Structural Changes in Response of Stock Returns to Money and Inflation

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Abstract

This article aims at testing the structural changes in the correlation between stock returns and macroeconomic factors. I have tested the quarterly data from 1975 to 2019. The structural break I have set is at quarter 4, 2008, when Fed first implemented quantity easing (QE) policy. This article shall reveal the effects unconventional monetary policy has on U.S. stocks. The result shows that structural changes occur in the effects unexpected money supply and inflation have on stock returns. Regardless of expected or unexpected factors, the effects money supply and inflation have on risk premium underwent structural changes at the break point. The result of this study indicates that the implementation of QE policy and the change of the main goals of Fed affect the demanded compensation of risk to some extent. Later, I have tested whether the investors estimate future outputs precisely. I found out that the explanation capability of the prediction to future outputs from stock returns is weak, regardless of data before or after quarter 4, 2008.

Index Terms: **Macroeconomics, Monetary Policy, Financial Economics, Stock Return, Structural Change, Inflation, Financial Crisis, Quantity Easing**

1. Introduction

There are two purposes for this article. For one thing, this is a revised version of the previous research of Chen, Chiu, Tsai, Wang and Tsai (2021)[1]. Some of the processes that we have done with the data are found incorrect, and there are methods we can implement in order to make the economic explanation of the results less vague. For the other thing, this article is an expansion of our previous study. I applied economic models to form expectation of macroeconomic factors. Later, as suggested by the instructor[2], because Fed have implemented unconventional monetary policies since the financial crisis in 2008, I set a structural break to test if there is any structural change in stock's response to macroeconomic factors.

Firstly, I must specify that the process we have done for stock prices makes the conclusion of our previous research difficult to be explained. We have tested the *martingale pricing hypothesis* for S&P 500, and found the unit root pattern of it. Then, we directly took the first order difference of the index. We stated that the difference of logarithm is an imprecise estimation of return. Unfortunately, this is incorrect, since we should consider stock prices (as well as other macroeconomic growth rate) to be continuously compounded. Namely,

$$P_t = P_0 e^{rt} \tag{1}$$

where P_0 is the initial price, P_t is the price at time t and r is the continuously compounded growth rate (or return, interest rate). Taking logarithm to both sides of the equation and setting $t = 1$ will lead us to

$$r = ln\frac{P_1}{P_0} = ln\,P_1 - ln\,P_0 \tag{2}$$

This indicates that the difference of logarithm is indeed a good estimation of return and other macroeconomic growth rate. Hence, in this article we always utilize the continuously compounded rate as measure of growth and returns.

Secondly, the separation of expected and unexpected parts of macroeconomic factors is of importance for empirical economists. In this article I applied Barro and Rush's (1980) approach to distinguish expected and unexpected M1 money supply. Also, the method I utilized to separate expected and unexpected inflation is same as Fama (1981).

Lastly, I utilized dummy variable and Chow (1960) test to test whether there is structural change on the effect of the dependent variables have on the stock returns and equity risk premium of U.S. The structural break that I tested is Q4, 2008. The financial

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[1] J. H. Chen, C. H. Tsai, P. J. Tsai, Y. H. Wang, H. K. Chiu , "Financial Econometrics Final Report: Response of S&P 500 to Money Supply and Inflation", January 2021

[2] Professor Yan-Zhi Wang, Department of Finance, National Taiwan University

environment of U.S. changed hugely in the global financial crisis in 2008 and the following market recovery. The changes are mostly the result of QE policy implemented by Fed. QE policy is a series of measurement that reduce the financial cost of firms, mainly by reducing interest rate. QE policy includes large-scale asset purchases (LSAPs), lowering Federal interest rate, relief loans and more aggressive expansionary policies. Fed purchased a wide range of financial assets to increase their prices and lower the yields. This implicitly means that the money supply increases hugely. After the financial crisis, Fed does not consider open market operation as the sole measurement to affect the market and investors' expectations. Fed starts concerning financial stability in the U.S., so investors' expectation to future earnings, which stock prices directly reflects, may have changed after the implementation of such policy.

This article is composed of five parts. The first part is the introduction, and the second part reviews literatures related to this study. In the third part I will introduce the data source and the methodologies in detail. The fourth part will present the statistical results of the models. Finally, in the fifth part, I will make the final conclusion as well as economic explanation.

2. Literature Review

2.1 Inflation and Stock Returns

There are abundant papers that demonstrate the relation between stock returns and inflation. To begin with, Fisher (1930) proposed that stocks can be a hedge against inflation. Hence, in this classical view, stock returns should be positively related to inflation. Nevertheless, several empirical studies in 1970s did not conform to this perspective. To name a few, Nelson (1976), Fama and Schwert (1977), Schwert (1981) had found negative correlation between stock returns and inflation in post-war data. Fama and Schwert (1977) implemented expected and unexpected inflation as separate independent variables rather than actual inflation in the former studies. The separation can also be seen in Fama (1981).

