Monetary Policy Surprises and the Response of Asset Prices

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ABSTRACT

As an important monetary policy transmission channel, the financial markets behavior around interest rate decision of the Federal Reserve of U.S. have been widely discussed by people in academia and industrial world. This paper uses an event study of macroeconomics to exam the casual relationship of the monetary policy shock on asset prices. We find that treasury bills, exchange rates of developed countries are significantly influenced by the unexpected component of the monetary policy in U.S. from 1989 to 2008. In addition, emerging market exchange rates respond weakly to the policy surprise. We also pointed out that international equity markets and commodities prices are not sensitive to the rate decision of the Federal Reserve Bank in our sample of studies. The pre and post FOMC meeting day's Treasury bill yields are also respond to the anticipated and unanticipated of the rate decisions. We also show that the unexpected monetary policy in U.S. has significant 5-day post-meeting impacts on almost all asset classes.

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I. Introduction

The interest rates decisions of central banks are very important events in financial markets. Financial asset prices movement after monetary policy is especially interested for monetary policy makers, since financial markets are the reflection of real economies. Bernanke and Kuttner (2005) once pointed out that financial markets are the immediate and direct transmission channel that links the monetary policy and real economic activities. Monetary authority, like central banks, makes monetary policy, first directs the financial market through implementation and expectation, and then influences the real economic activities, such as output, unemployment rate, and the price of goods and service. Because financial asset prices are part of the price equilibrium through investment and financing behaviors, therefore, the study of asset prices' response to monetary policy is very important in understanding this transmission mechanism from central banks' monetary policy to the real economy. Furthermore, private sector's market participants, such as traders and portfolio managers from financial institutions, are focused on how asset prices could response before and after the announcement or the implementation of the monetary policy, in order to make better borrowing, lending and investment decisions.

Monetary policy has been demonstrated to have both direct and indirect impacts on almost all asset classes through the adjustment of short term nominal interest rates, since nominal interest rates are key variables in asset pricing and portfolio choice. The implementation of monetary policies, such as trading on treasury and federal agency securities, have direct influence on the asset prices' behavior. In U.S., The trading is implemented by the Federal Reserve Bank of New York through primary dealers, and then followed by the change of interbank borrowing and lending behavior and the fixed income arbitrage from money market fund and hedge funds. Previous researchers, however, by using event study, have found that monetary policy has indirect influence on asset prices from signaling of market expectation that the central bank will implement the monetary policy in the future periods. In an international finance framework, due to the arbitrage between two countries[1], freely traded floating exchange rates' movement are partly driven by interest rate differentials. This theoretical relationship can be derived from the famous uncovered in-

[1]International fixed income arbitrage can be illustrated as a carry trade behavior. The international investors borrow money from low interest countries and lending them into high interest rate countries, and gaining interest rate differential and exchange rate appreciation. Usually, U.S. interbank market is an important place for financing and investing, because U.S. dollar is the most popular currency asset in the money market. In addition, the interest rate of U.S. dollar is low, it is usually used to fund the hedge fund investing as a leverage liquidity. Third, the carry trade between Japan and U.S. is profitable in some period of time, thus, the trading activity between U.S. and Japan is very sensitive to the slight monetary policy between those two countries. About carry trading, please read Burnside (2011), Daniel, Hodrick, and Lu (2014) and Jiang (2016)

terest rate parity (UIP) hypothesis where it predicts that high interest currency should depreciate against the low interest rate currency, because profits should be arbitraged away to zero[2].

This paper quantifies the market expectation of the monetary policy. By modeling the price data of forward looking Fed Fund Futures rate (FFR) which is traded at the Chicago Mercantile Exchange (CME), this paper decomposed the Federal Reserve Bank's rate decision into the unexpected and expected components. Previous researchers have found that only the unexpected market news could impact the asset prices, because financial markets can assimilate financial information and learn to be at their "efficient" and "fair" value level immediately, from price competing of large number of market participants in a centralized secondary electronic markets[3]. This paper tries to answer the critical question of whether the U.S. monetary policy has impacts on U.S. treasury rate (Term Structure), U.S. equity prices, U.S. dollar exchange rate, especially the emerging market exchange rates, and whether the change in the target fed fund rate has spillover effect on international equity markets and commodities prices.

This paper is arranged by the following theme: Section (I) gives the introduction; Section (II) discusses the communication between FOMC of Federal Reserve Bank and market participants; Section (III) briefly investigates the previous related literatures; Section (IV) models the front month Fed Fund Futures contract to separate the monetary policy into expected and unexpected parts; Section (V) summarizes the empirical data sets; Section (VI) discusses the results of the regression models that whether the asset prices respond to the monetary policy surprises in an one day event study window by using GARCH(1,1); Section (VII) models the event windows in 11 days, and studies the response in 11 event days, to know the drift effect of asset prices with respect to the change of monetary policy; Section (VIII) gives the conclusion of the empirical findings of this paper.

II. Evolution of Central Bank Communication

Before February 1994, there was no public announcement from the Federal Open Market Committee (FOMC) regarding the Fed Fund Target Rate after that meeting. The financial markets behavior is based

[2]Regression work of UIP test and the theoretical argument, please read Chinn (2006) and Lothian and Wu (2011). UIP hypothesis is based on the non-arbitrage argument, which is consistent with the efficient market hypothesis and economics theory

[3]The liquidity in the secondary markets are usually very good and efficient price discovery could be realized by trading activities.

on the private sector's observation of the Open Market Operation[4] which is executed by the trading desk of the Federal Reserve Bank of New York. As transparency has increased, the unexpected part of the monetary policy has been reduced to a lower level, but not to a near zero level, because part of the role of the monetary policy is to sustain financial stability. The monetary authority reacted to outside economic random shocks, such as the spike and the drop of asset prices and financial crisis. Because the bubble and crisis are hard to predict, it is reasonable to expect that unexpected monetary policy will still reappear in the future, although the transparency between Fed and the public has been improved a lot by post-meeting announcements and the FOMC minutes. Our study is still meaningful in revealing the economic behavior based on market expectation and efficiency. Table 2 lists the historic rate decision by the Federal Reserve from 1989 to 2008, which covers the period of monetary policy mystique (2/24/1989 to 9/4/1992), the period of Alan Greenspan lead policy reaction to the dot-com equity price bubble (11/16/1999 to 5/16/2000), and the period of the sub-prime mortgage crisis (9/18/2007 to 12/16/2008). Figure 1 presents the graph for the evolution of the Fed Fund Target Rate and Figure 2 displays the distribution of rate decision across different time period. Figure 3 shows the size of the unexpected component of the policy where we could observe that there were more unexpected rate decisions in the hidden period before 1994. We also could observe that there were less but bigger size during the 2000 bubble and 2007-08 financial crisis periods. The announcement of the quantitative easing in U.K. and U.S. have been found to be significant in impacting domestic and international financial markets,which is argued by Joyce, Lasaosa, Stevens, Tong, et al. (2011); Glick and Leduc (2012); Wright (2012); Swanson and Williams (2014) and Fawley and Neely (2014). The direct measure and discussion in industrial world is more trivial and more popular.

III. Literature Review

A large amount of papers examined the relationship between market nominal term structure of interest rates and monetary policy surprises. Since short term interest rates are considered to be the first transmission channel[5] of monetary policy, a lot of researchers studied the nominal interest rates' reaction to

[4]For more research about the transparency of monetary policy, please read: Goodfriend (1986), Yellen et al. (2012) and Wynne et al. (2013)

[5]Also the most important channel, more information, please read Federal Reserve Bank of New York's research on monetary policy transmission on real economy: the Federal reserve bank trade the treasury and federal agent securities market by open market operations, in order to change and influence the fed fund rate in to the target level (policy rate). Fed fund rate is the overnight inter-bank lending rate from one financial institution to another similar financial institution, it's change and controlling by federal reserve can impact other short term interest rate and long term interest rate further. Market interest

monetary policy expectation and implementation, spans from short term to long term, short horizon to long horizons. In addition, the story of Taylor rule tells us that the central bank mainly targeted short-term nominal interest rate in order to control the inflation rate and growth rate of an economy. However, the previous results are mixed. Dwyer Jr and Hafer (1989) tested the unanticipated part of economic data releasing and its impact on nominal interest rate which are implied from mid-term and long term government bonds. They found that releasing of official government statistics has varied impacts on nominal bond interest rate over time by running rolling regression. Other people's findings are also fruitful. Cook and Hahn (1989) found that Fed fund target rate increases are positively related to the T-bill rate (55 bps) and 30 years bond yield (10 bps). Edelberg, Marshall, et al. (1996) found a large, highly significant response of bill rates to policy shocks, but only a small, marginal significant response of bond rates. Kuttner (2001) used the Fed fund futures to gauge the size of the monetary policy and separated it into the expected and unexpected part. He found that short term interest rate only responds to the unexpected change of fed fund rate, but not to the expected change of target rate. Furthermore, long term interest rate is less sensitive to the short term policy changes.

By studying the money markets of Australia, New Zealand, Canada, and UK, Kearns, Manners, et al. (2005) found that an unanticipated tightening of 25 basis points policy rate in Australia is associated with exchange rate appreciation of 0.35 percent. Pagano, Lombardi, and Anzuini (2010) found that expansionary U.S. monetary policy shocks drove up the commodity price index and all of its index's components. Hypothetical unanticipated 100 basis points hike in the federal funds target rate is associated with roughly an 3 percent decrease in West Texas Intermediate oil prices, which was been figured out by Rosa (2013). Jansen and Zervou (2015) found that increases in one percentage point surprise of federal fund rate decreases the one day stock return by 1.33 percent during the period of 1989 to 2000, and by 7.47 percent during the period 2001 to 2007, so the effect is varied over different time periods. Bernanke and Kuttner (2005) found that a hypothetical unanticipated 25 basis points cut in the federal fund rates target is associated with about one percent increase in broad stock indexes. In addition, the unanticipated monetary policy actions on expected excess returns accounted for the largest part of the response of stock prices. Fawley and Neely (2014) investigated the related research in recent years and gave the summary to those empirical findings.

rate thereby can direct the trader's behavior by arbitrage on financial assets, such as stock market, exchange rate, corporate bonds and other assets, and the change of asset prices can therefore influence the consuer behaviors and real business practice, and finally, impact the aggregate demand of the whole macro-economy. Other tools, such as the change of monetary base, loan supply also have been discussed. Kuttner, Mosser, et al. (2002) gives similar discussion too.

