Equity Premium and the Monetary Policy

Master's thesis in Financial Economics

Written by Yixuan Zhao

Supervisor: Thomas Niederkofler

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Radboud Universiteit

Abstract

The impact of the monetary policy, especially the impact of the forward-looking Taylor rules on the equity risk premium from the perspective of investor' risk perception was examined for the United States. This is done by using three forward-looking Taylor rules as well as the Fama-French five factors model. In addition, the impacts of federal funds rates before and after the financial crisis in 2008 are compared. This study adds to the literature by exploring the relationship between equity premium and the monetary policy with the usage of four variables from the Fama-French five factors model. The results show that a significant and negative relationship is observed between the monetary policy and excess return on equity. Moreover, the impact of federal funds rates is higher during the post-crisis period.

Keywords: the Taylor rule, the equity premium, Fama-French five factors model

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1.Introduction

Many policymakers and researchers are interested in the relationship between the monetary policy and the equity market since the monetary policy has an impact on the economy through asset prices. The financial crisis in 2008 makes the authorities realize that the movements of asset prices need to be attached importance to. However, scholars have not reached an agreement on whether the policymakers should consider asset prices as a monetary target. Some argue that policymakers should take asset prices into consideration. For instance, Genberg (2001) supported this view because he believed that the movements of asset prices imply some important information related to the trends of inflation and output in the future. However, others claim that it is barely possible to make appropriate policies through extracting dynamic elements from asset prices. Mishkin (2007) believed the policymaker should not target the asset price level because of the difficulty of measuring bubbles in asset prices and the uncertain influence of monetary policy on asset prices. Therefore, it is meaningful to explore how monetary policy affects asset prices. In this study, I study the role of equity risk premium in the above mechanism from the perspective of the risk perception of investors. This is because the equity risk premium can response to the risk perception of investors.

When investors expect a higher uncertainty, the equity risk premium will become larger. Particularly, when the changes in monetary policy affect the investors' risk perception, the equity risk premium would change correspondingly. The change of monetary policy in this study is expressed by the changes in the monetary policy interest rate estimated from the forward-looking Taylor rule. Hence, the following research question:

What is the impact of monetary policy on the level of excess equity return？

In order to answer the research question, the excess equity return in the US from 1980 to 2019 is studied. The federal funds rate is estimated through three types forward-looking Taylor rules. By doing so, the federal funds' rates expected by investors is captured. Those interest rates indicate the risk perception of investors. After that, the Fama-French five factors model is employed with an alternative variable of the federal funds rate estimated previously. The main purpose of this step is to test the relationship between the equity risk premium and the federal funds' rates while the other four variables of the Fama-French five factors model are used as control variables. In addition, the impacts of federal funds rates before and after the financial crisis in 2008 are compared.

The results of this study will add to the literature by exploring the relationship between equity premium and the monetary policy with the usage of four variables from the Fama-French five factors model. The statistical analysis shows that a significant and negative relationship is observed between the monetary policy and excess return on equity. Moreover, the impact of federal funds rates is larger during the post-crisis period than during the pre-crisis period.

The remainder of this study is organized as follows: some literature relevant to monetary policy and asset pricing as well as hypotheses will be discussed in chapter 2. Section 3 discusses the data, and chapter 4 describes the methodology of the analysis. The results will be presented in chapter 5. Finally, section 6 concludes.

2. Literature review

2.1 The theory of Taylor rule

2.1.1 The original Taylor rule

In the Federal Reserve's semiannual monetary policy report to the Congress on 23 July 1993, Alan Greenspan who was the chairman of the Federal Reserve indicated that they would take the interest rate, especially the long-term interest rate, into account when they make monetary policies instead of solely relying on the guide of M2. This was the case because the short-term interest rate in the US declined in the past few years and it had achieved the lowest level in history. Americans tended to put their money into investment products with a higher return. However, most of those high return projects were not included in M2, which leads to a weakening of the relationship between M2 and inflation as well as output. Not only are the movements of interest rates related to the US economy，but also they affect financial variables, such as bonds, stocks, etc. Thus, investors were concerned about the federal funds rate itself and the trend of the federal funds rate. The Taylor rule proposed by Taylor (1993) offered investors a reliable monetary policy rule to calculate the federal funds rate in the future. He believed that the federal funds rate was decided by both price level and output and conducted the following equation through studying the US monetary policies from 1987 to 1992:

After that, Taylor (1993) proposed a simple interest monetary rule where both the coefficients of the inflation gap and output gap are assumed to be 0.5. He set the equilibrium real federal funds rate and target inflation rate to 2 through studying the US monetary policies from 1987 to 1992. The interest monetary rule is demonstrated as follows:

$$i_t = 2 + \pi_t + 0.5(\pi_t - 2) + 0.5y_t \qquad (2\text{-}1)$$

where i_t is the federal funds rate, π_t-2 is the inflation gap, y_t is the percent deviation of real GDP from a target. π_t is the average inflation of the inflation rates over the last four quarters. The target inflation rate as well as the real equilibrium interest rate are assumed to be 2. The constant term is 2+π_t, which is the actual equilibrium interest rate. Taylor (1993) set both the coefficients of the inflation gap and the output gap to 0.5. Equation 2-1 compared the path for the federal funds rate implied by the above equation to the actual federal funds rate path from 1987 to 1992, finding it fits well (except for 1987).

Even though the Taylor rule captured US monetary policy remarkably well, different countries have a different power to inflation and output gap because of various targets of monetary policies. For the sake of generalizing how inflation and output gap affecting policy rates in reality, the original Taylor rule can be formulated as follows:

$$i_t = i^* + \pi_t + \alpha(\pi_t - \pi^*) + \beta y_t \qquad (2\text{- }2)$$

where i^* is the equilibrium real federal funds rate, $\pi^*$is the target inflation rate. Based on the equation, the nominal federal funds rate equals to the equilibrium real federal funds rate plus the target inflation rate when the numbers of the real inflation rate and output are the target values. What's more, in order to remain the stability of equilibrium real federal funds rate, the monetary authorities should raise the short-term interest rate if the inflation gap or output gap is above zero. The short-term interest rate should be lowered by the monetary authorities using various monetary policy tools if the inflation or output is below the target value. The Taylor rule is also able to be shown as the following:

$$r_t = \delta + \alpha\pi_t + \beta y_t \qquad (2\text{- }3)$$

where r_t is the real interest rate.