To explain such negative correlation, Fama (1981) argued that the correlation itself is spurious. To be more specific, he considered the correlation is the aftermath of proxying the positive correlation between stock returns and real activity. This is known as "Fama's proxy hypothesis". The statistical model indicates that the negative correlation is largely induced when involving real activity and money supply in the model.

However, Geske and Roll (1983) argued that Fama (1981) did not take the exogenous shock of aggregate output into consideration. They considered a central bank conducting counter-cyclical policies and explain the negative correlation between stock returns and inflation. In their point of view, a decline shock of expected output will decrease the stock prices. The government will go into deficit when the output actually declines. To monetize the deficit, central bank will conduct expansionary monetary policy, causing increasing money supply and decreasing inflation. For this reason, the negative correlation between stock returns and inflation does not show causality. Reversely, if that is the case, stock prices can be used to predict money supply and inflation. This is the so-called “debt-monetization hypothesis”. However, this hypothesis was later rejected by Ely and Robinson (1992).

2.2 Money Supply and Stock Returns

The relation between money supply and stock returns is always an intriguing topic for macroeconomists. Friedman (1961) proposed that money supply can be used to predict stock returns, but this was later rejected by Rozeff (1974) empirically since Friedman’s (1961) proposition could not generate any profitable result in post-war data. Rozeff (1974) also found that stock returns are related to contemporaneous and future money growth, which gave rise to the adverse causality problem.

In more recent papers, the positive relation between money supply and stock returns were found frequently. Lastrapes (1998) utilized vector autoregression (VAR), finding that money supply and stock prices are positively correlated. Pícha (2017) and Maskay (2007) also found positive correlation between money supply and stock prices. Maskay (2007) implemented Barro and Rush’s (1980) method to distinguish expected and unexpected money supply, but in the study Maskay (2007) formed the expectation of M2, while Barro and Rush’s (1980) study was for M1.

2.3 Quantity Easing and Stock Returns

The data after the implementation of QE1 is relatively small. Most of the papers focus on how QE effect macroeconomic factors such as inflation, output and financial markets. Shah, Schmidt-Fischer, Malki and Hatfield (2019) showed that the implementation of QE lower equity’s risk premium. They pointed out that the magnitude of the response of stock market to QE becomes smaller over time. This is consistent with Hesse, Hofmann and Weber (2017). Hesse, Hofmann and Weber (2017) found that early LSAPs have significant macroeconomic effects. They also pointed out that asset purchasing had become a driven factor of stock prices valuation after the financial crisis in 2008. On the other hand, Balatti, Brooks, Clements and Kappou (2017) argued that QE does not help in regard to credit creation. They suggested that measurements aiming at monetary stimulus into lending is the main consideration for central banks to implement a new round of QE. Central banks shall not only focus on stimulus financial assets such as equities.

3. Data and Methodology

3.1 Data

I downloaded data from FRED (https://fred.stlouisfed.org/). The quarterly data includes Wilshire 5000 total market full cap index including reinvested dividends, Federal expenditure, unemployment rate, real growth of M1, treasury bill rate, inflation, GDP growth, GDP deflator and traded weighted dollar index of U.S. from Q1, 1975 to Q4, 2019. The return of Wilshire 5000 index, real growth of M1, inflation and GDP growth are calculated by continuous compounded formula. I used return of Wilshire 5000 index as stock returns, GDP as output measurement.

3.2 Separation of Expected and Unexpected Inflation

The following method of separating expected and unexpected inflation from actual inflation can be seen in Fama (1981). Let us start with Fisher's equation:

$$i_t = r_t^e + \pi_t^e \tag{3}$$

where i_t is the nominal interest rate (in our case, treasury bill rate), r_t is the real interest rate (the superscript of e stands for expectation) and π_t^e is the expected inflation for next period. This equation can be rewritten as

$$r_{t-1}^e = i_{t-1} - \pi_t + \eta_t \tag{4}$$

where η_t is the unexpected error. The assumption is that $i_{t-1} - \pi_t$ follows *random walk*. This is supported by Dickey-Fuller test (see Dickey and Fuller (1981)) I implemented. The Dickey-Fuller test without intercept yields the p-value of 0.214, indicating that we cannot reject random walk model. Define $i_{t-1} - \pi_t$ as z_t and run

$$z_t = \rho z_{t-1} + \eta_t \tag{5}$$

Estimation of the residuals of equation (5) yields the fitted value of $\widehat{z_t}$, and the expected inflation is

$$\pi_t^{ex} \equiv i_t - \widehat{z_t} \tag{6}$$

So, the unexpected inflation is

$$\pi_t^{ue} \equiv \pi_t - \pi_t^{ex} \tag{7}$$

Figure 1 demonstrates the data and the results.

