.863*** (7.67) | 1.544*** (9.69) | 0.707*** (6.54) | 0.667*** (8.61) | 0.29 (1.41) |
| Output Gap | 0.809** (2.17) | | 0.349** (2.20) | | |
| 1-Year real GDP growth | | 0.907*** (3.24) | | 0.191* (1.97) | −0.160 (−1.24) |
| Cointegration coefficient | −0.099*** (−7.54) | −0.125*** (−6.95) | −0.129*** (−4.56) | −0.161*** (−4.17) | −0.097*** (−4.20) |
| ARDL Specification | 8,4,9 | 8,4,10 | 6,2,0 | 6,2,0 | 4,0,11 |
| F-test | 13.94*** | 11.83*** | 5.01** | 4.19** | 4.32** |
| R-square | 45.07% | 46.84% | 28.67% | 26.27% | 44.11% |

***Note:*** *T-statistics are calculated using the Newey-West standard errors estimates. ***, ** and * mean that the coefficients are significant at 1%, 5% and 10% respectively. The ARDL specification lists the lagged used for the Fed Funds rate, the 1-year inflation and the output gap (alternatively the 1-year real GDP growth) respectively. The output gap is calculated as the difference between the potential real output (log, as calculated by the Congressional Budget Office) and the real GDP (log). Inflation (CPI) and bond yield data is obtained from Shiller's website. Output gap and real GDP growth are obtained from FRED Economic Database.*

*Table 4: Estimated Coefficients for the Long-Term Equation of S&P 500 Earnings Yield*

| | 1978-2016 | | | | |
|---|---|---|---|---|---|
| Model # | (1) | (2) | (3) | (4) | (5) |
| Constant | 0.014<br>(1.38) | −0.008<br>(−0.76) | −0.002<br>(−0.23) | −0.002<br>(−0.42) | −0.009<br>(−1.40) |
| 1-Year Inflation | 1.085***<br>(3.58) | 1.308***<br>(5.05) | 1.242***<br>(6.45) | 1.262***<br>(14.76) | 1.160***<br>(11.51) |
| 3-Month Variance | | 0.463***<br>(2.91) | 0.443***<br>(3.18) | 0.451***<br>(4.84) | 0.445***<br>(5.95) |
| 1996-2000 Dummy | | | −0.027***<br>(−5.65) | −0.023***<br>(−4.26) | −0.030***<br>(−5.25) |
| Output Gap | | | | −0.080<br>(−0.56) | |
| 1-Year real GDP Growth | | | | | 0.492***<br>(−3.07) |
| Cointegration Coefficient | −0.076***<br>(−4.01) | −0.078***<br>(−5.21) | −0.106***<br>(−7.22) | −0.143***<br>(−11.27) | −0.140***<br>(−4.09) |
| ARDL Specification | 2,5 | 10,6,2 | 8,6,1,0 | 1,7,0,0,6 | 1,6,0,0,6 |
| F-Test | 5.27** | 6.64*** | 10.15*** | 20.45*** | 19.77*** |
| R-Square | 14.41% | 39.57% | 41.35% | 53.55% | 50.48% |

***Note:*** *T-statistics are calculated using the Newey-West standard errors estimates. ***, ** and * mean that the coefficients are significant at 1%, 5% and 10% respectively. The ARDL form lists the lagged used for Fed Funds rate, 3-month S&P 500 variance, 1-year inflation (CPI) and output gap (alternatively the 1-year real GDP growth) respectively. The output gap is calculated as the difference between the potential real output (log, as calculated by the Congressional Budget Office) and the real GDP (log). Inflation and earnings yield data is obtained from Shiller's website. Output gap and real GDP growth are obtained from FRED Economic Database*