IV. The Model: Quantitative Measure of Monetary Policy

From the point of view of the efficient market hypothesis (EMH) by Malkiel and Fama (1970), asset prices only respond to the unanticipated part of the economic information, since the financial markets are forward looking and exhibit future equilibrium. Due to the fact that private entities are majority forces of financial market, the group decisions of buying and selling assets in a centralized market can improve the market efficiency and help to discover fair value of the asset prices. Private sectors look at the positive and negative news of the economy and decide to buy or sell securities by their own judgement. Measuring the market expectation can be done by reading the news and comparing the pre and post-event news, but quantifying the expectation is not an easy task, since most of the expectation is reflected from the market news. Kuttner (2001) pioneered a tool to quantify the size of the monetary policy shock by using the Federal Fund Rate Futures contract which is an interest rate derivatives traded in Chicago Board of Trade (CBOT). The settlement futures rate is traded by the average of that month's effective fed fund rate, plus a risk premium:

$$FFR^1_{s,t} = E_t \frac{1}{m} \sum_{i=1}^{m} r_i + \rho^1_{s,t} \tag{1}$$

in the equation above, $FFR^1_{s,t}$ denotes the yield of the first federal fund futures contract[6] at day t of month s, which is equal to the expected average federal fund rate, r_i, from day 1 to day m in that month. We assume that month s has total m days, and $\rho^1_{s,t}$ is the risk premium for the first futures contract. From the past observation of data sets, we can decompose the futures rate further by:

$$FFR^1_{s,t} = \frac{1}{m} \sum_{i=1}^{t} r_i + E_t \frac{1}{m} \sum_{i=t+1}^{m} r_i + \rho^1_{s,t} \tag{2}$$

Then, we have:

$$FFR^1_{s,t} = \frac{t}{m} \bar{r}_{i \leq t} + \frac{m-t}{m} E_t \bar{r}_{i>t} + \rho^1_{s,t} \tag{3}$$

Where $\bar{r}_{i \leq t}$ is the average effective fed fund rate before rate decision day d and $E_t \bar{r}_{i>t}$ is the expected average fed fund rate after rate decision in month s. Kuttner (2001) thinks that the difference in fed future rate in the FOMC rate decision day correctly captures the market difference in expectation before and

[6] We use the 1 at the upper right space to denote the first month futures contacts. FFR stands for Federal Fund Futures Rates, which is calculated by $FFR^1_{s,t} = 100 - Futures\_Prices^1_{s,t}$ in this paper's data transformation processes. We have the data sets of the form like Futures Prices, which is quoted by the 100 - interest rate (%) in Chicago Board of Trade(CBOT).

after the rate decision[7]. Then we could quantify the unexpected rate decision by the following formula:

$$FFR^1_{s,t} - FFR^1_{s,t-1} \approx \frac{m-t}{m}\Delta FFR_t^{unexpected} \tag{4}$$

Consequently, the unexpected part of the fed fund rate decision cound be computed by:

$$\Delta FFR_t^{unexpected} = \frac{m}{m-t}(FFR^1_{s,t} - FFR^1_{s,t-1}) \tag{5}$$

One concerning about using the difference of the event day's closing price to measure the unexpected part of the rate decision is that other data releases and information shock could contaminate the event day federal fund futures price behaviors. However, most of the data releases and fundamental changes have been reflected in the future monetary policy behavior. Over the very short horizons, monetary policy is the major driven force of the short-term interest rate, thus we do not need to worry about other informational shocks.

Once we have computed the unexpected component of the rate decision, then we can compute the expected component of the rate decision by subtracting the unexpected component from the actual rate decision. The variables have the following relationships:

$$\Delta FFR_t^{expected} = \Delta FFR_t - \Delta FFR_t^{unexpected} \tag{6}$$

One day response is usually enough to detect the surprising effect, since the asset prices after event day could be easily contaminated by other information, but we will examine the effect in the last section by extending our regression framework into more event days[8]. In this paper, we add a GARCH(1,1) process to detect the relationship between monetary policy and asset prices response in event days. The estimation of the monetary policy on asset prices can be written as the following function:

$$R_t = \gamma_0 + \gamma_1 \Delta FFR_t^{expected} + \gamma_2 \Delta FFR_t^{unexpected} + \epsilon_t \tag{7}$$

[7]The quantitative measure of the change of the FFR in two different day is:

$$\begin{aligned} FFR^1_{s,t} - FFR^1_{s,t-1} &= \frac{t}{m}\bar{r}_{i\leq t} + \frac{m-t}{m}E_t\bar{r}_{i>t} + \rho^1_{s,t} - \frac{t-1}{m}\bar{r}_{i\leq t-1} - \frac{m-(t-1)}{m}E_{t-1}\bar{r}_{i>t-1} - \rho^1_{s,t-1} \\ &= \frac{t-1}{m}\bar{r}_{i\leq t-1} + \frac{1}{m}r_{i=t-1} + \frac{m-t}{m}E_t\bar{r}_{i>t} + \rho^1_{s,t} - \frac{t-1}{m}\bar{r}_{i\leq t-1} - \frac{m-t}{m}E_{t-1}\tilde{r}_{i>t} - \frac{1}{m}r_{i=t-1} - \rho^1_{s,t-1} \\ &\approx \frac{m-t}{m}\Delta FFR_t^{unexpected} \end{aligned}$$

Finally, we have the approximate difference in expectation on target federal fund rate: $\Delta FFR_t^{unexpected} = E_t\bar{r}_{i>t} - E_{t-1}\tilde{r}_{i>t}$.

[8]In addition, direct observation of trading behaviors supports the argument that most of the unexpected announcement can drive the asset prices in that day, but it also disappears very fast.

while we assume different variance across time period that:

$$\epsilon_t|\epsilon_{t-1}, \epsilon_{t-2}, \epsilon_{t-3}, ... \sim N(0, u_t^2) \tag{8}$$

where

$$u_t^2 = \beta_0 + \beta_1 \epsilon_{t-1}^2 + \beta_2 u_{t-1}^2 \tag{9}$$

In the equation above, $R_t \approx log(P_t) - log(P_{t-1})$ denote the return of asset prices in the event date t compares to the previous date $t-1$. P_t is the asset prices at day t and P_{t-1} is the asset prices at day $t-1$, which is the closing price before interest rate decision date. γ_0, γ_1 and γ_2 denote the regression coefficients for equation (7), they are the reflection of the size of the monetary policy effect. We assume that the error term ϵ_t is distributed normally, but we relax the assumption that it is independent and identically distributed (IID). Thus, in this paper, a GARCH(1,1) model, which is introduced by Bollerslev (1986), based on the pioneering work of Engle (1982) on ARCH, has been employed to estimate the process of variation in variances of the time series regression error term ϵ_t. The GARCH specification is illustrated by the equation (9), while β_0, β_1 and β_2 are the coefficients of maximum likelihood estimation (MLE) based on the GARCH(1,1) processes. ϵ_{t-1}^2 is the squared last period residual estimate, and u_{t-1}^2 is the variances of the error term. We study the event day's response of multiple asset prices to the unexpected and expected part of the monetary policy.

V. The Data Sets

The data sets in this paper are collected mainly through Bloomberg LLC Terminal. We use the first front month price of Fed Fund Futures which are actively traded in the Chicago Board of Trade (CBOT) to gauge the size of the monetary policy shock. The daily time series with closing settlement price spans from February 1989 to December 2008. Given the superiority of the futures market data on predicting policy behavior, we use the possible maximum length of the Fed Fund Futures data from the first listed futures contract in 1989 to the post-crisis unconventional monetary policy period futures data in 2008.

For the asset price's response part, we incorporate different kinds of asset classes in our research, based on the theory of transmission channels' signaling effect. First, we study the response of the term structure of interest rate in U.S. The yield curve is constructed based on the implied nominal interest rate of 3, 6, and 12 months; 2, 5, 10 and the 30 years Treasury securities. The dependent variables are the differences in basis points in the study of Treasury securities. For currencies, we select the group 10 (G-10) exchange rates which are the popular currency pairs in trading volume: U.S. Dollar (USD), EURO (EUR), Pounds

Sterling (GBP), Swiss Franc (CHF), Japanese Yen (JPY), Canadian Dollar (CAD), Australian Dollar (AUD), New Zealand Dollar (NZD), Swedish Krone (SEK), Norwegian Krone (NOK). In addition, 9 Emerging Market free traded currency pairs are added in the study: Brazilian Real (BRL), South African Rand (SAR), Polish Zloty (PLN), Romanian Leu (RON), Indian Rupee (INR), Czech Koruna (CZK), Chilean Peso (CLP), Hungarian Forint (HUF), and Mexican Peso (MXN). Equities Indexes are studied, both for developed and developing countries. We include S&P 500 index as the approximate response of U.S. equity market; Nikkei 225 for Japan; DAX for Germany or Euro Areas; FTSE 100 for United Kingdom; Hang Seng Index which is traded in Hong Kong for Chinese Companies; and IBOVESPA Index for Brazilian Listed Companies. Commodities Prices also have been added, they are Gold Spot Prices and the first contract of WTI Crude Oil Futures in Chicago Mercantile Exchange (CME). Table 1 summarizes the information of financial market data sets. Figure 1 plotted the historical level of the fed fund target rate. The trend is lowering as the time approach the recent period. The federal reserve has circles to adjust the bench market federal fund rate.

VI. Effective and Spillover of the Monetary Policy: Does the Asset Prices Respond to Monetary Policy Shock?

The U.S. Federal Open Market Committee (FOMC) sets the Federal funds rate at a level that can improve the macroeconomic condition that will help to achieve the goal of monetary policies. The Federal Reserve Bank controls the short term overnight Fed Fund rate through open market operation and signaling on market expectations, then the federal fund rate can thereby influence other types of short term interest rate, such as 3 month and 6 month treasury bills, and extend the effect to long term rate, such as treasury notes and bonds, since the long term rate is the traded future short term interest rate. In addition, foreign exchange rates, domestic and international stock market prices, and the commodities prices are the other three classes of asset that the short term target rate can influence further.

A. The Treasury Bill, Notes and Bonds

A.1. The Relationship Between Short Term and Long Term Interest Rate

The long term interest rate is the future period short term interest rate, and is partly determined by the short term rate from the point of view of yield curve arbitrages, since people can borrow in short term and lend in long term, or borrow in long term and lend in short term, and push the yield spread to the equilibrium level. Figure 4 displays the relationship between short term and long term interest rate in U.S. From the graph, we can observe directly that the correlations between each treasury securities are

very high, they move in the same direction from the sample history to the current trading level. Most of the time, the effective overnight federal fund rate is controlled by the Federal Reserve Banks open market operation, while the longer term rate is mainly traded by the private sector market participants. The closely related price pattern for each treasury securities is consistent with the story that the Federal Reserve can impact the short term interest rate and thereby change the long term interest rate.

A.2. Regression Results

Table 4 (Panel A) reports the results of the linear regression equation (7) and GARCH(1,1) regression equation (9) on the expected and unexpected components of the monetary policy. We can conclude that only the unexpected monetary policy could influence the interest rate on treasury securities. Although the 3 month bill and 6 month bill are also sensitive to the expected part of the rate decision, the size is very small, only one fourth of the size of the coefficients from unexpected rate decision. 100 basis points (bps) unexpected cut of federal fund rate in Federal Reserve Bank have lowered down the yield of 3 month bill by 44 bps, 6 month bill by 37 bps, 1 year bill by 33 bps, 2 year notes by 31 bps, 5 year note by 23 bps, 10 year bond by 9 bps and also has no effect on the 30 year bonds' yield. The impacts on yield curve favored the short term interest rate, and the impacts weakened as the term structure changed to the long term, such as 30 years. At the same time, the R^2 as the measure of goodness of fit also decreases as the dependent variables changed to the longer term yield. Volatility prediction is mixed, some variances are correlated to the past variances, but some are correlated to the past squared residuals. Those results on interest rate's response to the monetary policy surprises are consistent with the previous study which is given by Kuttner (2001), whose sample length spans from 1989 to 2000[9], which is less than the data length in this paper.