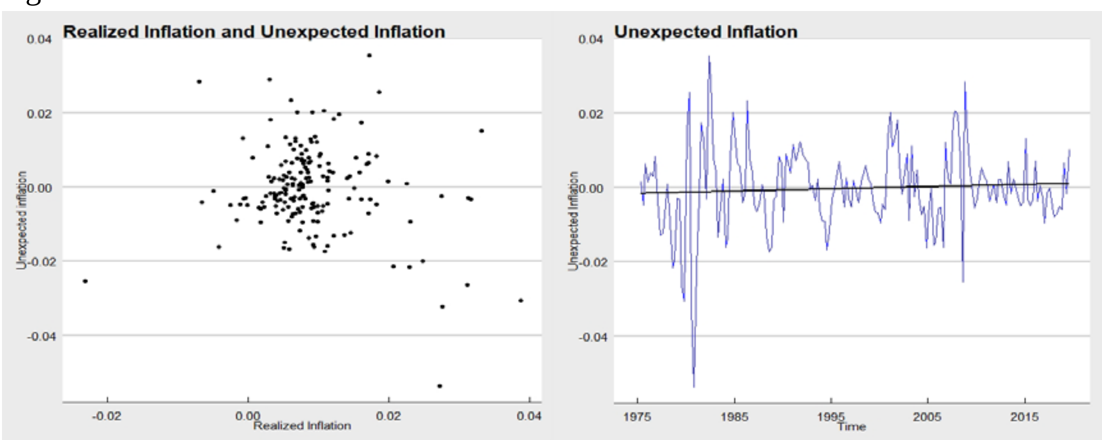


Figure 1: Unexpected inflation

From figure 1 we can observe that there is no obvious correlation between actual inflation and unexpected inflation, and between time and unexpected inflation. That is, it is convincing that the expected inflation capture “predictable” part of inflation as the unexpected inflation is random enough.

3.2 Separation of Expected and Unexpected Money Supply

Barro and Rush (1980) and Barro (1977) proposed a model that can form expectation of money supply and demonstrate it with M1 annually and quarterly data. The model for quarterly data is shown as follow.

$$DM_t = \alpha_0 + \sum_{i=1}^{6} \alpha_i DM_{t-i} + \sum_{i=1}^{3} \alpha_{i+6} ln(U/1-U)_{t-i} + \alpha_{10} FEDV_t + e_t \tag{8}$$

where $DM_t = ln\,M_t - ln\,M_{t-1}$, M_t is M1 money supply, U is the unemployment rate, $FEDV_t$ is described as “real federal expenditure relative to normal”, and e_t is the residuals. To be more specific, $FEDV_t$ is defined as fallows.

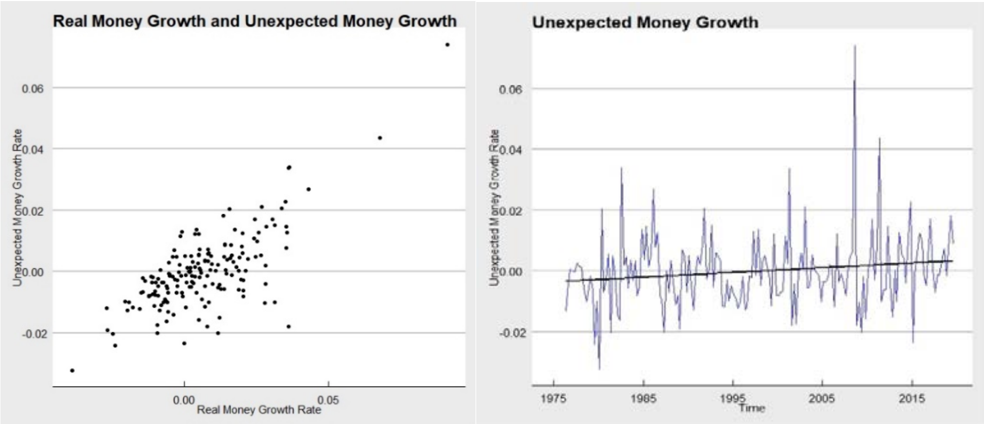
$$FEDV_t = ln\,FED_t - [ln\,FED]_t^e \tag{9}$$

where FED_t is the total federal expenditure divided by GNP deflator. One difference between Barro and Rush’s (1980) method and mine is that I implemented GDP deflator instead of GNP deflator. The reason is that I consider GDP better capture the “domestic” output of U.S. than GNP.

The expectation of $ln\,FED_t$, $[ln\,FED]_t^e$ is obtained from *adaptive expectation model*. A model[3] is designed as

$$[ln\,FED]_t^e = 0.2\,ln\,FED_t + 0.8[ln\,FED]_{t-1}^e \tag{10}$$

At $t = 1$, I assume that investors formed precise expectation. Now equation (8) can be fitted. The fitted values of DM_t with equation (8) is the expected money supply growth in time t. Figure 2 demonstrate the result of this model.