Assuming that $\alpha<0$, a rise in the inflation rate leads to a fall in the real interest rate. The aggregate demand is stimulated by a decline in the real interest rate, leading to a further rise in the inflation rate and the increase of economic instability. When α is above 0, an increase in the inflation rate results in an increase in the real interest rate. After that, the aggregate demand will decline, and the price level and the inflation rate will decrease to the equilibrium state. Therefore, α is above 0 is a requirement in sustaining economic stability.

2.1.2 The forward-looking Taylor rule

The original Taylor rule employs the current data of price level and the output level when it estimates the federal funds' rate. However, it is not in line with reality. The central banks make monetary policies based on their expectations of the key factors in the economy. Therefore, it is reasonable to include forward-looking factors to study monetary policy. Clarida, Gali, and Gertler (2000) proposed the forward-looking Taylor rule:

$$i_t^* = i^* + \beta\left(E\left(\pi_{t,k}\right) - \pi^*\right) - \gamma E(y_{t,q}) \qquad (2\text{-}4)$$

where $i_t^*$is the target federal interest rate at time t, i^* is the equilibrium long-term nominal interest rate, $E\left(\pi_{t,k}\right)$ is the expected inflation rate from time t to time t+k , π^* is the target inflation rate, and $E(y_{t,q})$ is the expected output gap from time t to time t+q, namely the deviation of real GDP from target GDP.

2.1.3 The smoothing Taylor rule

The central bank always tries to make the movements of interest rate smoothly, so that the interest rate moves slowly in one direction rather than moving to different directions frequently. This is because frequent changes in the direction of interest rate may leave the public the impression that the central bank is wrong and cause fluctuations in the capital market. Therefore, continuous interest rate movements one direction increases the credibility of the central bank (Williams, 1999). The modified Taylor rule with adding the independent variable of lagged interest rate explains the movements of interest rate better because of reflecting the above considerations of the central bank.

Judd and Rudebush (1998) complemented the original Taylor rule through the usage of an error correction method to adapt to the characteristics of the gradual adjustment of the nominal interest rate of the central bank. The modified Taylor rule is:

$$\mathrm{i_t}^{*} = \mathrm{r}^{*} + \pi_{\mathrm{t}} + \lambda_1(\pi_{\mathrm{t}} - \pi^{*}) + \lambda_2 \mathrm{y_t} + \lambda_3 \mathrm{y_{t-1}} \tag{2- 5}$$

where $i_t{}^{*}$ is the recommended federal interest rate after gradual adjustment.

The adjustment mechanism of the funds' rate from the actual level to $i_t{}^{*}$ is based on the following equation:

$$\Delta i_t = \gamma(i_t{}^{*} - i_{t-1}) + \rho \Delta i_{t-1} \tag{2- 6}$$

The adjustment of the fund rate at time t consists of two parts. The first term is used to adjust the deviation between the fund rate at time t-1 and the recommended value. The other term remains the momentum of the last adjustment of the fund rate.

2.1.4 The Taylor rule with asset price

The development of the equity market is so rapid that any large movement of stock prices would lead to a significant change on the economy. However, economists have different opinions on whether the central banks should target asset prices when they set the policy rate. Bernanke and Gertler (1999) suggest the asset price should not be considered. They drew the conclusion by comparing the performances of three policy rules. Their targets are pure inflation, inflation, and output as well as inflation, output, and asset prices, respectively. The best performance policy rule is the one with a pure inflation object. Their result was criticized by Cecchetti, Genberg, Lipsky, and Wadhwani (2000). They did so by pointing out that the result of Bernanke and Gertler (1999) was under certain conditions. Cecchetti et al. (2000) drew an opposite conclusion by means of extending other dimensions of the previous work and adding interest rate smoothing process into their analysis. In spite of the debate, economists agree that policymakers should react to asset prices when they make monetary policies. Follow Chadha, Sarno, and Valente (2004), the dividend-price ratio which is the dividend divided by the share price, is used to represent the asset price of the equity market. The relationship between monetary policy and the stock market is demonstrated as following:

$$i_t = r^{*} + \pi_t + \alpha(\pi_t - \pi^{*}) + \alpha_2 y_t + \alpha_3(\rho_t - \rho^{*}) \tag{2-7}$$

where ρ_t is the dividend ratio of the stock index, ρ^{*} is the target value of dividend ratio set by the central bank.

The Taylor rule has become a systematic monetary policy rule after years of continuous development. The factors of forward-looking, smoothing process and asset prices are all added into the model in this paper when estimating the federal funds’ rate.

2.2 The empirical measurement of Taylor rule

2.2.1 The calculation of inflation

Economists have not reached a consent on which index should be used in the Taylor rule as proxies for price level variable and how long the inflation period should be selected. Taylor (1993) calculated the average of the year-over-year change in the GDP deflator in four quarters as a measure of inflation in the original formula, while Clarida（2000）used the annualized rate of change of GDP deflator between two subsequent quarters to measure the inflation level. In Taylor rule conducted by Kozicki (1999), the GDP deflator, consumer price index, and core consumer price index, and the average expected inflation in private sectors are also used to calculate the expected inflation level.

2.2.2 The calculation of potential output

The output gap is an important but hard to test variable while employing the Taylor rule. The nominal interest rate is vulnerable to the subjective measurement deviations of output. Researchers take different approaches for calculating potential output. Taylor (1993) simply used a linear trend of log GDP from 1984 to 1992. Clarida et al. (2000) used a potential output gap estimated by the Congressional Budget Office (1995). In addition to using the CBO method, Judd and Rudebusch (1999) also performed segmented linear and quadratic regression on actual output. However, different potential output measurements will lead to different policy rates. The analysis results of Kozicki (1999) showed that the recommended interest rate levels obtained from different methods vary from 0.9% to 2.4%.

2.3 The equity risk premium and monetary policy

Mehra and Prescott (1985) find the average return of the equity in the period of 1889-1978 was 7.9%，higher than the return on short-term default-free debt. They did so by using the average return of S&P500 minus the three-month federal bond rate. However, the theoretical risk premium they obtained through the classical growth model is 1.4% which is far lower than the empirical result. This phenomenon is called “the equity premium puzzle”.