A.3. Discussion: Monetary Policy Effects when the Bubble and Crisis Periods have been Excluded

We conduct a new study which compares with the previous results by excluding the rate decision observation during the dot-com bubble (1999-2000) and sub-prime mortgage crisis period (2007-2008). In response to the persistent soaring of high tech company stock prices, the Federal Reserve Bank[10] held four

[9]This part is similar to Kuttner (2001) and Bernanke and Kuttner (2005) in ideas and objective, but the data and the model is different. We have better data quality to test the hypothesis. We derived the futures contract's expectation formation process, as well as the modeling in volatility by GARCH(1,1), a non linear relationship is included. And the assumption of IID error term is also relaxed due to the time series data's property. This is paper is different from Jansen and Zervou (2015) in data sample selection, ideas and objectives.

[10]The Federal Reserve is chaired by Alan Greenspan during the dot-com bubble period, so as the related monetary policies.

consecutive interest hikes from 5.25 percent to 6.5 percent, from the 16th December 1999 to the 16th May 2000. From the 18th September 2007 to the 16th December 2008, the Federal Reserve cut the federal fund rate from 5.25 percent to 0-0.25 percent level, supporting the falling housing prices, and helping to boost investments and consumption activities, purchasing mortgage backed securities (MBS) in order to provide liquidity, and finally trying to bail out the economy from crisis. These periods are different from the normal policy time, since most of the decisions are temporal and emergent reactions to market volatility. The communication between policy makers and markets is more transparent, but surprising policies are more in quantity than the normal markets condition. By excluding the observations in Bubble and Crisis periods, we find that there is no big difference when we compare it with the regression results when we did not exclude them. The results have been reported in table 4's Panel B. In this case, we only include the rate decisions which exists in normal periods in our sample of study.

A.4. Shift of the Yield Curve

Figure 5 displays a single case of shifting yield curve when the market encounters a monetary policy surprise during 2008 financial crisis period. The Federal Reserve Board cut the target interest rate from 4.25 percent to 3.5 percent which is 75 basis points. However, the fed fund futures only implied a modest 9 (0 to 25) basis points cut which had made an unexpected component of 66 basis points cut that was implied from the change of front month overnight Fed Fund futures. Consistent with the previous finding in this paper (table 4, Panel A, B) that the short term interest rate of the yield curve had been lowered more than the long term interest rate of the yield curve. We also can conclude that after the unexpected cutting of fed fund rate, the yield curve had dropped down significantly, and steepened at the same time. It is probably due to the uncertainty of the future period monetary policy that the market did not respond a lot on the longer term part of the yield curve, but the short term part of the curve is very sensitive to the rate decision.

A.5. Foreign Exchange Rate

Exchange rate is also an important transmission channel. Higher interest rate in U.S. makes the dollar more attractive for international investors, and thereby can induce capital inflow to U.S. and dollar exchange rate appreciation. However, this argument is contrary with the famous Uncovered Interest Rate Parity (UIP) hypothesis in international finance. Because of zero profit arbitrage, high interest rate currency should depreciate against the low interest rate currency. In this case, the monetary policy surprise effects provide an alternative test to the UIP hypothesis.

Table 5's Panel A reports the results. We can see that most of the currency responds significantly to

the unexpected part of the monetary policy. Unexpected hike of the Dollar interest rates have depreciated the dollar exchange rate against any other currencies, including G-10 and Emerging market exchange rate. 100 bps unexpected hike of U.S. federal fund rate could appreciate dollar with Japanese Yen (JPY) by 65 bps; appreciate dollar with Swedish Krone (SEK) and Norwegian Krone (NOK) also around 60 bps. For emerging market currencies, the scale of the effect is also in similar size. Russian Rubble (RUB), South Africa Rand (ZAR) and Czech Republic Koruna (CZK) have depreciated by 56, 45, and 84 bps when they face a 100 bps unexpected hike on U.S Fed Fund Rate. Our results support the capital inflow story with the high interest rate country, and again contradicted the UIP theory. Chin (2006) investigated the UIP empirical test literatures, and he also summarized that the high interest rate currencies usually appreciated against the low interest rate currencies, when the researcher used short term interest rate differential as the predictor of the next period exchange rate.

Table 5's Panel B reports the results when excluding dot-com bubbles and financial crisis period. We can see that Euro (EUR), Sterling (GBP), Swiss Franc (CHF), Swedish Krone (SEK), Russian Ruble (RUB) and Czech Republic Koruna (CZK), although they were previously significant, have become insignificant when excluding observations during bubble and crisis periods. Those differences in coefficients tell us that only during special periods of the time are they sensitive to the monetary policies. These results are very different from the last section when we study the treasury securities responses where their responses are consistent in different periods.

A.6. U.S. and International Equities Markets

Previous empirical findings support the argument that monetary policy can drive U.S. equities market, see Bernanke and Kuttner (2005) and Jansen and Zervou (2015). The midterm and long term interest rate changes could be variables in investment, consumption and therefore dividend yields of equities, and then the stock market prices. However, in contrast to the theory and previous findings, we neither find significant results for the U.S. equity market, nor international equities market. When we exclude bubble and crisis periods, the results have not changed so much. This difference may be caused by the selection of the sample event study, since we included more sample of data in this paper, the monetary policy effect is more significant in the recent periods. The discussion of the non traditional monetary under the zero lower bound (such as QEs) in post crisis periods (2008-2016) demonstrated the effectiveness of the monetary policy on equity market in U.S. The international effect is not significant in the long run.

A.7. Commodities Price

The list in Table 7, Panel A includes the results of full sample regression, while Panel B reports the more robust results which are from the data sets that have excluded the periods of the dot com and financial crisis. We find that gold prices are sensitive to the monetary policy shock. 100 basis points or 1 percent of unexpected hiking of fed fund rate declines -0.46 percent spot gold prices in all periods, and -0.57 percent when excluding bubble and crisis periods. Gold prices have been considered as the indicator of future period inflation, but it is also hard to predict the prices, at least from the point of view of Federal Reserve Bank. Bernanke (2013)[11] once argued that there is no one in the world who can predict and understand gold prices, including him. But, in this paper, our strong empirical results indicate that the monetary policy decision (actual change in rate) can influence the gold prices. It is therefore a reflection of the effectiveness of the monetary policys influence on inflation. In contrast to some researchers, we did not find crude oil was responsive to the policy shock.

VII. Pre-Meeting and Post-Meeting Effect of FOMC Rate Decision

A. Econometric Estimation

In order to know financial markets' behavior around several days of the rate decision, this section extended our view about the response of market in a longer time horizon. We look at the financial assets' response in an event window which includes 11 event days: 5 event days before the rate decision and 5 event days after it. We regress the asset return on the expected and unexpected part of the monetary policy in the open market days of $\{t+i\}_{i=-5}^{+5}$ where t is the event date, the weekend and the non-trading days are excluded, i only counts trading day. This experimental design can help to answer the question of whether the financial markets are under reacted to the policy actions or a pre-announcement effect is existed. The estimation has the following form:

$$R_{t+i} = \gamma_{0i} + \gamma_{1i}\Delta FFR_t^{expected} + \gamma_{2i}\Delta FFR_t^{unexpected} + \epsilon_{t+i} \tag{10}$$

where $i \in [-5, 5]$, and R_{t+i} denotes the financial asset returns between event days [-5, 5]. When the price data sets of event days are missing, we just left it empty, and then conduct regression with missing values; γ_{0i}, γ_{1i} and γ_{2i} are each of the coefficients; ϵ_{ti} is assumed to be iid normal, which means $E_t(\epsilon_{t+i}) = 0$ and $VAR(\epsilon_{t+i}) = \sigma^2$. By regressing each event day's different assets return, we then could know the market

[11] He gives public speech. For more details, please click the link below:
http://business.financialpost.com/news/economy/ben-bernanke-nobody-understands-gold-prices-including-me

movement before rate decision, how the market could predict the monetary policy, or the market movement after rate decision, how the market could respond after rate decision for several days.

B. Results: Pre-Meeting and Post-Meeting Effect

Tables 8, 9, and 10 report the results of estimation framework of equation (10). Although the 1 day before and 1 day after FOMC rate decision days asset returns are significantly impacted by the rate decision of Fed, the coefficients are much smaller. They are only 1/3 or 1/4 of the size when compared with the coefficients at the rate decision day 0. In 3 month and 6 month T-bills part, the expected component has impact on the [-1,1] windows asset return, but the returns have been taken back at the 3rd event day. Our estimations show that expected 100 basis points cut of the fed fund rates lower the 3 month T-bill yield by 18 basis points in event day 0, and continue to lower the yield by 8 basis points in the event day +1, but rise up to 11 basis points in the event day +3. For unexpected 100 basis points fed fund rate cut, it lowers the 3 month T-bill yield by 10 basis points in the day -1, 44 basis points in the day 0, and continues to lower in the day +1 by 10 basis points and the +3 day by 10 basis points. Furthermore, the impacts from monetary policy shock on treasury yields only significantly impact the near term yield curve, such as 3 month, 6 month, 1 year, and 2 year interest rates. Usually, the size of the responses are much larger for the shorter term interest rate. Figure 6 shows the coefficients of [-5, 5] event window estimation of the monetary policys effect. We can conclude that only the unexpected monetary policy shock could impact the bond yield. In most of the cases, they have impacts on event day 0, but continue to event day +1 and +3.

For the exchange rate, we find serious post-announcement effects, but those effects are offset for each other when horizon goes to the 4th and 5th day. Post-announcement effects can be interpreted as the under reaction of markets, while the efficient markets hypothesis is not always happening. In this paper, we find that an unexpected 100 basis points cut of Fed Fund rate can appreciate Swedish Krona vs U.S. dollars (SEK/USD) exchange rate by 0.61% on day 0, and it continue to appreciate by 0.45% on day 1, but depreciated by 0.34% on day 4 and 0.35% on day 5. For another example, the appreciation of Great British Pound (GBP) of 0.38% on day 0 is due to the unexpected shock of 100 basis points Fed fund hike. The effect extended to the day 1 (the second day), but recover 0.41% of the appreciation, which means that the post-meeting effects had been offset to each other further in a 5-day post-meeting horizon. Similar results can be seen from most of the exchange rates. Although different from the previous research, we did not find any evidence that there is an one day effect of monetary policy shock on equity prices. But we can see apparently from table 10 that the equities index in other countries are negatively related to the unexpected interest rate hikes of the Federal Reserve Bank. For instance, a 100 bps unexpected hike of

federal fund rate drove down Hong Kong's Hang Seng Index by 2.84% on the 2nd event day, and then the index return continued to decline on the 3rd and the 5th day.