[3] The coefficient 0.2 is obtained by *maximum likelihood* in Barro (1977). Barro (1977) tested post-war data of U.S. and assign the coefficient.

Figure 2: Unexpected money growth

Figure 2 shows some interesting observations. First, we can see that the unexpected money growth rate is positively correlated with the actual money growth. This implicitly implies that the investors tend to form lower expectation of money. Furthermore, the extreme peak of unexpected money growth throughout time is at Q4, 2008. This shows that it is reasonable for us to consider the structural break at that time is exogenous. The R-squared of fitting equation (8) is 0.4753, implying that the expectations are effective over time.

3.3 Chow Test

Chow (1960) proposed a method to test the equality of coefficients in two same model using two different sets of data. The method is known as "Chow test". In fact, Chow test can be a joint F-test utilizing dummy variables. Suppose there is a suspicious structural break τ in the data, and we would like to test the equality the coefficients of two models.

$$y_t = \beta_0 + \sum_{i=1}^{k} \beta_i x_{t,i} + u_t \; \forall t < \tau \tag{11}$$

$$y_t = \beta_0{}' + \sum_{i=1}^{k} \beta_i{}' x_{t,i} + u_t{}' \;\; \forall t \geq \tau \tag{12}$$

That is, we would like to test that $\beta_j = \beta_j' \; \forall j \in \{0,1,2, \ldots k\}$. To test this null hypothesis, consider the following model for all t.

$$y_t = \alpha_0 + \sum_{i=1}^{k} \alpha_i x_{t,i} + \gamma_0 D_t(\tau) + \sum_{i=0}^{k} \gamma_i \left[D_t(\tau) \times x_{t,i} \right] + e_t \tag{13}$$

The dummy variable $D_t(\tau)$ is defined as

$$D_t(\tau) = \begin{cases} 0, & if \; t < \tau \\ 1, & if \; t \geq \tau \end{cases} \tag{14}$$

The F-statistic of Chow test is the joint F-statistic testing the null hypothesis of $\gamma_0 = \gamma_1 = \cdots = \gamma_k = 0$. So, the statistic is

$$F = \frac{(SSR^r - SSR^{ur})/(k+1)}{SSR^{ur}/(T - 2k - 2)} \tag{15}$$

where SSR^r is the sum of squared residuals of the restricted model, while SSR^{ur} is the sum of squared residuals of the unrestricted model. Chow test is widely implemented in testing structural change in time-series data.

2.4 Models Design

There are two dependent variables that I put into the models: real stock returns and risk premium. Stock returns are measured by Wilshire 5000 total market full cap index, and risk premium is measured by stock returns minus treasury bill rate. Let us define the following variables: R_t is the stock returns, $EXDM_t$ is the expected money growth, RP_t is the risk premium, $UNEXDM_t$ is the unexpected money growth, $EXINF_t$ is the expected inflation, $UNEXINF_t$ is the unexpected inflation, $DGDP_t$ is the real GDP growth, DDI_t is the growth of traded weighted dollar index, $\tau = Q4{,}2008$ is the structural break, and $D_t(\tau)$ is the dummy variable described as section 3.3. My first model is

$$R_t = \beta_0 + \beta_1 EXDM_t + \beta_2 UNEXDM_t + \beta_3 EXINF_t + \beta_4 UNEXINF_t$$

$$+\beta_5 DGDP_t + \sum_{i=0}^{2} \beta_{i+6} DDI_{t-i} + u_t \qquad \text{(mod1)}$$

The reason why I set the lag term of 2 in DDI_t is from the result of Chen, Chiu, Tsai, Wang and Tsai (2021). However, this model shows no significance in β_6, β_7 and β_8. Hence, I did not involve DDI_t in the later models for R_t. The second model is actually the same as model 1 but without DDI_t.

$$R_t = \beta_0 + \beta_1 EXDM_t + \beta_2 UNEXDM_t + \beta_3 EXINF_t + \beta_4 UNEXINF_t + \beta_5 DGDP_t + u_t \qquad \text{(mod2)}$$

Then, I ran the model without DDI_t before and after the structural break.

$$R_t = \beta_0 + \beta_1 EXDM_t + \beta_2 UNEXDM_t + \beta_3 EXINF_t + \beta_4 UNEXINF_t + \beta_5 DGDP_t + u_t \ \ \forall t < \tau \qquad \text{(mod3)}$$

$$R_t = \beta_0{'} + \beta_1{'} EXDM_t + \beta_2{'} UNEXDM_t + \beta_3{'} EXINF_t + \beta_4{'} UNEXINF_t + \beta_5{'} DGDP_t + u_t \ \ \forall t \geq \tau \qquad \text{(mod4)}$$

Until now, a chow test can be conducted on mod3 and mod4. That is, we can check the null hypothesis of $\beta_j = \beta_j{'} \ \forall j \in \{0,1,2,\ldots,5\}$. The significance of Chow test indicates the presence of structural change occurring along with unconventional monetary policy.