Researchers have come up with numerous explanations to explain this puzzle during recent decades. Weil (1991) suggests that the incomplete markets and the heterogeneity exist in the individual consumptions can account for the equity premium puzzle. Constantinides, Donaldsom, and Mehra (2002) identifies the borrowing constraint on consumers is of the factors that affect the equity risk premium. Constantinides (1990) find that habit preferences affected by the distribution of consumption volatility can influence the equity premium. Benartzi and Thaler (1995) explain from the perspective of behavioral finance. They believe that the reason why the equity premium is so high is investors are both myopic and lose averse, and they need high returns to invest in the equity market. Joshua (2005) study the relationship between the equity premium and the market integration based on the evidence from international data. Jaroslav (2002) studies the impact of macroeconomic disasters on the equity premium in both advanced countries and emerging countries. Sie, Lilian, and Bohui

(2012) believe that improvement in a country's information disclosure and transparency helps decrease the volatility of risk premiums.

Economists also explain the equity risk premium form the perspective of monetary policies. Bernanke and Kuttner (2005) study the effect of changes in monetary policy on stock prices, finding that the unexpected 25-basis-point reduction of federal funds rate will lead to around 1% increase in stock indexes. They also find that the above phenomenon happens along with a lower-than-normal excess return, which explains a large part of the reactions of stock prices to unexpected changes in the federal funds rate. Bekaert, Hoerova, and Duca (2013) separated VIX, the volatility based on the stock option, into two parts which represented risk aversion and uncertainty respectively. When the policymakers employ a lax monetary policy, such as adequate money supply, both the risk aversion and uncertainty decrease, and the former respond more strongly. This indicates a lax monetary policy would lead to a low equity risk premium. However, Apergis and Payne (2018) drew the opposite conclusion. They investigate the relationship between equity premium and the monetary policy in America with a forward-looking Taylor rule and find the estimated federal funds rate affected the equity premium negatively.

Overall, economists do not agree on how the monetary policy affects the equity premium. Since this paper is written from the perspective of the risk perception of investors, consistent with Apergis and Payne (2018)， a negative relationship is expected in the result. The first hypothesis is derived:

H1: The federal funds rate positively affects the equity premium

2.4 CAPM and its development

Sharpe (1964), Lintner (1965), and Black (1972) proposed the Capital Asset pricing model，based on the mean-variance theory of asset returns equilibrium model. CAPM and the literature based on CAPM provide investors with useful and influential concepts. Specifically, the concept of systemic risk is crucial to understanding multi-factor models. There are many different types of risks, but they are usually not important in terms of the valuation of the investment. The theory believes that part of the risk in the portfolio can be offset by various risks of other assets. Therefore, those risks do not need to be compensated with higher expected returns. Instead, investors should be compensated for non-diversifiable risks (systemic risks) in the asset portfolio.

In the capital asset pricing model, the systemic risk of an asset measures the degree to which the asset return rate responds to the market return rate. According to CAPM, the average return of the asset portfolio can be explained by a single factor which is the return of the market portfolio. The more sensitive an asset is to the market return rate, the higher return it will have.

In the 1980s, many researchers found that the single-factor model could not explain changes in asset returns enough. Therefore, they began to explore more impact factors. Ross (1976) proposed an arbitrage pricing theory (APT) based on the assumption of a completely competitive and frictionless market. The APT model proposes a series of factors that can represent the systemic risk of assets or asset portfolios to explain the expected return of assets or asset portfolios. Unlike CAPM, APT does not specify specific risk factors, nor does it require the number of risk factors. Since then, asset pricing theory has expanded from a single factor to a multi-factor theory. The three-factor model of Fama and French (1992) and the five-factor model of Fama and French (2015) are widely demonstrated and used.

Fama and French (1992) added the market size and book-to-market ratio of listed companies to CAPM to form a three-factor asset pricing model. The size factor and book market value ratio can explain most stock price changes and abnormal market returns. Fama and Fernch (2015) proposed to take the asset profit rate and investment factor into consideration by adding them to the three-factor model and constructed a five-factor asset pricing model. Empirical research on the US stock market data showed that the FF five-factor model has a stronger explanatory power than the three-factor model, but the value factor is redundant after adding the profitability factor and investment factor. Fama and French (2015) find the coefficient of profitability factor is positive while the coefficient of investment factor is negative. This means that profitability has a positive impact on the return while the investment affects the equity return negatively. However, other scholars draw different conclusions when they employ the model to different counties. For instance, Nichol and Dowling (2014) find both the profitability and the investment factors have a positive impact on the equity return. I use the conclusion of Fama and French as my hypothesis since I analyze the US stock market in this paper. The second and third hypothesis are derived:

H2: The profitability factor positively affects the equity premium.

H3: The investment factor negatively affects the equity premium.

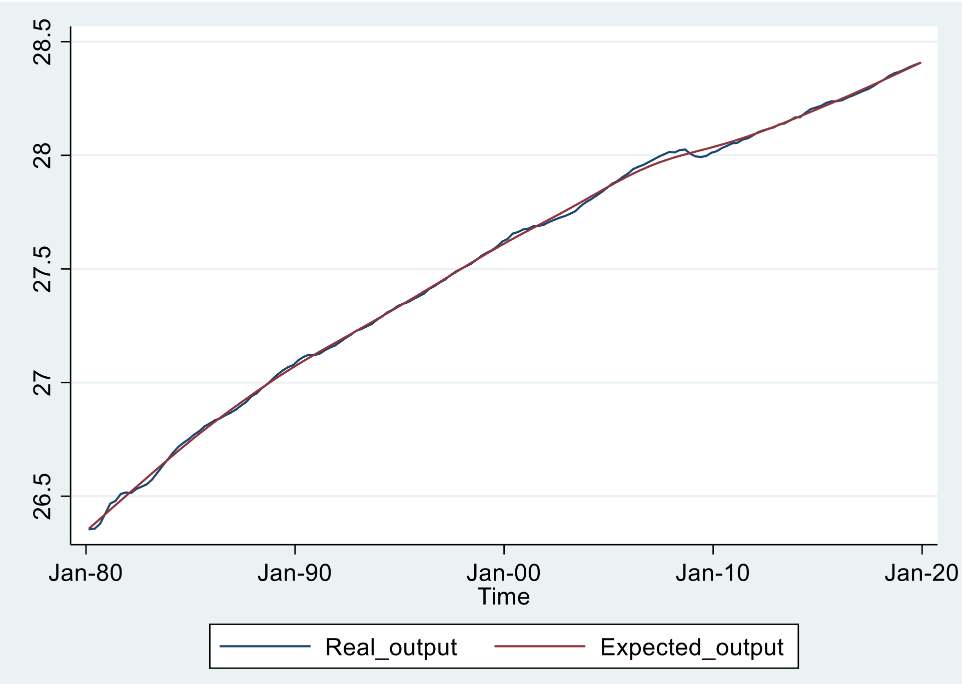
3.Data

The period from 1992:1 to 2019:4 is studied in this paper because of data availability. The reason why I use quarter data is to acquire as many samples as possible in a certain period so that the result can be more reliable. The federal funds rate is the dependent variable in the monetary policy rule. The relevant data can be downloaded from Datastream.