C. Implications for Investing

Investors and money managers focus highly on the information of rate decisions, since interest rate is a key variable to them to make investment decisions. In addition, they also know that the Federal Reserve Bank has a policy tool to influence the market by expectation through monetary policy news releasing. Thus, announcement of monetary policy news, especially interest rate decision, is valuable to market participants. They could make decision and take investing action after the FOMC, since the monetary policy could impact the market beyond one day, and extend to several days. The private sectors decision on buying and selling securities determined the asset prices movements. However, the under reaction of the market participants after the surprising monetary policy or policy shock gives the fast mover more opportunities to speculate and rebalance the portfolio with lower cost. Furthermore, if the monetary authority shows unexpected expansionary policy in the future, the interest rate in the future is more likely to be lower and the monetary authority signal a negative economic perspective; while if it shows unexpected tightening, the interest rate is more likely to be higher than the previous expectation, and the central bank signals a stronger perspective of future economic growth. The feature of high autocorrelation of the short-term interest rate also implies the future conduct of central bank and infers a lot about the economist's long term perspective of macro economies and inflation. Thus, a short term unexpected change of nominal interest rates is very informative for the market participant, not only to the short-term asset prices, but also to the long term monetary policy conduct.

VIII. Concluding Remarks

This paper uses the event study methods in a macroeconomic framework to study a broad class of assets response to monetary policy surprises in U.S. The assets cover U.S. government fixed income and equities, U.S. dollar against the major G-10 and major emerging market currencies, international stock markets, and commodities prices. We use the Fed Futures Fund rate to gauge the market expectation of the interest rate decision of FOMC of Federal Reserve Bank and separate the market expectation on target rate decision into unexpected and expected components. By using GARCH(1,1) specification in a one day event horizon, we find that treasury bills, exchange rates of developed countries are significantly influenced by the unexpected component of the monetary policy in U.S. from 1989 to 2008, while emerging market exchange rates respond weakly to the monetary policy surprises in U.S. In addition, we also find

that international equity markets and commodities prices are not sensitive to the monetary policy of the Federal Reserve Bank in an one day horizon.

However, the condition is different when we extend the event window into [-5, 5] days. The unexpected component of monetary policy has a long horizon impact on the financial markets, which is contrary to the efficient market hypothesis. Almost all of the financial assets in our study significantly respond to the monetary policy shock with 5-day post-meeting effects. The features are slightly different from fixed income, foreign exchange rate, and international equities. When encountering an unexpected increasing in fed fund rate, only the Treasury bills have late responses, not midterm notes and long term bonds. In addition, they respond a little before decision making of interest rate, inferring that fixed income markets are more informative than other financial markets. For the exchange rate, the markets have a mean reversion effect on the post-meeting effect, which means a reaction after rate decision date, usually recovered back in the next few days. The most consistent response is from other countries' equities market, a surprise in monetary policy in U.S. has several days of the responding effect to other countries' stock markets, especially emerging markets. Further study should be conducted to show how long the monetary policy could influence each asset price and how many days the effects are persistent.

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Table 1: Summary of Data Sets and Key Variables

This table reports the source of the data sets and the time span of the financial market data. They are daily frequency. Most the data sets are drawn from the Bloomberg Terminal. We use spot exchange rate, interest rate, commodities and equities index to identify the response of the financial markets, which are supposed to play the same role when other people use the futures contract of those financial assets. After Dec 2008, the federal reserve bank had kept the fed fund target rate into 0-0.25 percent level, and although the futures prices are available, there is no rate decision since 2015. While before 1989 Feb, the Futures contract of the fed fund rate has not been introduced, thus the data is not available for researchers.

Financial Market Variables	*Source of Data*	*Sample Periods*	*Frequency*
Front Month Fed Fund Futures Contract #1	Bloomberg	Feb 1989-Dec 2008	Daily
Front Month Fed Fund Futures Contract #2	Quandl	Feb 1989-Dec 2008	Daily
U.S. 3 Month Treasury Bill	Bloomberg	Feb 1989-Dec 2008	Daily
U.S. 6 Month Treasury Bill	Bloomberg	Feb 1989-Dec 2008	Daily
U.S. 12 Month Treasury Bill	Bloomberg	Feb 1989-Dec 2008	Daily
U.S. 2 Year Treasury Notes	Bloomberg	Feb 1989-Dec 2008	Daily
U.S. 5 Year Treasury Notes	Bloomberg	Feb 1989-Dec 2008	Daily
U.S. 10 Year Treasury Notes	Bloomberg	Feb 1989-Dec 2008	Daily
U.S. 30 Year Treasury Bonds	Bloomberg	Feb 1989-Dec 2008	Daily
U.S. S&P 500 Index	Bloomberg	Feb 1989-Dec 2008	Daily
Japan, Nikkei 225 Index	Bloomberg	Feb 1989-Dec 2008	Daily
Hong Kong (PRC), Hang Seng Index	Bloomberg	Feb 1989-Dec 2008	Daily
U.K., FTSE 100 Index	Bloomberg	Feb 1989-Dec 2008	Daily
Germany, DAX Index	Bloomberg	Feb 1989-Dec 2008	Daily
Gold Spot Prices, U.S. dollar denominated	Bloomberg	Feb 1989-Dec 2008	Daily
CME, WTI Crude Oil Futures, Contract #1	Bloomberg	Feb 1989-Dec 2008	Daily
EURO, EUR Spot Exchange Rate	Bloomberg	Feb 1989-Dec 2008	Daily
Pounds Sterling, GBP Spot Exchange Rate	Bloomberg	Feb 1989-Dec 2008	Daily
Swiss Franc, CHF Spot	Bloomberg	Feb 1989-Dec 2008	Daily
Japanese Yen, JPY Spot	Bloomberg	Feb 1989-Dec 2008	Daily
Canadian Dollar, CAD Spot	Bloomberg	Feb 1989-Dec 2008	Daily
Australian Dollar, AUD Spot	Bloomberg	Feb 1989-Dec 2008	Daily
New Zealand Dollar, NZD Spot	Bloomberg	Feb 1989-Dec 2008	Daily
Sweden Krone, SEK Spot	Bloomberg	Feb 1989-Dec 2008	Daily
Norwegian Krone, NOK Spot	Bloomberg	Feb 1989-Dec 2008	Daily
Brazilian Real, BRL Spot	Bloomberg	Feb 1989-Dec 2008	Daily
South African Rand, ZAR Spot	Bloomberg	Feb 1989-Dec 2008	Daily
Polish Zloty, PLN Spot	Bloomberg	Feb 1989-Dec 2008	Daily
Romanian Leu, RON Spot	Bloomberg	Feb 1989-Dec 2008	Daily
Indian Rupee, INR Spot	Bloomberg	Feb 1989-Dec 2008	Daily
Czech Koruna, CZK Spot	Bloomberg	Feb 1989-Dec 2008	Daily
Chilean Peso, CLP Spot	Bloomberg	Feb 1989-Dec 2008	Daily
Hungarian Forint, HUF Spot	Bloomberg	Feb 1989-Dec 2008	Daily
Mexican Peso, MXN Spot	Bloomberg	Feb 1989-Dec 2008	Daily

Table 2: Historic Rate Decision for U.S. Federal Reserve Board, Feb 1989 to Dec 2008

Table 2 listed the historic rate decision. The Mystique periods (orange colored) are the times before February 1994, the FOMC did not announce their rate decision, but implemented the monetary policy through Open Market Operation by the trading desk from New York Fed. The Grey color area covers the period of bubble and financial crisis periods. The orange area covers the periods of no announcement monetary policy periods.

Date	*Changes*	*New Level*	*Time*	*Methods of Announcement*	*Intermeeting?*	*Unexpected*	*Expected*
12/16/2008	-1	0-0.25	2:15 PM	Post-meeting Press Release		-0.11	-0.89
10/29/2008	-0.5	1	2:15 PM	Post-meeting Press Release		-0.28	-0.22
10/8/2008	-0.5	1.5	7:00 AM	immediate release (Press Release)		-0.14	-0.36
4/30/2008	-0.25	2	2:15 PM	Post-meeting press release		0.3	-0.55
3/18/2008	-0.75	2.25	2:15 PM	Post-meeting Press Release		0.16	-0.91
1/30/2008	-0.5	3	2:00 PM	intermeeting press release	Y	0	-0.5
1/22/2008	-0.75	3.5	2:00 PM	Post-meeting Press Release		-0.67	-0.08
12/11/2007	-0.25	4.25	2:00 PM	intermeeting press release	Y	0.01	-0.26
10/31/2007	-0.25	4.5	2:15 PM	post meeting press release		0	-0.25
9/18/2007	-0.5	4.75	2:15 PM	post meeting press release		-0.14	-0.36
6/29/2006	0.25	5.25	2:15 PM	Post-meeting Press Release		-0.08	0.33
5/10/2006	0.25	5	2:00 PM	Discount Rate Change Press Release	Y	-0.01	0.26
3/28/2006	0.25	4.75	2:15 PM	Post meeting press release		0	0.25
1/31/2006	0.25	4.5	2:15 PM	Post meeting press release		0	0.25
12/13/2005	0.25	4.25	2:15 PM	Post meeting press release		0	0.25
11/1/2005	0.25	4	2:15 PM	post meeting press release		0	0.25
9/20/2005	0.25	3.75	2:15 PM	Post meeting press release		0.01	0.24
8/9/2005	0.25	3.5	2:15 PM	Post meeting press release		0	0.25
6/30/2005	0.25	3.25	2:15 PM	post meeting press release		0	0.25
5/3/2005	0.25	3	2:15 PM	post meeting press release		0	0.25
3/22/2005	0.25	2.75	2:15 PM	post meeting press release		0	0.25
2/2/2005	0.25	2.5	2:15 PM	post meeting press release		0	0.25
12/14/2004	0.25	2.25	2:15 PM	post meeting press release		0	0.25
11/10/2004	0.25	2	2:15 PM	post meeting press release		0	0.25
9/21/2004	0.25	1.75	2:15 PM	post meeting press release		0.02	0.23
8/10/2004	0.25	1.5	2:15 PM	post meeting press release		0.02	0.23
6/30/2004	0.25	1.25	2:15 PM	post meeting press release		0.15	0.1
6/25/2003	-0.25	1	2:15 PM	post meeting press release		0	-0.25
11/6/2002	-0.5	1.25	2:15 PM	post meeting press release		-0.19	-0.31
12/11/2001	-0.25	1.75	2:15 PM	post meeting press release		0	-0.25
11/6/2001	-0.5	2	2:20 PM	post meeting press release		-0.1	-0.4
10/2/2001	-0.5	2.5	2:15 PM	post meeting press release		-0.07	-0.43
9/17/2001	-0.5	3	8:20 AM	intermeeting press release	Y	-0.3	-0.2
8/21/2001	-0.25	3.5	2:15 PM	post meeting press release		0.01	-0.26
6/27/2001	-0.25	3.75	2:12 PM	post meeting press release		0.04	-0.29
5/15/2001	-0.5	4	2:15 PM	post meeting press release		-0.07	-0.43
4/18/2001	-0.5	4.5	10:54 AM	Intermeeting press release	Y	-0.39	-0.11
3/20/2001	-0.5	5	2:15 PM	Post meeting press release		0.05	-0.55
1/31/2001	-0.5	5.5	2:15 PM	Post meeting press release		0	-0.5
1/3/2001	-0.5	6	1:13 PM	intermeeting press release	Y	-0.01	-0.49
5/16/2000	0.5	6.5	2:15 PM	post meeting press release		0.05	0.45
3/21/2000	0.25	6	2:15 PM	post meeting press release		-0.03	0.28
2/2/2000	0.25	5.75	2:15 PM	post meeting press release		-0.05	0.3
11/16/1999	0.25	5.5	2:15 PM	post meeting press release		0.08	0.17
8/24/1999	0.25	5.25	2:15 PM	post meeting press release		0.02	0.23
6/30/1999	0.25	5	2:15 PM	post meeting press release		-0.3	0.55
11/17/1998	-0.25	4.75	2:15 PM	post meeting press release		-0.05	-0.2
10/15/1998	-0.25	5	3:15 PM	intermeeting press release	Y	0.04	-0.29
9/29/1998	-0.25	5.25	2:15 PM	post meeting press release		0	-0.25
3/25/1997	0.25	5.5	2:15 PM	post meeting press release		0.04	0.21
1/31/1996	-0.25	5.25	2:15 PM	post meeting press release		-0.16	-0.1
12/19/1995	-0.25	5.5	2:15 PM	post meeting press release		-0.1	-0.15