Later, I designed a series of models that test on any structural change in $\beta_1, \beta_2, \beta_3$ and β_4 individually. To introduce the concept, suppose that I would like to test the structural change on $EXDM_t$. Viewing the other independent variables as control variables, consider the model

$$R_t = \beta_0 + \beta_1 EXDM_t + \beta_2 UNEXDM_t + \beta_3 EXINF_t + \beta_4 UNEXINF_t + \beta_5 DGDP_t + \gamma_0 D_t(\tau) + \gamma_1 [D_t(\tau) \times EXDM_t] + u_t \qquad (16)$$

The joint F-test testing $\gamma_0 = \gamma_1 = 0$ can be implemented. The rejection of null hypothesis implies structural change on the effect that $EXDM_t$ has on R_t. The same method can be implemented for testing the effects of β_2, β_3 and β_4.

I implemented all of the models above with dependent variable switching from R_t to RP_t.

$$RP_t = \beta_0 + \beta_1 EXDM_t + \beta_2 UNEXDM_t + \beta_3 EXINF_t + \beta_4 UNEXINF_t + \beta_5 DGDP_t + \sum_{i=0}^{2} \beta_{i+6} DDI_{t-i} + u_t \qquad \text{(mod5)}$$

Same as mod1, mod7 shows no significance in β_6, β_7 and β_8. The following models are basically the same as above.

$$RP_t = \beta_0 + \beta_1 EXDM_t + \beta_2 UNEXDM_t + \beta_3 EXINF_t + \beta_4 UNEXINF_t + \beta_5 DGDP_t + u_t \qquad \text{(mod6)}$$

$$RP_t = \beta_0 + \beta_1 EXDM_t + \beta_2 UNEXDM_t + \beta_3 EXINF_t + \beta_4 UNEXINF_t + \beta_5 DGDP_t + u_t \ \ \forall t < \tau \qquad \text{(mod7)}$$

$$RP_t = \beta_0' + \beta_1' EXDM_t + \beta_2' UNEXDM_t + \beta_3' EXINF_t + \beta_4' UNEXINF_t + \beta_5{}' DGDP_t + u_t \ \ \forall t \geq \tau \qquad \text{(mod8)}$$

A Chow test for mod7 and mod8 can be implemented, and the same method mentioned before can test the structural change on $\beta_1, \beta_2, \beta_3$ and β_4 respectively.

Finally, my last model test on the effect that investors' expectation of future earnings to future output. The model is designed as

$$DGDP_t = \beta_0 + \beta_1 R_{t-1} + \beta_2 R_{t-2} + \beta_3 R_{t-3} + \beta_4 EXDM_t + \beta_5 UNEXDM_t + \beta_6 EXINF_t + \beta_7 UNEXINF_t \qquad \text{(mod9)}$$

$$DGDP_t = \beta_0 + \beta_1 RP_{t-1} + \beta_2 RP_{t-2} + \beta_3 RP_{t-3} + \beta_4 EXDM_t + \beta_5 UNEXDM_t + \beta_6 EXINF_t + \beta_7 UNEXINF_t \qquad \text{(mod10)}$$

These two models shall allow us to see whether the investors make good expectation of future output throughout the time. All of the models and chow test should be adjusted by Newey-West standard errors (see Newey and West (1987)) to avoid potential heteroskedasticity and autocorrelation issues.

4. Result

In this section I present the statistical results. The estimations of mod1~10 are shown in the following table 1.

Table1: Statistical results of mod1~mod10

Model	R^2	$\widehat{\beta_0}$	$\widehat{\beta_1}$	$\widehat{\beta_2}$	$\widehat{\beta_3}$	$\widehat{\beta_4}$	$\widehat{\beta_5}$	$\widehat{\beta_6}$	$\widehat{\beta_7}$	$\widehat{\beta_8}$
mod1	0.0779	0.0030 (0.0160)	0.0838 (0.3483)	−0.2140 (0.6250)	−0.2103 (0.8551)	0.6190 (0.9381)	2.5378 ∗ (1.0715)	−0.2658 (0.2786)	−0.1925 (0.1933)	0.0292 (0.2353)
mod2	0.0763	−6.01e-5 (1.69e-2)	0.1660 (0.4427)	−0.1862 (0.6643)	−0.0617 (0.8459)	0.8517 (1.0435)	2.6995 ∗ (1.1521)	–	–	–