The measurement of the inflation rate in the Taylor rule has been controversial. Popular methods used to measure the inflation rate are the Consumer Price Index (CPI), and the GDP deflator, etc. The measurement of the inflation rate has a significant impact on the coefficient of inflation rate in Taylor rule. Follow Clarida et al. (2000), CPI serves as the proxy for inflation in this paper.

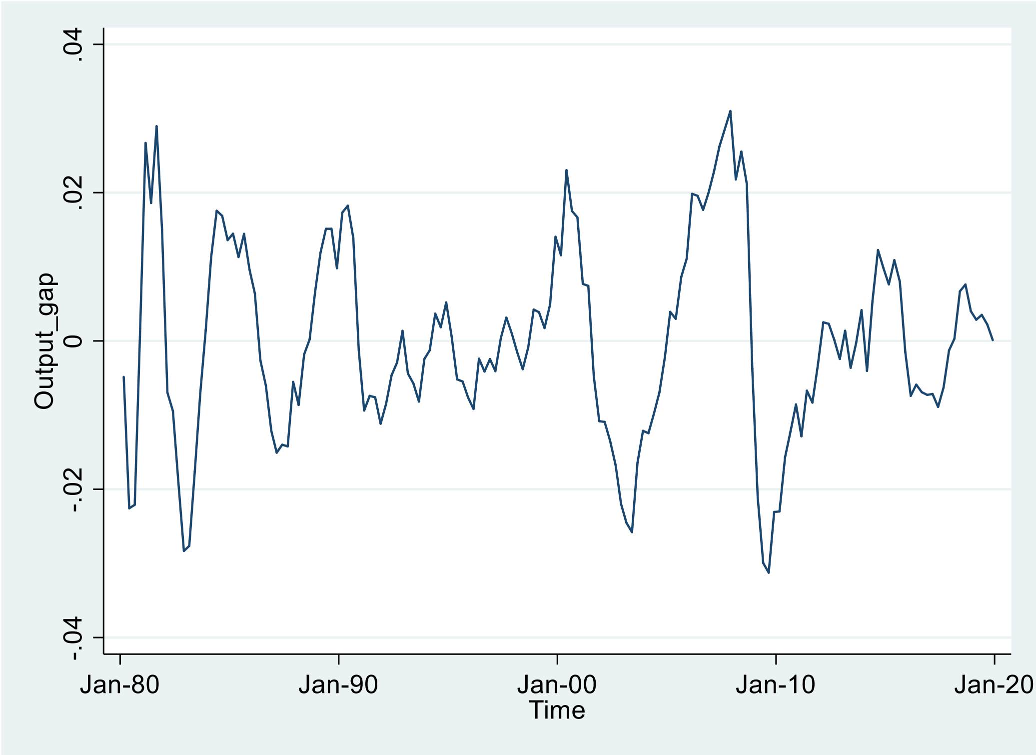
The next variable that needs to be measured is the output gap which equals the difference between the potential output and the actual output. The potential output refers to the output when all resources are made the best use of, namely the output under full employment. It can be estimated through detrending the actual GDP. There are three leading methods of detrending, which are linear, quadratic, and Hodrick-Prescott (HP) detrending methods. Although the linear detrend method is commonly used, it does not take into consideration the non-stationarity characteristics of output data. Therefore, I estimate the output gap through the HP filtering method. The actual GDP value of the US can be extracted from Datastream. Figure 1 shows the actual GDP and the potential GDP

Figure 1 the actual GDP and the potential GDP



The output gap is calculated through the actual GDP subtracting the potential GDP. The output gaps in America from 1980 to 2019 are shown in figure 2.

Figure 2 the US output gap



The last variable used to predict the federal funds rate is the asset price which is used to test the relationship between the interest rate and the equity market. Follow Chadh et al. (2004), the asset piece of the equity market is the dividend ratio of the S&P 500, and it can be obtained through Datastream.

The following data are used to test the relationship between the equity premium and monetary policies.

The excess returns on the US stock market are computed by Standard & Poor's 500 Index (S&P 500) minus the 10-year treasury bill interest rate which serves as the risk-free rate in this paper. These data can also be extracted from Datastream.

The control variables I employ are inspired by the Fama-French five factors model (Fam a and French, 2015). Therefore, follow the Fama-French five factors model, the size of the US stock market is measured by the logarithmic value of market capitalization. The book to market ratio is used to measure the value of the US stock market. The profitability is calculated by the sum of operating profits of the companies in the stock market divided by the total assets of companies in the stock market. The investment factor is measured through the increase in total assets for the current year divided by the total assets of the last year.

4.Methodology

This paper studies the relationship between the monetary policy and the equity premium from the perspective of investors' risk perception. Especially, the effect of monetary policy is represented by the policy interest rate which is estimated from the forward-looking Taylor rules. Therefore, this section is divided into two parts. The forward-looking Taylor rules and the estimated interest rate will be demonstrated in the first part. The methodology of exploring the role of monetary policy on the equity premium will be demonstrated in the second part.

4.1 Forward-looking Taylor rules

The applications of Taylor Rule are obtained by forward-looking monetary policies in this study. This is the case because some scholars have found that America policymakers have forward-looking behavior when they make decisions about monetary policies. For instance, Orphanides and Wieland (2008) find that the Taylor rule based on policymakers' forecasts of inflation can explain the decision of the Federal Open Market Committee (FOMC) better compared with one based on the observed outcome through investigating the policy decisions of FOMC from 1988-2007. The forward-looking Taylor rule extends the simple Taylor rule by replacing the current inflation and output value with forecasting ones. When the expected inflation and the expected output are not equal to the target ones, the authorities should adjust the interest to achieve their goals.

The best-known forward-looking Taylor Rule, which is proposed by Clarida et al. (1998, 2000) who describe how the authorities respond to the inflation and output deviation as follows:

$$i_t = \alpha + \beta[E(\pi_{t+n}) - \bar{\pi}] + \gamma E(y_{t+q}) \quad (4\text{-}1)$$

where β is the coefficient for the inflation gap with a subscript of t+n which means the predicting range. γ is the coefficient for the output gap with a subscript of t+q denoting the forecasting duration. α is a constant term that is defined as the equilibrium nominal interest rate minus the inflation target of multiple β. $E(\pi_{t+n})$ is the expected inflation rate over the period of t to t+n, and $E(y_{t+q})$ is the expected output gap with the forecasting horizon of t+q.