7/6/1995	-0.25	5.75	2:15 PM	post meeting press release		-0.01	-0.24
2/1/1995	0.5	6	2:15 PM	post meeting press release		0.05	0.45
11/15/1994	0.75	5.5	2:20 PM	post meeting press release		0	0.75
8/16/1994	0.5	4.75	1:18 PM	post meeting press release		0	0.5
5/17/1994	0.5	4.25	2:26 PM	post meeting press release		0.13	0.37
4/18/1994	0.25	3.75	10:06 AM	post meeting press release		0.09	0.16
3/22/1994	0.25	3.5	2:20 PM	Post meeting press release		-0.03	0.28
2/4/1994	0.25	3.25	11:05 PM	post meeting press release		0.11	0.14
9/4/1992	-0.25	3	11:30 AM	open market operation	Y	-0.21	-0.04
7/2/1992	-0.5	3.25	9:15 AM	Discount rate change press release	Y	-0.35	-0.15
4/9/1992	-0.25	3.75	11:30 AM	Open Market Operation	Y	-0.23	-0.02
12/20/1991	-0.5	4	8:30 AM	Discount Rate change press release	Y	-0.26	-0.24
12/6/1991	-0.25	4.5	11:30 AM	Open market operation	Y	-0.08	-0.17
11/6/1991	-0.25	4.75	8:45 AM	Discount Rate Change Press Release	Y	-0.12	-0.13
10/31/1991	-0.25	5				-0.62	0.37
9/13/1991	-0.25	5.25	9:10 AM	Discount Rate Change Press Release	Y	-0.05	-0.2
8/6/1991	-0.25	5.5	11:30 AM	Open market operation	Y	-0.14	-0.11
4/30/1991	-0.25	5.75	9:30 AM	Discount Rate Change Press Release	Y	-0.3	0.05
3/8/1991	-0.25	6	11:30 AM	open market operation	Y	-0.16	-0.1
2/1/1991	-0.5	6.25	9:15 AM	discount rate change press release	Y	-0.53	0.03
1/9/1991	-0.25	6.75				-0.12	-0.13
12/18/1990	-0.25	7	3:30 PM	Discount Rate Change Press Release	Y	0.02	-0.27
12/7/1990	-0.25	7.25	11:30 AM	Open Market operation	Y	-0.26	0.01
11/13/1990	-0.25	7.5				-0.03	-0.22
10/29/1990	-0.25	7.75	11:30 AM	open market operation	Y	-0.21	-0.04
7/13/1990	-0.25	8	11:30 AM	open market operation	Y	-0.13	-0.12
2/24/1989	0.25	9.75				0.04	0.21

Total Observation: 79

Source of Data: Federal Reserve Bank of Kansas and New York City

Table 3: Unusual Periods for Monetary Policy in United States, 1989 to 2008

We intend to omit the data point/observations during the financial crisis periods, for robustness checks. In the table below, we only list the crisis events that have been covered by the time from 1989 to 2008 which is the time length of our data sample.

Years	*Financial Crisis Event and the Federal Reserve's Reaction on Monetary Policy*
2007 to 2008	Subprime Mortgage Crisis. The crash of the U.S. housing market triggered the crisis, followed by the bankruptcy of large financial institutions and stock market turmoil. Fed's reaction on policy: Interest Rate Cut from 5.25% to 0-0.25% level, from the 18th Sept, 2007 to the 16th Dec, 2008's zero lower bound. The chairman was Ben S. Bernanke.
1999 to 2000	Dot-com Bubble. Internet related stock prices raised to a level that is apparently higher than their fundamental values. Fed's reaction on policy: Four consecutive Interest Rate hikes from 5.25% to 6.5%, from the 16th December, 1999 to the 16th May, 2010. The chairman was Alan Greenspan.
Prior to September 1994	No announcements after the FOMC meeting, but Open Market Operation on Fed Fund Rate. It is called the mystique period of monetary policy.

Figure 1: The Evolution of the Fed Fund Target Rate

This figure shows the historic level of the fed fund target rate. We can see that the interest rate lowers as the time approaches the recent periods.

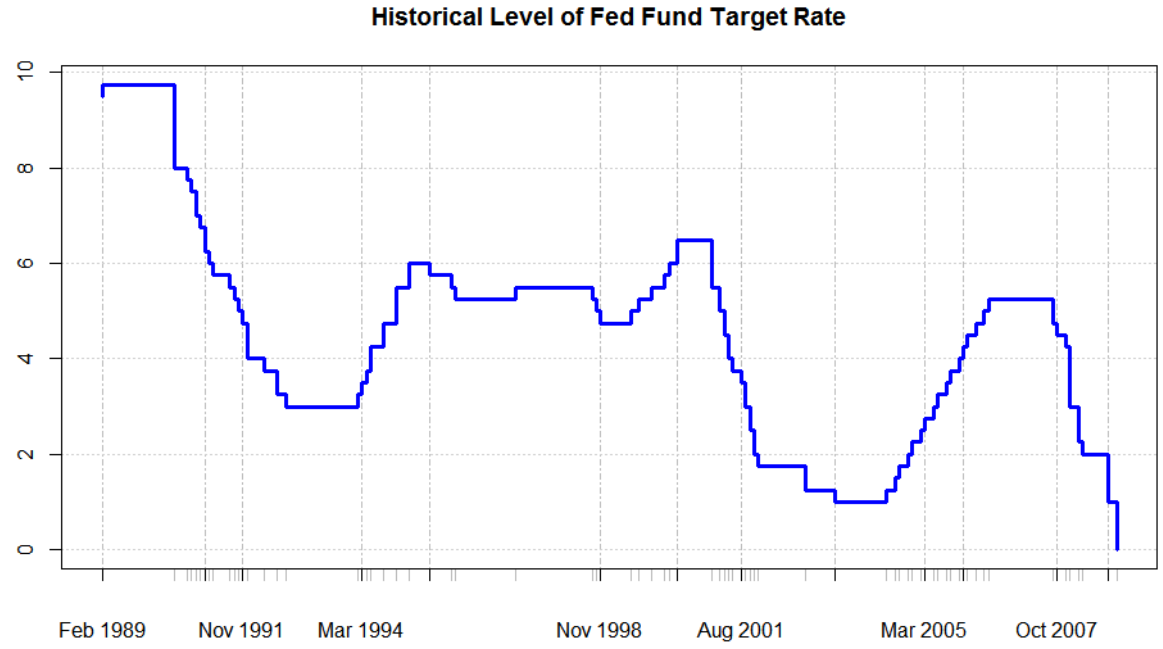


Figure 2: The Distribution of Rate Decision across Different Time Period

Figure 2 displays the changes of rate decision from February 1989 to December 2008. After the subprime mortgage financial crisis, Federal Reserve has kept the target Fed Fund Rate at 0.00-0.25% level until December 2015.

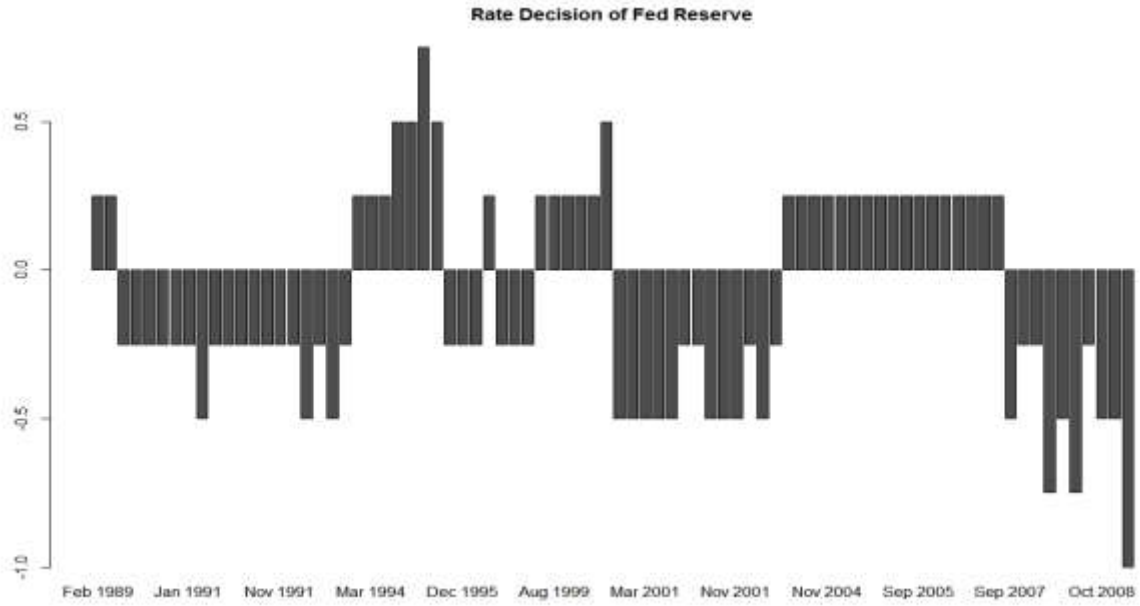


Figure 3: The Size of the Unexpected Monetary Policy which is Measured by Fed Fund Futures

The figure below shows the unexpected component of the monetary policy which is implied from the Fed Fund Futures, we use the equation:

$$\Delta FFR_t^{unexpected} = \frac{m}{m-t}(FFR_{s,t}^1 - FFR_{s,t-1}^1)$$

to compute the unexpected monetary policy $\Delta FFR_t^{unexpected}$. m is the number of days in month s, while t is the event day. Below is the figure that listed the $\Delta FFR_t^{unexpected}$ over time. We can directly observe that before 1994, there are much more unexpected rate decisions, the sizes are big enough to drive the market prices. During the financial crisis period from 2007 to 2008, the market (fed fund futures) also had wrong predictions of the actual rate decision behaviors and the monetary policy shock still existed in that period, although federal reserve started to increase the transparency between monetary authority and market participants.