mod3	0.0588	0.0171 (0.0175)	0.0852 (0.6616)	1.1403. (0.6374)	−0.8264 (1.0841)	−0.7831 (1.2983)	1.3273. (0.7918)	–	–	–
mod4	0.5728	−0.0113 (0.0268)	0.1295 (1.0834)	−0.8683 (0.9145)	5.2071 * (2.1198)	5.5586 ** (1.7218)	3.2554 (1.9625)	–	–	–
mod5	0.1677	−0.0179 (0.0154)	0.6049 (0.4965)	−0.4143 (0.5929)	−2.113 * (0.9619)	−1.0300 (1.1855)	2.3452. (1.2153)	−0.4610 (0.3248)	−0.2908 (0.2417)	−0.1479 (0.2424)
mod6	0.1368	−0.0240 (0.0169)	0.7598 (0.5034)	−0.3544 (0.6001)	−1.8269. (1.0074)	−0.6598 (1.3799)	2.6725. (1.3887)	–	–	–
mod7	0.1441	−0.0170 (0.0152)	−0.0835 (0.6147)	0.8123 (0.5306)	−2.327 * (1.0946)	1.7539 (1.2419)	1.6211 (1.0536)	–	–	–
mod8	0.6033	−0.0273 (0.0201)	0.6704 (0.7781)	−0.7277 (0.6412)	6.1503 ** (1.7389)	6.421 *** (1.7061)	3.6983 * (1.6813)	–	–	–
mod9	0.1622	0.006 *** (0.0012)	0.031 *** (0.0087)	0.0131 (0.0076)	0.0130 (0.0073)	−8.20e − 5 (3.86e − 2)	−0.0677 (0.0652)	−0.0159 (0.1316)	−0.1333 (0.1575)	–
mod10	0.1294	0.007 *** (0.0010)	0.0245 ** (0.0089)	0.0098 (0.0067)	0.0055 (0.0072)	−0.0320 (0.0475)	−0.0655 (0.0652)	0.0545 (0.1365)	−0.0545 (0.1647)	–

The parentheses show the corresponding Newey-West standard error of the estimator. The reported R-squared are adjusted R-squared. Significance code: '***': 0.001, '**': 0.01, '*': 0.05, '.': 0.1

From table 1 we can tell a few stories. The huge differences in R^2 between mod3 and mod4, as well as mod7 and mod8 imply that the explanatory capability of my models is higher when fitting post-2008 data. This is an evidence that the effect of Fed's decision-making has on the stock markets have enhanced with unconventional monetary policies. After the global financial crisis, Fed has more "power" to intervene the equity markets. The models also tell that stock returns reflect inflation more rather than fluctuation in money supply. Focus on the effects of inflation, stock returns tend to reflect unexpected inflation more than its expected counterpart. This observation supports the belief that stock returns are adjustment to inflation.

Chow tests between mod3 and mod4, as well as mod7 and mod8 are presented in table 2. The rejection of the null hypothesis of both of the tests show that the market did undergo structural changes at Q4, 2008. The implementation of unconventional monetary do change the equity markets.

Table 2: Chow test

Models	F-statistic	p-value
mod3 and mod4	5.3359/16.439	$4.7461e-5$ ***/$9.4871e-15$ ***
mod7 and mod8	9.7442/22.826	$3.7024e-9$ ***/$< 2.2e-16$ ***

Before slash are the statistics and p-values with no Newey-West adjustment. After slash are the numbers that are adjusted by Newey-West standard errors. Significance code: '∗∗∗': 0.001, '∗∗': 0.01, '∗': 0.05, '.': 0.1

Table 3. Analysis of structural change for mod3 and mod4

Coefficients	mod3	mod4	Difference	F-statistic	p-value
$\widehat{\beta_1}$	0.0852 (0.6616)	0.1295 (1.0834)	0.0443	0.7919	0.4547
$\widehat{\beta_2}$	1.1403. (0.6374)	−0.8683 (0.9145)	−2.0086	8.0796	0.0004 ∗∗∗
$\widehat{\beta_3}$	−0.8264 (1.0841)	5.2071 ∗ (2.1198)	6.0335	2.3033	0.1031
$\widehat{\beta_4}$	−0.7831 (1.2983)	5.5586 ∗∗ (1.7218)	6.3417	9.9679	8.162e − 5 ∗∗∗

The parentheses show the corresponding Newey-West standard error of the estimator. Significance code: '∗∗∗': 0.001, '∗∗': 0.01, '∗': 0.05, '.': 0.1

Table 4. Analysis of structural change for mod7 and mod8

Coefficients	mod7	mod8	Difference	F-statistic	p-value
$\widehat{\beta_1}$	−0.0835 (0.6147)	0.6704 (0.7781)	0.7539	8.3946	0.0003 ∗∗∗
$\widehat{\beta_2}$	0.8123 (0.5306)	−0.7277 (0.6412)	−1.5400	13.776	2.917e − 6 ∗∗∗
$\widehat{\beta_3}$	−2.327 ∗ (1.0946)	6.1503 ∗∗ (1.7389)	8.4773	8.2392	0.0004 ∗∗∗
$\widehat{\beta_4}$	1.7539 (1.2419)	6.421 ∗∗∗ (1.7061)	4.6671	19.559	2.359e − 8 ∗∗∗