Besides, the central bank always shows the behavior of smoothing the policy rate movement in the process of changing the interest rate. Part of the reason is that fluctuations in interest rates in different directions might deliver wrong messages to the public. Moreover, the smoothing behavior of the central bank has been helpful in declining the instability in the financial sector by making the interest rate more predictable (Coibion and Gorodnichenko, 2012). Therefore, I involve the factor which indicates the smoothing process of the interest rate in the model. Follow Castro (2011), the above equation can be translated as follow:

$$i_t = (1-\rho)(\alpha + \beta\pi_{t+1} + \gamma y_{t+1}) + \rho i_{t-1} + \varepsilon_i \quad (4\text{-}2)$$

where ρ is the coefficient of the lagged interest rate which is introduced to describe how the policymakers gradually adjust the current interest rate to the target rate.

Last but not least, the relationship between the interest rate and asset price cannot be ignored when the central bank sets the policy interest rate. Follow Chadha et al. (2004), the augmented Taylor rule is demonstrated as the following:

$$i_t = (1-\rho)(\alpha + \beta\pi_{t+1} + \gamma y_{t+1}) + \rho i_{t-1} + \delta p_{t-1} + \varepsilon_i \quad (4\text{-}3)$$

where p_{t-1} denotes the lagged stock price.

In the process of estimating the policy rate, the first step is to estimate it with the forward-looking Taylor rule with solely the inflation variable. This is because Svensson (2003) finds that the success or failure of monetary policy during different periods in America is related to the effect of controlling inflation. Secondly, the estimations of the forward-looking Taylor rule are constructed with both the inflation forecasts and the output gap. Finally, except for the inflation gap and the output gap, my empirical analysis also accounts for the interest rate with the asset price.

4.2 Monetary policy and the equity premium

This paper mainly discusses the process of the stock market responding to monetary policy through changes in investors' perception of risk. Therefore, the elements that might affect the decisions of investors are what I focus on. Three leading factors will be discussed: the future dividends paid by the firm, movements in the short-term interest rate, and the risk faced by investors when they invest in one certain asset. The capital asset pricing model fully illustrates the relationship between the expected return and the risk in the stock market. The main idea of CAPM is that the expected return consists of two parts: the risk-free rate and the risk premium. If investors feel the degree of uncertainty will be higher in the future, they would invest in a certain asset only if its return comes higher. For example, an increase in the interest rate will make the investors require a higher return. This is the case because the increase in interest rate will increase the cost of funding of a company and make it difficult for the company to obtain the necessary money to support the operating of the firm. In this way, the company has to reduce its production scale. The reduction of the production scale will lead to a reduction in the company's future profits. The central bank and the monetary policy can influence the three factors related to the investors' decisions. Besides, the implementation of some monetary rules can indicate changes and uncertainties in the macroeconomy, leading to an increase in the expected return.

A multifactor model based on CAPM is employed for the purpose of exploring the relationship between the monetary policy and the risk premium. In particular, the monetary policy is presented with the federal funds' rates previously estimated by the forward-looking Taylor rule. Inspired by Apergis and Payne (2018) who employ the Fama-French three factors model (Fama and French, 1995) in their study to investigate the relationship between the equity premium and the monetary policy. The Fama-French five factors model is used in this paper. However, I do not use the methodology of the five factors model because it focuses on the investment portfolio and is used to study the equity premium from the firm level. Thus, I refer to the model and extend the work by Apergis and Payne (2018) by adding two more control variables of the profitability and the investment factors. The regression model is demonstrated as the following:

$$MR_t - RF_t = RP_t \tag{4-4}$$

$$= \alpha + \beta_1 FFR_t + \beta_2 S_t + \beta_3 BM_t + \beta_4 RMW_t + \beta_5 CMA_t + \eta$$

where MR_t denotes the rate of stock market return; RF_t the risk-free rate; RP_t the risk premium; FFR_t the monetary policy rate (calculated through the monetary policy rule approach above); S_t the size of the stock market; BM_t the value of the stock market; RMW_t the profitability; CMW_t the investment; and η the error term.

Before running the regression, it is necessary to test the stationarity of the variables when applying time-series data in case of spurious regression. Follow Apergis and Payne (2018), I employ a range of unit tests. They are the Dickey-Fuller generalized least squares (DFGLS) test and the point optimal test recommended by Elliott, Rothenberg, and Stock (1996) (ERSPO), which are built based on the conventional augmented Dickey and Fuller (1981) and Phillips and Perron (1988) tests. Besides, I also use four test statistics (MZa, MZt, MSB, and MPT) constructed by Ng and Perron (2001) using detrended data so that they are better in the size as well as the power of the unit root tests. After that, the Johansen and Juselius (1990) cointegration tests proceed.

5. Results

5.1 The estimated federal interest rate

Table 1 shows the regression results of three forward-looking Taylor rules.

As shown in column (1) where the inflation rate is the only independent variable, the result of CPI indicates that the inflation rate has a positive but relatively low impact on the policy rate since the coefficient is 0.0013. Moreover, the effect of inflation is statistically significant as the p-value is smaller than 0.01. With regard to the lagged interest rate of *li*, the positive coefficient (0.872) indicates that the relationship between the interest rate and its value of the previous period is positive. A p-value under 0.01 could be derived from the OLS regression, concluding that the relationship is significant. When it comes to *DUM2008*, the coefficient of -0.00437 indicates the subprime crisis in 2008 has a negative effect on the interest rate set by the policymakers. It also implies the monetary policy after 2008 turns into an expansionary one in order to stimulate the development of the economy.

Column (2) of Table 1 demonstrates the results of the model with the explanatory variables of the inflation rate and output gap. The conclusion of regression in model 2 is the same as that of regression in model 1 since the outcomes of both regressions did not differ a lot. The results of the lagged interest variable *li* in model 1 and model 2 are the same as well, indicating a positive and statistically significant impact on the interest rate. The variable *y* seems to have a positive impact on the interest rate. The coefficient is 0.139. The p-value is smaller than 0.01 which indicates that the effect is significant. It is worth noting that the coefficient of the output gap is larger than that of the inflation rate, which means the interest rate is more affected by the output gap than the inflation rate.