*Table 5: Estimated Coefficients for the Long-Term Equation of S&P 500 Earnings Yield*

| | *1955-1977* | | | | *1915-1954* | | |
|---|---|---|---|---|---|---|---|
| Model # | (1) | (2) | (3) | (4) | (1) | (2) | (3) |
| Constant | 0.006 (0.15) | −0.016 (−0.28) | −0.026 (−1.77) | 0.002 (0.05) | 0.073*** (2.79) | 0.067*** (5.81) | 0, 080*** (3.32) |
| 1-Year Inflation | 1.593 (1.55) | 1.574 (1.10) | 1.054** (2.47) | 1.622 (1.49) | 0.613 (1.07) | 0.178 (01.04) | 0.671 (1.30) |
| 3-Month Variance | | 1.888 (0.96) | | | | 0.188 (1.79) | |
| Output Gap | | | −0.609** (−2.18) | | | | |
| 1-Year Real GDP Growth | | | | 0.550 (0.16) | | | −0.244 (−1.21) |
| Cointegration Coefficient | −0.053*** (−3.45) | −0, 044*** (−4.36) | −0.092*** (−3.74) | −0.052*** (−3.45) | −0.069*** (−3.98) | −0.198*** (−3.70) | −0.072*** (−4.21) |
| ARDL Specification | 3,4 | 3,3,1 | 3,4,6 | 3,4,0 | 6,0 | 6,0,0 | 6,0,0 |
| F-Test | 3.87* | 5.26** | 3.37 | 2.87 | 5.21** | 3.32 | 4.34** |
| R-Square | 43.79% | 48.18% | 48.46% | 43.81% | 24.08% | 28.91% | 24.91% |

***Note:*** *T-statistics are calculated using the Newey-West standard errors estimates. ***, ** and * mean that the coefficients are significant at 1%, 5% and 10% respectively. The ARDL form lists the lagged used for the Fed Funds rate, the 1-year inflation and the output gap (alternatively the 1-year real GDP growth) respectively. The output gap is calculated as the difference between the potential real output (log, as calculated by the Congressional Budget Office) and the real GDP (log). Inflation and earnings yield data is obtained from Shiller's website. Output gap and real GDP growth are obtained from FRED Economic Database.*

Table 6: Estimated Coefficients for the Long-Term Equation of S&P 500 Earnings Yield between 2008:Q4 and 2016:Q4

| | Fed Funds rate | | Bond Yield | | Earnings Yield | | |
|---|---|---|---|---|---|---|---|
| Constant | −0.002<br>(−0.67) | 0.001*<br>(1.80) | 0.021***<br>(5.70) | 0.031***<br>(8.74) | 0.027<br>(1.48) | 0.035***<br>(1.58) | 0.034***<br>(5.05) |
| 1-year Inflation | 0.020<br>(0.45) | 0.033<br>(0.96) | −0.283<br>(−1.30) | −0.350<br>(−0.94) | 0.81<br>(0.87) | 0.139<br>(1.58) | 0.137<br>(6.41) |
| Output Gap | −0.072<br>(−1.35) | | −0.236***<br>(−3.47) | | | | |
| 1-Year Real GDP Growth | | −0.034*<br>(−1.75) | | −0.173<br>(−1.38) | | | 0.030<br>(0.25) |
| 3-Month Variance | | | | | | 0.173***<br>(13.80) | 0.182**<br>(2.75) |
| Cointegration Coefficient | −0.134***<br>(−3.72) | −0.197***<br>(−3.06) | −0.327***<br>(−3.26) | −0.198***<br>(−2.81) | −0.114***<br>(−2.55) | −0.245***<br>(−3.35) | −0.239***<br>(−3.35) |
| ARDL Specification | 1,0,0 | 1,0,0 | 3,1,0 | 3,1,0 | 3,0 | 1,0,2 | 1,0,0,2 |
| F-test | 3.13 | 2.12 | 2.38 | 1.76 | 2.00 | 2.52 | 1.95 |
| R-square | 25.96% | 17.76% | 59.33% | 56.30% | 56.51% | 83.97% | 83.39% |

***Note:*** *T-statistics are calculated using the Newey-West standard errors estimates. ***, ** and * mean that the coefficients are significant at 1%, 5% and 10% respectively. The ARDL specification lists the lagged used for the Fed Funds rate, the 1-year inflation and the output gap (alternatively the 1-year real GDP growth) respectively. The output gap is calculated as the difference between the potential real output (log, as calculated by the Congressional Budget Office) and the real GDP (log). Inflation (CPI) and bond yield data is obtained from Shiller's website. Output gap and real GDP growth are obtained from FRED Economic Database.*