The parentheses show the corresponding Newey-West standard error of the estimator. Significance code: '∗∗∗': 0.001, '∗∗': 0.01, '∗': 0.05, '.': 0.1

Table 3 and table 4 analyze the structure change of each coefficient. In the return's case, one can observe that the structural changes happen mainly on the effect of unexpected factors. On the other hand, in the risk premium's case, structure changes are for all of the factors, whether the factor is expected or not. Interestingly, there are some effects being reversed ($\widehat{\beta_2}$, $\widehat{\beta_3}$, $\widehat{\beta_4}$ in mod3 and mod4, and $\widehat{\beta_1}$, $\widehat{\beta_2}$, $\widehat{\beta_3}$ in mod7 and mod8). The return's case tells little story, though, for none of the coefficient in mod3 is statistically significant. However, the risk premium's case shows that the $\widehat{\beta_3}$ is reversed significantly. I suspect this is because that the high inflation comes with expansionary monetary policy, and aggressive expansionary monetary policy is usually the respond of recession. In recession, risk premiums of risky assets such as equity rise. The response is quick enough that the quarterly data fails to capture it. Hence, there is a reversed effect on the relation between expected inflation and risk premium.

Lastly, I visualize the structural changes of each coefficient on figure 3~6. Notice that since the models are multi-variable regressions, the fitted line in the figure only demonstrate the slope of single effect. The line are not the actual fitted model.