The outcome of model 3 which involves the independent variable of the asset price is shown in column (3). The effects of the variable *li* and *DUM2008* on the interest rate remain statically significant since their p values are smaller than 0.01, although the lagged variable has a positive influence on the interest rate while the dummy variable has a negative influence. The effect of the inflation rate on the interest rate reduces in model 3 as the coefficient is 0.00871, smaller than 0.0013 in model 1. What's more, the p-value in model 3 is larger even though the effect is still significant. The coefficient of *li* is positive and its p-value shows its effect on interest rate is significant, which are consistent with those in model 2 and model 3. However, like *CPI*, the introduction of asset prices declines the weights policymakers place on the output gap. The variable *Asset prices* seem to have a somewhat positive impact on the interest rate. The coefficient, in this case, is 0.116, which means that if the asset price increases by one unit, the number of interest rate could increase by around 11%.

Table 1 Forward-looking rule estimation

Variable	(1) i	(2) i	(3) i
CPI	0.00130***	0.00132***	0.000871*
	(3.03)	(3.14)	(1.91)
li	0.872***	0.858***	0.809***
	(28.03)	(27.72)	(22.14)
DUM2008	-0.00437**	-0.00473**	-0.00676***
	(-2.29)	(-2.52)	(-3.32)
y		0.139***	0.150***
		(2.73)	(2.96)
Asset prices			0.116**
			(2.38)
_cons	0.00243	0.00314**	0.000810
	(1.55)	(2.01)	(0.44)
N	160	160	160
r2	0.959	0.961	0.962
r2_a	0.958	0.960	0.961
F	1209.2	946.2	780.9

Notes：1. t statistics in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01

2.Model (1) represents the regression with only inflation forecasts；Model (2) represents the regression with output gap and inflation forecasts；Model (3) represents the regression with output gap, inflation forecasts, and asset prices;

As shown in Figure 3, the trends of the actual federal funds rate and the three estimated ones are quite similar. The differences between the actual and estimated ones are not large either.

Figure 3 the actual federal funds rate and three estimated ones

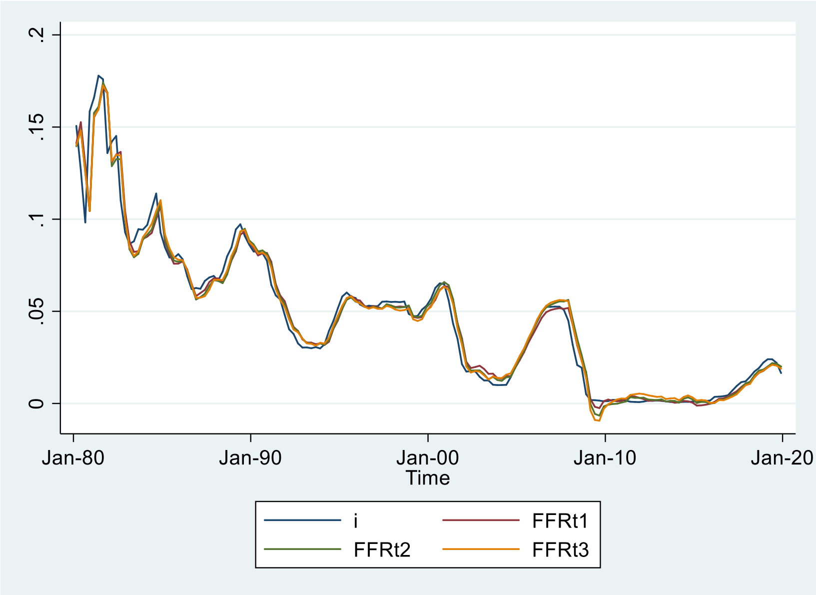


Table 2 the descriptive statistics of federal funds rates

Specification	Variable	Sample	Minimum	Mean	Medium	Maximum	Standard deviation
Pre-crisis	i	112	0.0100	0.0638	0.0557	0.1779	0.0363
	FFRt1	112	0.0134	0.0638	0.0556	0.1717	0.0348
	FFRt2	112	0.0123	0.0638	0.0554	0.1741	0.0348
	FFRt3	112	0.0130	0.0638	0.0555	0.1726	0.0349
Post-crisis	i	48	0.0007	0.0069	0.0018	0.0318	0.0085
	FFRt1	48	-0.0025	0.0069	0.0024	0.0426	0.0097
	FFRt2	48	-0.0066	0.0069	0.0022	0.0454	0.0105
	FFRt3	48	-0.0093	0.0069	0.0036	0.0426	0.0098
Full	i	160	0.0007	0.0467	0.0462	0.1779	0.0403
	FFRt1	160	-0.0025	0.0467	0.0467	0.1717	0.0395
	FFRt2	160	-0.0066	0.0467	0.0473	0.1741	0.0395
	FFRt3	160	-0.0093	0.0467	0.0457	0.1726	0.0395

Table 3 unit root tests

	DFGLS Trend	DFGLS No trend	ERSPO Trend	ERSPO No trend	Mza Trend	Mza No trend	MZt Trend	MZt No trend	MSB Trend	MSB No trend	MPT Trend	MPT No trend
RPt	-11.688*	-10.717*	-9.980*	-1.524	-75.382*	-4.044	-6.138*	-1.246	0.081	0.308*	1.212	6.267*
FFRt1	-3.390*	-2.770*	-2.270*	-0.303	-10.511	-0.329	-2.172	-0.226	0.207*	0.687*	9.256*	27.953*
FFRt2	-3.388*	-2.681*	-2.411	-0.384	-12.017	-0.515	-2.344	-0.327	0.195*	0.634*	8.165*	23.778*
FFRt3	-3.447*	-2.674*	-2.444	-0.373	-12.341	-0.505	-2.381	-0.319	0.193*	0.632*	7.952*	23.728*
St	-1.488	-2.031	-0.757	1.828*	-1.744	1.224	-0.785	2.112*	0.450*	1.725	41.163*	203.544*
BMt	-2.478	-1.779	-2.481	-0.731	-11.512	-1.886	-2.395	-0.712	0.208*	0.378*	7.940*	10.201*
RMW	-4.034*	-4.201*	-1.150	-0.066	-2.398	-0.019	-1.081	-0.015	0.451*	0.790*	37.385*	37.407*
CMA	-6.279*	-5.895*	-6.078*	-3.300*	-45.930*	-17.768*	-4.781*	-2.973*	0.104	0.167	2.044	1.408
Critical values												
1%	-4.017	-3.472	-3.509	-2.580	-23.800	-13.800	-3.420	-2.580	0.143	0.174	4.030	1.780
5%	-3.438	-2.880	-2.971	-1.943	-17.300	-8.100	-2.910	-1.980	0.168	0.233	5.480	3.170
10%	-3.143	-2.576	-2.681	-1.615	-14.200	-5.700	-2.620	-1.620	0.185	0.275	6.670	4.450