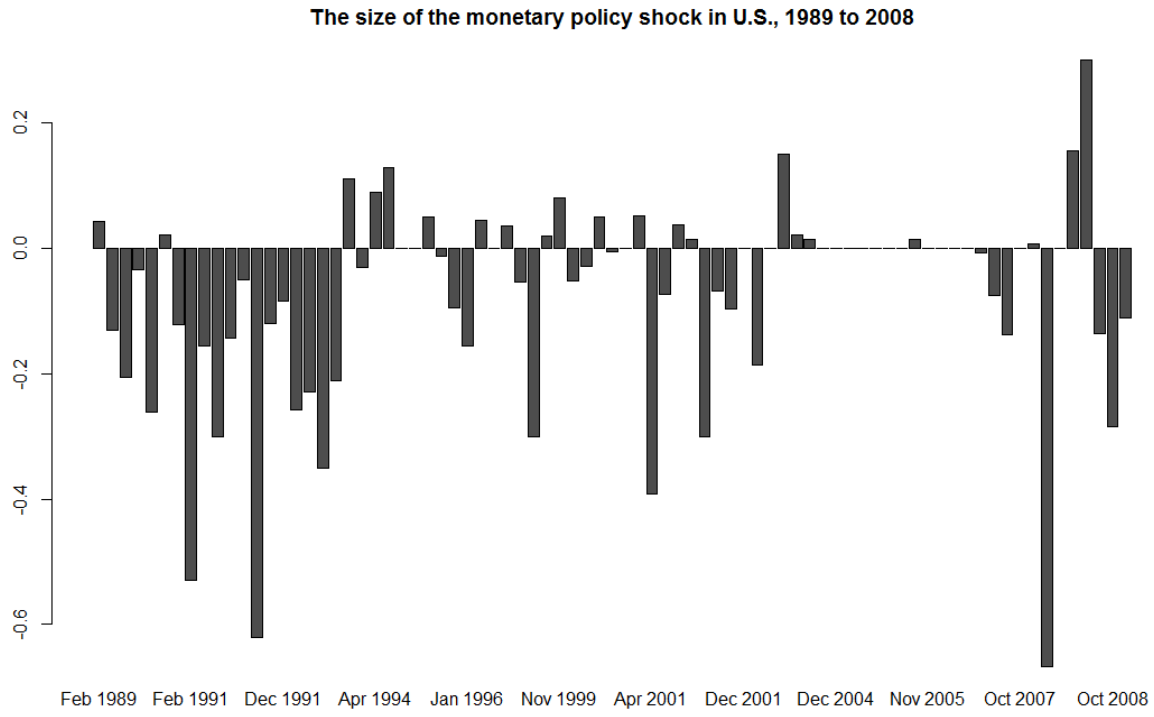


Figure 4: The Yield of the Fed Fund Rate and the Treasury Bill, Notes and Bonds in U.S., 1989 to 2015.

Figure 4 displays the relationship between short term and long term interest rate in U. S. Most of the time, the effective overnight fed fund rate is targeted by the Federal Reserve Bank's open market operation, but the long term rate is traded and thereby determined by the private sector market participants. We can observe that the up and down fluctuation of the short term interest rates have impacts on long term rate. Notice: FF1 stands for the Fed Fund Futures Rate which is implied from the 1st month fed fund futures. 3m is the 3 month's yield of treasury bill, while 30 y stands for the 30 year's treasury bond yield.

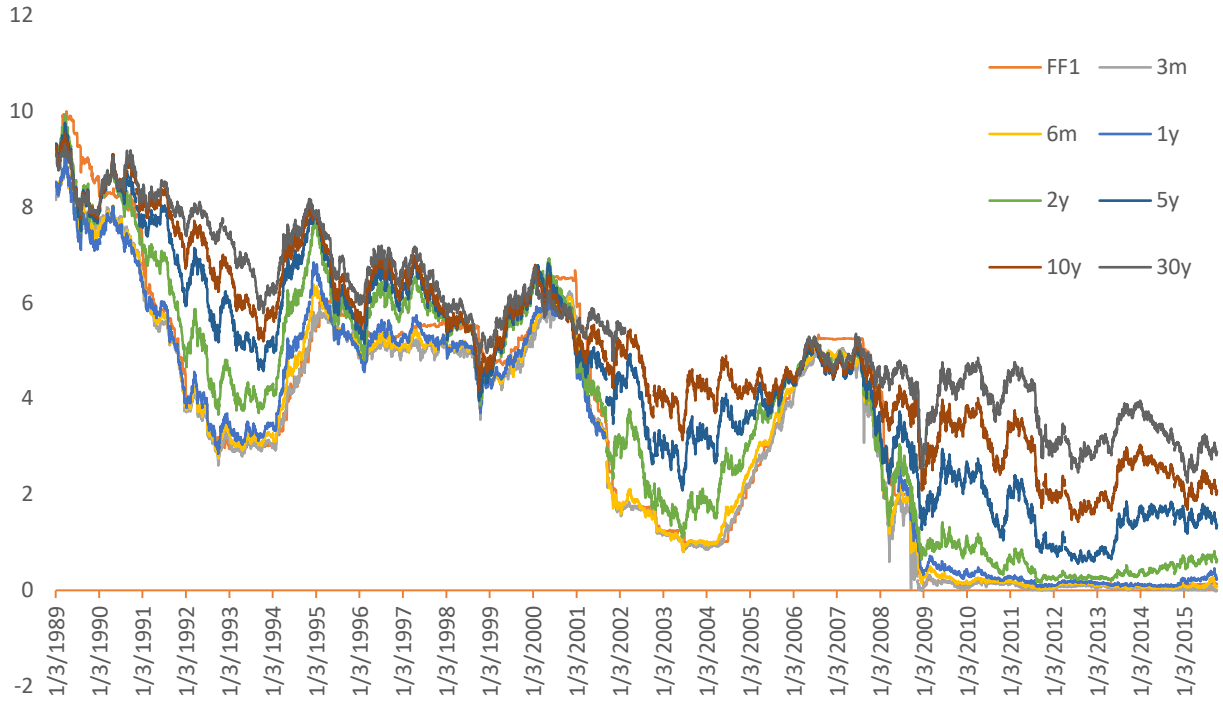


Table 4: Treasury Bond's Response to Monetary Policy Surprises: Response of Interest Rates to the Expected and Unexpected Component of Federal Fund Target Surprises (1989-2008)

The results of this table are based on the GARCH(1,1) process regression:

$$R_t = \gamma_0 + \gamma_1 \Delta FFR_t^{expected} + \gamma_2 \Delta FFR_t^{unexpected} + \varepsilon_t$$
$$\varepsilon_t | \varepsilon_{t-1}, \varepsilon_{t-2}, \varepsilon_{t-3}, \ldots \sim N(0, u_t^2)$$
$$u_t^2 = \beta_0 + \beta_1 \varepsilon_{t-1}^2 + \beta_2 u_{t-1}^2$$

R_t denotes the return of asset prices in the event date t compares to the previous date t-1. P_t is the asset prices at day t and P_{t-1} is the asset prices at day t-1, which is the date before interest rate decision date. γ_0, γ_1 and γ_2 are the linear regression coefficients. β_0, β_1 and β_2 are the coefficients of maximum likelihood estimation (MLE) based on the GARCH(1,1) processes. ε_{t-1}^2 is the squared last period residual estimate, while u_{t-1}^2 is the variances of the error term. The parenthesis reports the robust standard error.

Panel A (Full Sample):

Parameters	*3 month*	*6 month*	*12 month*	*2 year*	*5 year*	*10 year*	*30 year*
γ_0	-0.013	-0.021**	-0.009	0.001	-0.005	0.002	-0.029**
	(0.013)	(0.009)	(0.012)	(0.010)	(0.011)	(0.010)	(0.011)
γ_1	0.167***	0.104***	0.005	0.041	-0.009	-0.041*	-0.067*
	(0.032)	(0.025)	(0.040)	(0.032)	(0.030)	(0.025)	(0.038)
γ_2	0.442***	0.371***	0.335***	0.314***	0.229***	0.092**	0.016
	(0.046)	(0.033)	(0.080)	(0.057)	(0.063)	(0.042)	(0.059)
β_0	0.004	0.005**	0.001*	0.001	0.002	0.002**	0.002
	(0.007)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.005)
β_1	-0.042	0.448**	0.539**	0.173	0.120	0.647*	0.071
	(0.067)	(0.164)	(0.24)	(0.120)	(0.141)	(0.343)	(0.200)
β_2	0.570	-0.070	0.405*	0.641***	0.678**	0.182	0.587
	(0.821)	(0.289)	(0.233)	(0.174)	(0.229)	(0.179)	(0.972)
R^2	0.51	0.48	0.39	0.27	0.14	0.04	0.06
Durbin- Watson	1.83	2.22	2.00	2.30	2.17	2.14	2.14
Observations	79	79	46	79	79	79	63

*Notice: the code *** denote the significance level of α<0.01; ** α<0.05; * α<0.10.*

Panel B (Subsample):

Parameters	*3 month*	*6 month*	*12 month*	*2 year*	*5 year*	*10 year*	*30 year*
γ_0	-0.011	-0.019**	-0.004	-0.002	-0.007	-0.001	-0.001***
	(0.015)	(0.008)	(0.016)	(0.001)	(0.013)	(0.000)	(0.000)
γ_1	0.166***	0.096***	0.104	0.061	0.019	-0.018	-0.067***
	(0.027)	(0.025)	(0.058)	(0.041)	(0.042)	(0.092)	(0.000)
γ_2	0.418***	0.316***	0.380***	0.309***	0.282***	0.161**	0.008***
	(0.064)	(0.036)	(0.106)	(0.065)	(0.070)	(0.042)	(0.000)
β_0	0.004	0.003***	0.001	0.002	0.000	0.000	0.000
	(0.007)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)
β_1	-0.045	0.769***	0.465	0.172	-0.154	-0.132	6.336***
	(0.071)	(0.164)	(0.296)	(0.154)	(0.103)	(0.092)	(0.634)
β_2	0.574	-0.033	0.437	0.618*	1.15***	1.161***	0.000
	(0.733)	(0.041)	(0.310)	(0.286)	(0.146)	(0.130)	(0.143)
R^2	0.46	0.43	0.42	0.29	0.14	0.05	-0.12
Durbin- Watson	1.95	1.96	2.01	2.15	2.13	2.19	1.74
Observations	65	65	42	65	65	65	65

*Notice: the code *** denote the significance level of α<0.01; ** α<0.05; * α<0.10.*

Figure 5: The Unexpected Interest Rate Cut and the Movement of Yield Curve

This figure shows one of the event date of rate decisions during the financial crisis period in 2008. The Federal Reserve Board cut the target interest rate from 4.25% to 3.5%, which is 75 basis points. However, the fed fund futures only implied a modest 0 to 25 basis points cut which had made an unexpected component of 66 basis points cut that was implied from the change of front month overnight Fed Fund futures. Consistent with the finding in the table 5 that the front month part of the yield curve lowered more than the back month part of the yield curve, such as 30 years yield. Notice: The dashed line is the yield curve at the date 18th January, 2008, which is the prior trading day before FOMC rate decision. The solid line is the yield curve at the date 22th January, 2008, which is the event day closing price of the treasury securities. We can see that after the unexpected cutting of fed fund rate, the yield curve lowered significantly, but became steeper.