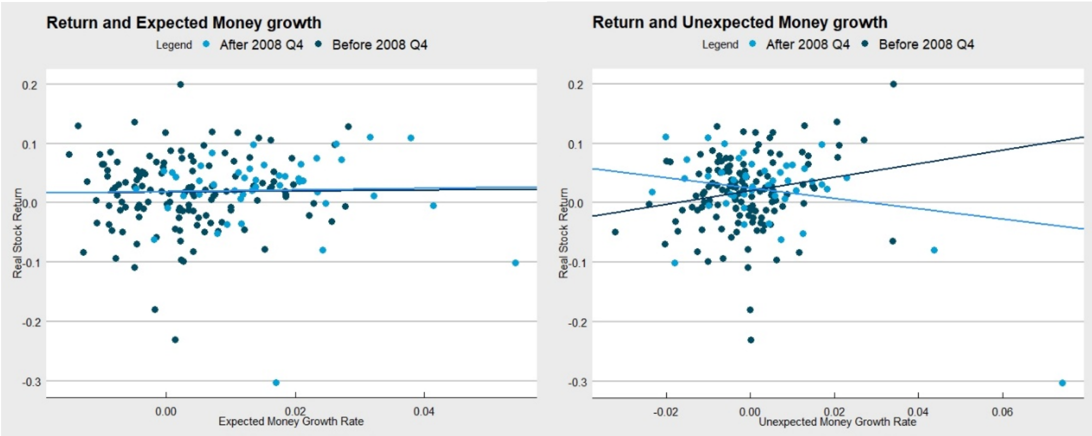


Figure 3: Return and money growth

Figure 4: Return and inflation

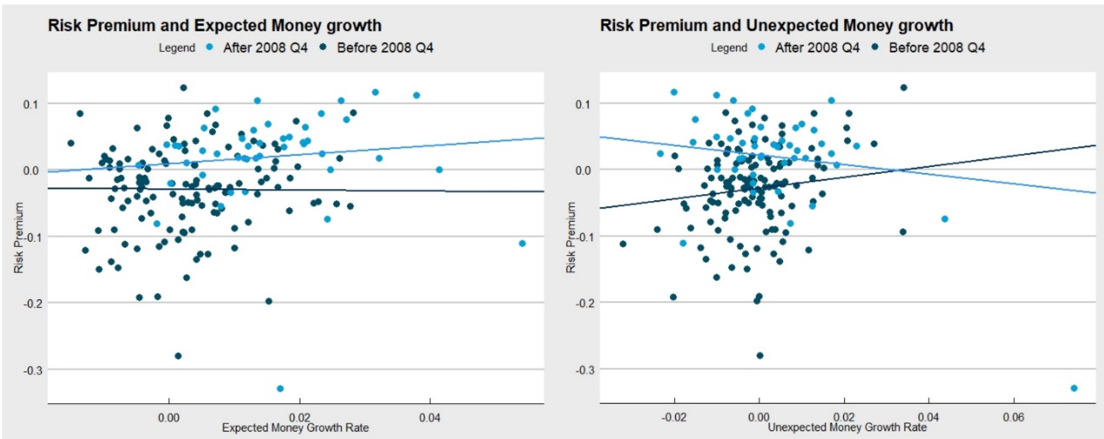


Figure 5: Risk premium and money growth

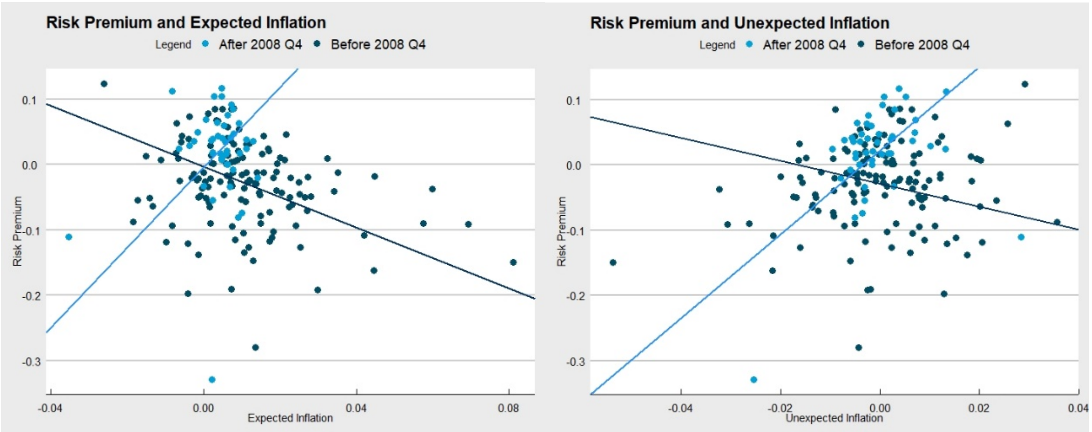


Figure 6: Risk premium and inflation

From the figures one may notice that both of the volatilities of expected inflation and the unexpected inflation decrease after the structural break. This shows that after the financial crisis, Fed successfully control the expectation of inflation. The main difference, again, is the effect of inflation has on stock returns and risk premiums.

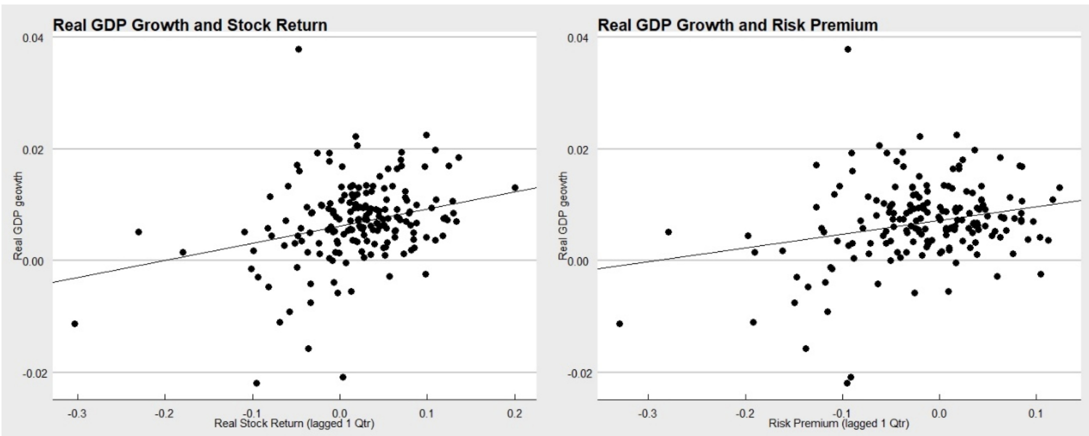


Figure 7: Prediction of GDP growth

The correlations between GDP growth and stock returns, as well as risk premiums, are shown in figure 7. One can see that return and risk premium can effectively predict future output. This implies that stock returns reflect expectation of future output. However, since the R^2 of mod9 and mod10 are low, the investors' expectation seem to be imprecise.

5. Conclusion

In this article I have tested the structural break happened at Q4, 2008, when Fed started to implement unconventional monetary policy to stimulate the U.S. economy. The main discovery of this article is that the effect inflation has on stock returns and risk premiums are significantly reversed at the break point. A possible explanation is that of classical view. Equities, or claims for future real output, are good hedge to high inflation. Another possible explanation relies on the coincidence of recession and expansionary monetary policy, though this explanation implicitly raises endogeneity issues to my models. My research also finds out that the macroeconomic factors' explanation ability to stock returns and risk premiums rises hugely after the structural break, implying Fed is more powerful to affect equity markets than before. This is an uplifting result since this implies that unconventional monetary policy does help in the recession. Lastly, I found that stock returns and risk premiums can be utilized to predict future outputs, confirming the general belief that stocks are the expectation of future earnings, thus the expectation of future output. Nevertheless, the explanation abilities of the models are weak, indicating that output not only reflect to past stock returns but also other factors. Or, simply, the investors' expectation over time is imprecise. Perhaps, the most important conclusion of this article is that the investors change their ways to form the demanded compensation of risk after Q4, 2008.

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