Notes：* $p < 0.10$

Table 4 Johansen-Juselius cointegration tests

Model	H0	H1	Eigenvalues	Max-lambda			Trace		
				statistics	CE	VAR	statistics	CE	VAR
FFRt1	r=0	r=1	0.3064	57.0801	40.3000	39.3700	180.7997	102.1400	94.1500
	r<=1	r=2	0.2855	52.4366	34.4000	33.4600	123.7196	76.0700	68.5200
	r<=2	r=3	0.1729	29.6085	28.1400	27.0700	71.2830	53.1200	47.2100
	r<=3	r=4	0.1426	23.9928	22.0000	20.9700	41.6744	34.9100	29.6800
	r<=4	r=5	0.0902	14.7413	15.6700	14.0700	17.6817	19.9600	15.4100
	r<=5	r=6	0.0187	2.9404	9.2400	3.7600	2.9404	9.2400	3.7600
FFRt2	r=0	r=1	0.3074	57.2993	40.3000	39.3700	181.7855	102.1400	94.1500
	r<=1	r=2	0.2825	51.7960	34.4000	33.4600	124.4862	76.0700	68.5200
	r<=2	r=3	0.1820	31.3382	28.1400	27.0700	72.6902	53.1200	47.2100
	r<=3	r=4	0.1393	23.3935	22.0000	20.9700	41.3520	34.9100	29.6800
	r<=4	r=5	0.0932	15.2597	15.6700	14.0700	17.9585	19.9600	15.4100
	r<=5	r=6	0.0172	2.6988	9.2400	3.7600	2.6988	9.2400	3.7600
FFRt3	r=0	r=1	0.3029	56.2931	40.3000	39.3700	181.3045	102.1400	94.1500
	r<=1	r=2	0.2852	52.3670	34.4000	33.4600	125.0114	76.0700	68.5200
	r<=2	r=3	0.1838	31.6817	28.1400	27.0700	72.6443	53.1200	47.2100
	r<=3	r=4	0.1376	23.0942	22.0000	20.9700	40.9627	34.9100	29.6800
	r<=4	r=5	0.0935	15.3214	15.6700	14.0700	17.8684	19.9600	15.4100
	r<=5	r=6	0.0162	2.5470	9.2400	3.7600	2.5470	9.2400	3.7600

Table 2 demonstrates the descriptive statistics of the actual federal funds rate and the three estimated ones based on forward-looking Taylor rules. As shown in table 2, the total number of samples is 160, including 112 samples before the financial crisis in 2008 and 48 samples after the financial crisis. Before the financial crisis, the minimum of the actual federal funds rate *i* is 0.01, which is smaller than those of *FFRt1, FFRt2,* and *FFRt3*. The median of *i* is the largest among the four variables (0.0557), while those of *FFRt1, FFRt2,* and *FFRt3* are 0.0556, 0.0554, and 0.0555 respectively. In addition, the maximum value and standard deviation of *i* are larger than *FFRt1, FFRt2,* and *FFRt3* as well. With regard to the post-financial crisis period, this situation has changed greatly. Except that the mean value of *i* is still equal to those of other three variables, the minimum value of *i* becomes the largest of the four, which is 0.0007, while the median value, maximum value and standard deviation of *i* are all smaller than those of FFRt1, FFRt2, and FFRt3. This is opposite to the situation before the financial crisis.

5.2 The equity premium and monetary policy

Table 3 presents the results of unit root tests. Even though the variables do not pass one test altogether, all of them have passed at least one-unit root test among the six tests. This means that the test statistics are higher than the critical values in a 90% confidence interval and the unit root null hypothesis cannot be rejected. Therefore, the variables pass the unit root tests.

The results of Johansen-Juselius cointegration tests are reported in Table 4. *FFRt1* is the estimated value of the federal funds rate through forward-looking Taylor rule with the only independent variable of inflation forecast. With regard to the Johansen-Juselius cointegration tests of *FFRt1*, the results from both the max-lambda and the trace tests indicate a cointegration, which means *FFRt1* passes this cointegration tests. *FFRt2* and *FFRt3* are the estimated value of the federal funds rate through forward-looking Taylor rule with the independent variables of the inflation forecasts and the output gap as well as the independent variables of inflation forecasts, the output gap, and the asset prices. The outcomes of the max-lambda and the trace tests for both of the two estimated policy rate specifications mean there exits long- term equilibrium relationship.

Table 5 shows the regression results of the coefficients of the equity premium.

As shown in column (1) where the explanatory variable is FFR_{t1}, the result of FFR_{t1} indicates that the estimated federal funds rate has a negative impact on the equity risk premium since the coefficient is -1.023, which is consistent to hypothesis 1. Moreover, the effect of FFR_{t1} is statistically significant as the p-value is smaller than 0.01. With regard to the control variable of *BMt,* the positive coefficient (0.0844) indicate that the relationship between the equity premium and the book-to-market ratio is positive. A p-value under 0.01 could be derived from the regression, concluding that the relationship is significant. As for the variable of *CMA*, its impact on the equity premium is larger than *BMt* for its coefficient is higher, which means the equity risk premium is more vulnerable to the investment style than the book-to-market ratio. The coefficient is positive, contrary to hypothesis 3. However, the p-value of *CMA* is higher than that of *BMt*. When it comes to *St* and *RMW*, the high p-values indicate that the null hypothesis cannot be rejected. The impact of the size and profitability of the US stock market does not have an impact on its equity risk premium. This result is contradicted to hypothesis 2 which indicates a significant and positive relationship between the equity premium and the profitability factor.

The coefficients of the equity risk premium model with the federal funds rate estimated from a forward-looking Taylor rule whose independent variables are the inflation rate and the output gap are presented in column (2). The negative coefficient of -1.056 and the p-value which is smaller than 0.01 indicate that the independent variable *FFRt2* has a significant negative effect on the dependent variable. The positive coefficients of the control variables *St* and *CMA* indicate the equity risk premium will increase if there is an increase in the size or the investment of the stock market. Unlike the statistically insignificant impact resulted in model 1, the p-value of *St* is smaller than 0.1 which means the null hypothesis can be rejected. The result of *RMA* in model 2 is the same as that in model 1 since the outcomes of both regressions did not differ a lot.