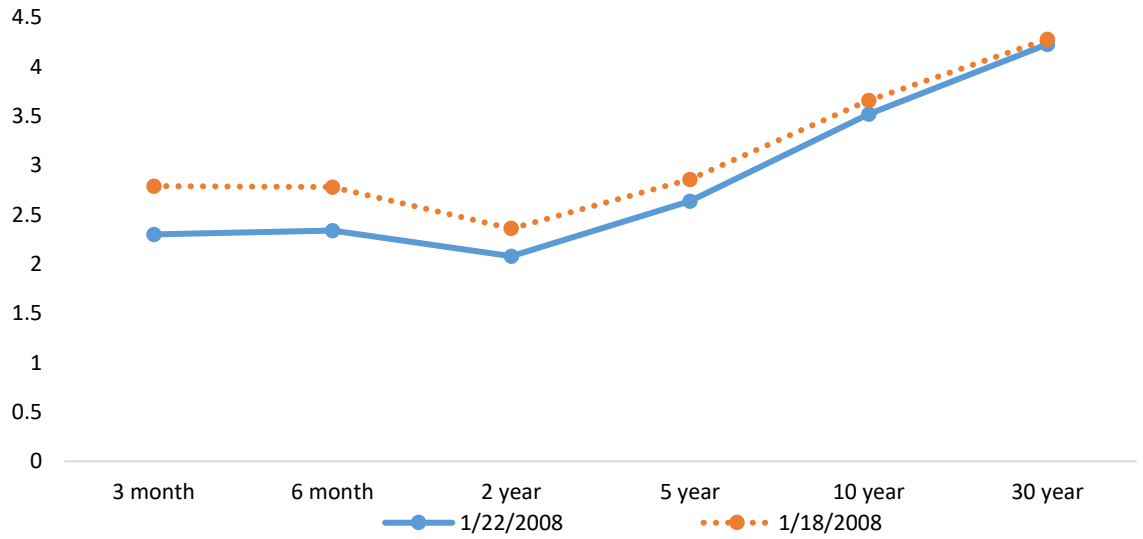


Table 5: Monetary Policy Surprises on Exchange Rate: Response of Exchange Rates to the Expected and Unexpected Component of Federal Fund Target Surprises (1989-2008)

This table reports the results of the sample of study to G-10 and Emerging Market exchange rate. All of the exchange rates have been transformed to the quote $\frac{Foreign\ Currency}{US\ dollar}$, which is the one dollar unit price of foreign country currency. The estimation is also based on GARCH(1,1) process regression, which is consistent with table 4, equation (8) and (9). The parenthesis reports the robust standard error.

Panel A: G-10 Exchange Rates (Full Sample)

Parameters	*EUR*	*GBP*	*JPY*	*CAD*	*CHF*	*NOK*	*SEK*	*AUD*	*NZD*
γ_0	0.049	-0.003	0.015	-0.016***	-0.027	-0.004	0.004	0.092**	0.034
	(0.024)	(0.032)	(0.030)	(0.000)	(0.041)	(0.012)	(0.030)	(0.034)	(0.057)
γ_1	0.017	-0.184**	0.014	0.051	0.189	0.104***	0.294***	0.007	-0.054
	(0.070)	(0.094)	(0.096)	(0.083)	(0.132)	(0.000)	(0.087)	(0.160)	(0.158)
γ_2	-0.211*	-0.376**	0.654***	0.063	0.528**	0.608***	0.630***	0.135	0.050
	(0.126)	(0.175)	(0.169)	(0.068)	(0.241)	(0.197)	(0.236)	(0.282)	(0.361)
β_0	0.032*	0.016*	0.016	0.001***	0.027**	0.005	0.021*	0.012***	0.021**
	(0.016)	(0.011)	(0.011)	(0.000)	(0.016)	(0.005)	(0.012)	(0.002)	(0.006)
β_1	0.565*	0.083	0.516*	-0.188***	-0.025	-0.191***	-0.090**	-0.163***	-0.035
	(0.274)	(0.119)	(0.323)	(0.037)	(0.056)	(0.054)	(0.034)	(0.023)	(0.032)
β_2	0.041	0.609**	0.423*	1.063***	0.728***	1.113***	0.807***	1.030***	0.83***
	(0.282)	(0.234)	(0.214)	(0.053)	(0.241)	(0.06)	(0.139)	(0.040)	(0.052)
R^2	0.01	0.13	0.07	-0.03	0.13	0.09	0.123	-0.004	0.003
Durbin-Watson	1.41	2.00	2.30	1.66	1.84	1.88	1.98	2.12	1.83
Observations	79	79	79	79	79	79	79	79	79

*Notice: the code *** denote the significance level of $\alpha<0.01$; ** $\alpha<0.05$; * $\alpha<0.10$.*

Panel B: G-10 Exchange Rates (Subsample)

Parameters	*EUR*	*GBP*	*JPY*	*CAD*	*CHF*	*NOK*	*SEK*	*AUD*	*NZD*
γ_0	0.062**	0.012	0.004	-0.026	-0.072***	-0.027	-0.049**	0.037	0.012
	(0.025)	(0.037)	(0.028)	(0.025)	(0.002)	(0.039)	(0.020)	(0.056)	(0.068)
γ_1	0.018	-0.134***	0.066*	0.012	0.146	-0.006	0.115	0.051	-0.023
	(0.076)	(0.004)	(0.095)	(0.066)	(0.168)	(0.180)	(0.141)	(0.201)	(0.179)
γ_2	-0.053	-0.280	0.656***	0.067	0.333	0.387***	0.379	0.051	0.153
	(0.137)	(0.235)	(0.173)	(0.150)	(0.315)	(0.007)	(0.259)	(0.376)	(0.432)
β_0	0.038*	0.000	0.032*	0.009	0.002	0.002	0.001	0.005	0.046
	(0.019)	(0.005)	(0.021)	(0.011)	(0.007)	(0.005)	(0.005)	(0.006)	(0.298)
β_1	0.531*	-0.133	0.801*	0.069	-0.125	-0.144**	-0.126**	-0.177**	-0.015
	(0.243)	(0.128)	(0.426)	(0.131)	(0.071)	(0.053)	(0.051)	(0.087)	(0.146)
β_2	-0.066	1.140***	0.013	0.527	1.118***	1.124***	1.113***	1.000***	0.56
	(0.270)	(0.204)	(0.205)	(0.532)	(0.157)	(0.096)	(0.113)	(0.082)	(2.917)
R^2	-0.01	0.07	0.08	-0.01	0.05	0.04	0.06	0.006	0.004
Durbin-Watson	2.08	2.06	2.10	1.74	2.41	2.14	2.27	2.00	2.08
Observations	65	65	65	65	65	65	65	65	65

*Notice: the code *** denote the significance level of $\alpha<0.01$; ** $\alpha<0.05$; * $\alpha<0.10$.*

Panel C: Emerging Market Exchange Rates (Full Sample)

Parameters	*RUB*	*ZAR*	*PLN*	*RON*	*HUF*	*CZK*	*CLP*	*INR*	*MXN*	*BRL*
γ_0	-0.037	0.020	-0.066	-0.027***	-0.033	-0.05**	-0.028	0.003	-0.018***	0.195*
	(0.026)	(0.027)	(0.047)	(0.006)	(0.047)	(0.018)	(0.063)	(0.010)	(0.000)	(0.124)
γ_1	0.244***	0.008	0.099	-0.054	0.234	0.329***	0.105	-0.012	0.006***	0.820**
	(0.002)	(0.095)	(0.134)	(0.086)	(0.145)	(0.036)	(0.167)	(0.032)	(0.002)	(0.314)
γ_2	0.561**	0.450***	0.334	0.042	-0.031	0.840***	-0.430*	-0.088**	0.005*	-0.268
	(0.186)	(0.108)	(0.250)	(0.217)	(0.380)	(0.133)	(0.240)	(0.044)	(0.003)	(0.752)
β_0	-0.003**	0.001	0.023***	0.002**	0.009	0.009***	0.012**	0.001***	0.000	0.490
	(0.001)	(0.001)	(0.001)	(0.000)	(0.007)	(0.002)	(0.004)	(0.000)	(0.000)	(0.502)
β_1	-0.060***	0.138**	-0.112***	-0.231***	0.071	-0.160***	0.067	-0.075***	-0.049**	-0.475
	(0.007)	(0.065)	(0.016)	(0.057)	(0.082)	(0.043)	(0.068)	(0.015)	(0.022)	(0.238)
β_2	1.157***	0.781***	0.826***	1.115***	0.766***	0.982***	0.723***	0.912***	1.178***	0.593
	(0.037)	(0.044)	(0.043)	(0.100)	(0.128)	(0.091)	(0.100)	(0.032)	(0.038)	(0.511)
R^2	-0.003	0.04	0.08	-0.10	0.07	0.24	-0.04	-0.01	-0.18	-0.03
Durbin-Watson	2.08	2.47	2.33	0.81	1.75	1.62	1.89	1.85	1.34	1.19
Observations	79	79	79	49	79	79	79	79	79	79

*Notice: the code *** denote the significance level of $\alpha<0.01$; ** $\alpha<0.05$; * $\alpha<0.10$.*

Panel D: Emerging Market Exchange Rates (Subsample)

Parameters	*RUB*	*ZAR*	*PLN*	*RON*	*HUF*	*CZK*	*CLP*	*INR*	*MXN*	*BRL*
γ_0	0.048	0.024	-0.059*	-0.016	-0.053	-0.067	-0.040	-0.006	-0.014***	0.000
	(0.094)	(0.031)	(0.026)	(0.030)	(0.049)	(0.045)	(0.063)	(0.021)	(0.000)	(0.066)
γ_1	-0.304	0.006	0.174*	-0.084	0.129	0.238**	0.132	-0.051	-0.009***	-0.225
	(0.190)	(0.104)	(0.086)	(0.085)	(0.174)	(0.103)	(0.180)	(0.074)	(0.001)	(0.170)
γ_2	0.746	0.460***	-0.072	0.094	-0.575	0.326*	-0.654**	-0.169	0.003	-2.217***
	(1.627)	(0.114)	(0.204)	(0.101)	(0.506)	(0.208)	(0.278)	(0.128)	(0.451)	(0.542)
β_0	0.003	0.001	0.032*	0.001	0.008	0.002	0.010	0.005	0.000	0.158**
	(0.002)	(0.001)	(0.018)	(0.002)	(0.010)	(0.003)	(0.035)	(0.006)	(0.000)	(0.079)
β_1	-0.040***	0.199*	-0.538*	0.817	0.092	-0.119***	0.111	-0.071**	0.303	2.534**
	(0.004)	(0.096)	(0.336)	(0.572)	(0.124)	(0.039)	(0.218)	(0.026)	(0.251)	(0.987)
β_2	1.138***	0.765***	-0.116	0.427	0.768***	1.056***	0.741	0.565	1.131***	0.032
	(0.030)	(0.068)	(0.418)	(0.261)	(0.250)	(0.038)	(0.786)	(0.604)	(0.042)	(0.062)
R^2	-0.09	0.04	0.05	0.01	0.10	0.16	0.11	0.07	-0.12	-0.02
Durbin-Watson	1.99	2.09	2.76	1.95	1.22	1.83	1.74	1.99	1.50	1.46
Observations	65	65	65	35	65	65	65	65	65	65

*Notice: the code *** denote the significance level of $\alpha<0.01$; ** $\alpha<0.05$; * $\alpha<0.10$.*

Table 6, Monetary Policy Surprises on Equities: Response of Equity Index to Expected and Unexpected Component of Federal Fund Target Surprises (1989-2008)

Panel A (Full Sample):