Column (3) of Table 5 presents the results of the equity risk premium regression which has the explanatory variable of *FFRt3*, the federal funds rate estimated from the forward-looking Taylor rule including asset prices. The outcomes of each variable are similar to those in model 2.

Table 5 equity premium and the estimated federal funds rate: full sample

	(1)	(2)	(3)
Variables	RPt	RPt	RPt
St	-0.0271	-0.0280*	-0.0279*
	(-1.57)	(-1.67)	(-1.66)
BMt	0.0844***	0.0853***	0.0836***
	(2.95)	(3.00)	(2.93)
RMW	0.333	0.340	0.373
	(1.45)	(1.48)	(1.62)
CMA	0.595*	0.614*	0.619*
	(1.76)	(1.82)	(1.84)
FFRt1	-1.023***		
	(-3.32)		
FFRt2		-1.056***	
		(-3.58)	
FFRt3			-1.064***
			(-3.53)
_cons	0.598	0.623	0.618
	(1.27)	(1.37)	(1.35)
N	160	160	160
r2	0.237	0.245	0.243
r2_a	0.212	0.220	0.219
F	9.553	9.987	9.902

Notes:1.t statistics in parentheses

2.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The estimation results of equation (4-4) over the pre-and post-crisis period are shown in Table 6. With regard to the federal fund rates, the coefficients and the p values indicate the estimated federal funds' rates remain negative and significant impacts on the equity risk premium over three policy rule specifications, which is consistent with the results of the full sample. However, all p-values of the federal funds rate over the post-crisis period are larger than those over the pre-crisis period. This indicates that the impact of the federal funds rate is less significant after the subprime crisis. Moreover, policy rates tend to have a stronger effect on the equity risk premium during the post-2008 crisis period. This is the case because their coefficients (-2.457, -2.542 and -2.779 respectively) are larger across the monetary policy rates estimated from three monetary policy specifications. This finding suggests that the introduction of some monetary policy tools make intermediaries, such as banks, easier getting financing. Therefore, the credit conditions are laxer and reduce the risk premium that banks imposed on loans.

Table 6 equity premium and the estimated federal funds rate: pre- and post-crisis

Variables	Precrisis period			Post crisis period		
	(1)	(2)	(3)	(4)	(5)	(6)
	RPt	RPt	RPt	RPt	RPt	RPt
St	-0.0214	-0.0210	-0.0204	0.201	0.187	0.198
	(-1.09)	(-1.11)	(-1.08)	(1.03)	(0.97)	(1.03)
BMt	0.0686*	0.0679*	0.0648*	0.00973	0.0248	0.0245
	(1.94)	(1.93)	(1.83)	(0.09)	(0.24)	(0.24)
RMW	0.178	0.199	0.219	1.211	1.136	1.291
	(0.58)	(0.64)	(0.70)	(1.12)	(1.08)	(1.27)
CMA	0.937**	0.966**	0.976**	-0.130	-0.149	-0.181
	(2.01)	(2.07)	(2.09)	(-0.24)	(-0.27)	(-0.33)
FFRt1	-0.934**			-2.457*		
	(-2.62)			(-1.69)		
FFRt2		-0.967***			-2.542**	
		(-2.81)			(-2.02)	
FFRt3			-0.970***			-2.779**
			(-2.76)			(-2.19)
_cons	0.468	0.458	0.443	-5.788	-5.412	-5.740
	(0.88)	(0.89)	(0.86)	(-1.06)	(-1.00)	(-1.07)
N	112	112	112	48	48	48
r2	0.199	0.206	0.204	0.255	0.274	0.285
r2_a	0.161	0.169	0.167	0.166	0.188	0.200
F	5.263	5.504	5.437	2.868	3.178	3.350

Notes:t statistics in parentheses

** $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$*

Overall, the regression results of the federal funds rate for both the full sample and the pre- and post-crisis periods are consistent with *H1: The federal funds rate positively affects* *the equity premium*. Although the coefficients of profitability for the full sample are positive, consistent with *H2*, the p-values indicate the profitability of the stock market does not have a significant impact on equity risk premium. The coefficients of profitability in the pre- and post-crisis periods show the same result. Meanwhile, the regression outcomes of investment in the stock market for the full sample and the pre-crisis period show a contrary result with *H3: The investment factor negatively affects the equity premium*. The results of the investment factor during the post-crisis period show the same direction but they are non-significant.

6. Discussion and Conclusion

In this paper, the impact of the monetary policy, especially the impact of the forward-looking Taylor rules on the equity risk premium from the perspective of investor' risk perception was examined for the United States. This is done by using three forward-looking Taylor rules as well as the Fama and French five factors model.

The statistical analysis showed that a significant and negative relationship was observed between the federal funds rate and excess return on equity. In other words, the equity risk premium will decrease if the federal funds rate increases. When the investors predict a higher federal funds rate, the equity risk premium they claim will be lower. The result indicates that the monetary policy is able to effect on a stock market directly through the equity risk premium. However, the results of the statistical analysis are not consistent with the results that Bernanke and Kuttner (2005) and Bekaert et al. (2013) found. The reason could be that these authors used different methodologies and solved the research question from a different perspective.

Moreover, the impact of federal funds rates increases during the post-crisis period. Integrating with reality, the central bank introduces some monetary policy tools and employs the quantitative easing programs in order to stimulate the economy after the financial crisis in 2008. These measures ease the credit conditions for intermediaries and reduce the risk premium imposed on loans.

For other variables, the relationship between the investment factor of the stock market and the excess equity returns is positive when regressing using the full sample and the samples after the financial crisis, but it is not the same as *H2*. Additionally, the profitability factor does not have a significant impact on the equity premium, which is contrary to *H3*. The results of these control variables are not desirable. The reason might be the proxies for these variables used in this paper are exactly as same as those in the Fama-French five model. The Fama-French five factors model is employed from the firm level while I use it from a macroeconomic level. The results would be better if using more accurate variables or indexes to describe the value, size, profitability, and investment of the stock market. For example. Leite et al.(2020) suggest that *"the shocks to the aggregate dividend yield and term spread, default spread, one-month T-bill rate as well as the innovations in CPI are good proxies"* for the variables in the Fama-French five factors model.

One suggestion for further research is to adopt better proxies to do this analysis as I mentioned above. In addition, it could be interesting to explore whether the relationship between the monetary policy and the equity premium holds in different countries. For example, whether the results in developed and developing countries would be similar?

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