Parameters	*S&P 500 (U.S.)*	*FTSE 100 (U.K.)*	*DAX (Germany)*	*Hang Seng (Hong Kong, PRC)*	*Nikkei 225 (Japan)*	*Ibovespa (Brazil)*
γ_0	0.099	0.042	0.148	0.093	0.011*	0.496*
	(0.098)	(0.075)	(0.076)	(0.165)	(0.069)	(0.320)
γ_1	-0.0262	-0.107	-0.061	0.154	0.211	-0.568
	(0.0262)	(0.197)	(0.185)	(0.880)	(0.213)	(0.610)
γ_2	0.282	-0.238	-0.094	0.769	0.624*	-1.421
	(0.457)	(0.396)	(0.423)	(0.974)	(0.355)	(3.294)
β_0	0.067	0.056**	0.044**	-0.081	0.098	1.557
	(0.065)	(0.027)	(0.021)	(0.071)	(0.063)	(7.570)
β_1	0.110	0.035	0.032	-0.038***	1.154**	-0.035
	(0.128)	(0.073)	(0.074)	(0.007)	(0.441)	(0.180)
β_2	0.717***	0.692***	0.765***	1.056***	0.210**	0.560
	(0.244)	(0.147)	(0.087)	(0.026)	0.083	(2.168)
R^2	0.02	0.02	0.00	-0.02	0.00	0.04
Durbin-Watson	1.99	2.36	1.90	2.07	2.17	2.22
Observations	79	79	79	79	79	60

*Notice: the code *** denote the significance level of $\alpha<0.01$; ** $\alpha<0.05$; * $\alpha<0.10$*

Panel B (Subsample):

Parameters	*S&P 500 (U.S.)*	*FTSE 100 (U.K.)*	*DAX (Germany)*	*Hang Seng (Hong Kong, PRC)*	*Nikkei 225 (Japan)*	*Ibovespa (Brazil)*
γ_0	-0.011	0.053	0.134*	0.041	0.080	0.393
	(0.075)	(0.077)	(0.084)	(0.061)	(0.081)	(0.523)
γ_1	0.091	-0.066	-0.024	0.314***	0.184	-0.298
	(0.267)	(0.202)	(0.267)	(0.014)	(0.228)	(1.341)
γ_2	-0.065	-0.030	-0.130	0.467**	0.172	-2.76
	(0.563)	(0.534)	(0.467)	(0.156)	(0.359)	(6.190)
β_0	0.031	0.330*	0.019	-0.002	0.245**	1.856
	(0.037)	(0.189)	(0.021)	(0.007)	(0.010)	(6.428)
β_1	0.311	0.180	0.138	-0.040***	0.636**	-0.044
	(0.234)	(0.289)	(0.147)	(0.004)	(0.283)	(0.149)
β_2	0.671***	-0.520	0.784***	1.142***	-0.038	0.567
	(0.197)	(0.684)	(0.157)	(0.043)	(0.038)	(1.567)
R^2	-0.02	0.00	0.01	-0.04	-0.06	0.03
Durbin-Watson	2.10	1.60	1.86	2.06	1.68	2.18
Observations	65	65	65	65	65	46

*Notice: the code *** denote the significance level of $\alpha<0.01$; ** $\alpha<0.05$; * $\alpha<0.10$*

Table 7: Monetary Policy Surprises on Commodities: Response of Crude Oil and Gold Prices to Expected and Unexpected Component of Federal Fund Target Surprises (1989-2008)

The estimation is also based on GARCH(1,1) process regression, which is consistent with table 4, equation (8) and (9). The parenthesis reports the robust standard error.

Panel A (Full Sample):

Parameters	*Gold Spot*	*WTI Oil Futures*
γ_0	0.015	0.045
	(0.046)	(0.121)
γ_1	-0.142	-0.020
	(0.136)	(0.365)
γ_2	-0.467*	0.266
	(0.053)	(0.907)
β_0	0.005**	0.319
	(0.002)	(0.256)
β_1	-0.112***	-0.109
	(0.036)	(0.076)
β_2	1.077***	0.788***
	(0.053)	(0.221)
R^2	0.08	-0.00
Durbin-Watson	2.00	1.88
Observations	79	79

*Notice: the code *** denote the significance level of $\alpha<0.01$; ** $\alpha<0.05$; * $\alpha<0.10$*

Panel B (Subsample):

Parameters	*Gold Spot*	*WTI Oil Futures*
γ_0	-0.049	0.004
	(0.056)	(0.091)
γ_1	-0.212	0.422
	(0.175)	(0.334)
γ_2	-0.570*	0.118
	(0.278)	(0.818)
β_0	0.043	0.060
	(0.032)	(0.062)
β_1	-0.058	-0.157*
	(0.061)	(0.087)
β_2	0.90**	1.092***
	(0.265)	(0.059)
R^2	0.04	0.02
Durbin-Watson	1.82	1.84
Observations	65	65

*Notice: the code *** denote the significance level of $\alpha<0.01$; ** $\alpha<0.05$; * $\alpha<0.10$*

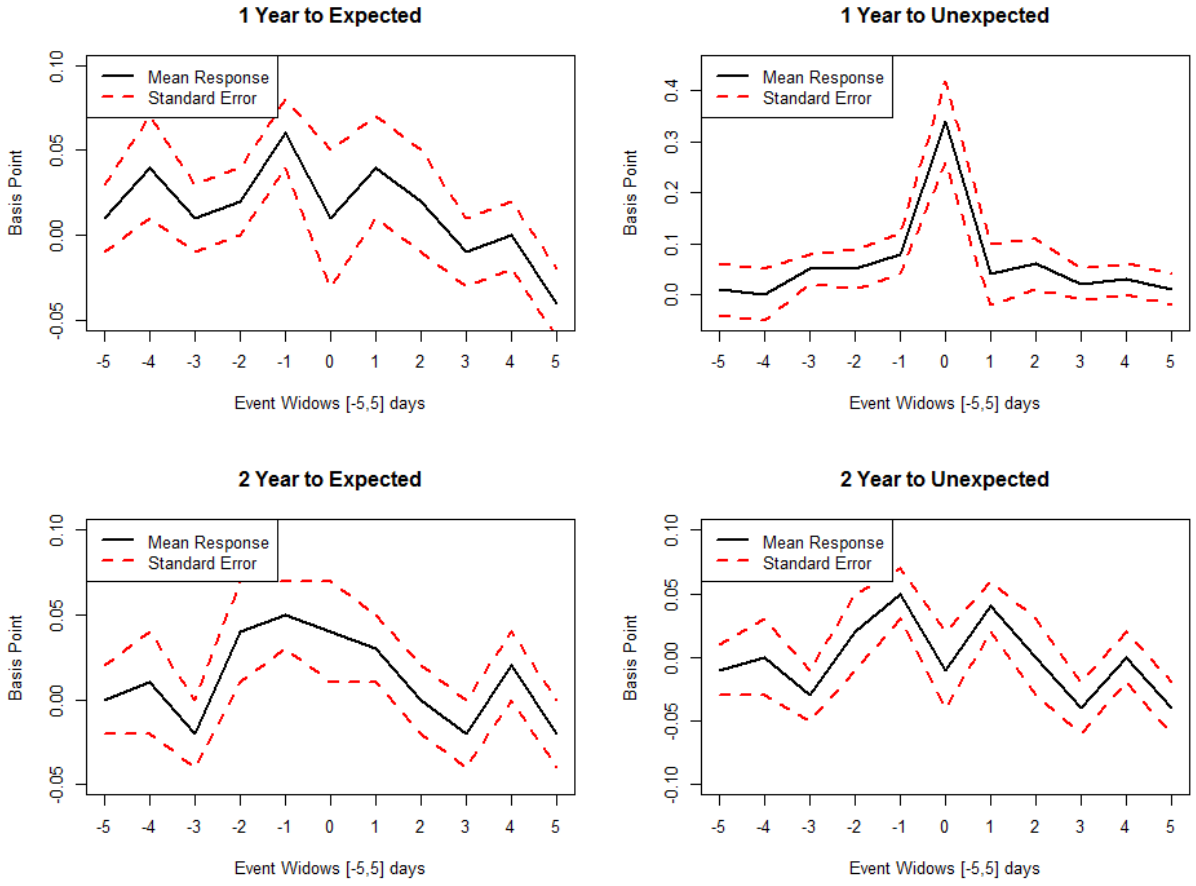
Table 8: Treasury Bond's Response to Monetary Policy Surprises: Response of Interest Rates to Expected and Unexpected Component of Federal Fund Target Surprises (1989-2008), Extended Estimation Windows.

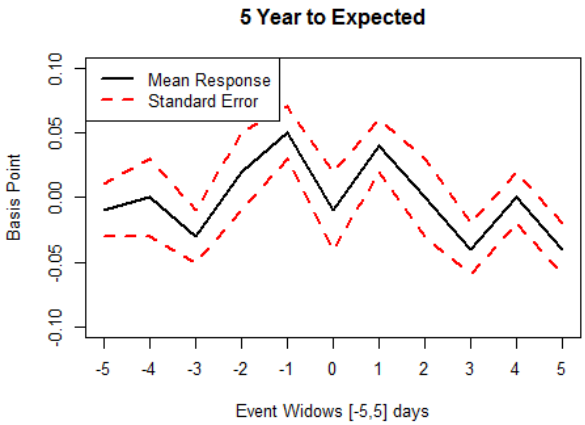
Treasuries	*Expected Policy Effect*											*Unexpected Policy Effect*										
	Event Days											*Event Days*										
	-5	-4	-3	-2	-1	0	1	2	3	4	5	-5	-4	-3	-2	-1	0	1	2	3	4	5
3 months	-0.02	0.02	0.03	0.04*	0.04**	**0.18*** **	0.08***	0.03	-0.11***	-0.02	0.01	0	0.01	0.06*	0.10*	0.11***	**0.44*** **	0.10*	0.06	0.10***	0.01	-0.01
	(0.03)	(1.09)	(0.02)	(0.02)	(0.02)	**(0.03)**	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.05)	(0.04)	(0.03)	(0.05)	(0.04)	**(0.05)**	(0.06)	(0.05)	(0.05)	(0.03)	(0.03)
6 months	0	0.04	0.02	0.05*	0.03**	**0.10*** **	0.05**	0.03	-0.08***	-0.00	0.00	0.04	0.03	0.04	0.08*	0.11***	**0.37*** **	0.09**	0.01	0.06	0.08***	-0.03
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	**(0.03)**	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)	**(0.03)**	(0.05)	(0.04)	(0.04)	(0.03)	(0.03)
12 months	0.01	0.04	0.01	0.02	0.06***	**0.01**	0.04	0.02	-0.01	-0.00	-0.04**	0.01	0	0.05	0.05	0.08**	**0.34*** **	0.04	0.06	0.02	0.03	0.01
	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	**(0.04)**	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.05)	(0.05)	(0.03)	(0.04)	(0.04)	**(0.08)**	(0.06)	(0.05)	(0.03)	(0.03)	(0.03)
2 year	0	0.01	-0.02	0.04	0.05	**0.04**	0.03	-0.00	-0.02	0.02	-0.02	0.04	0.08	0.03	0.09	0.07**	**0.31*** **	0.03	-0.00	0.04	0.03	-0.04
	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)	**(0.03)**	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)	(0.05)	(0.04)	(0.06)	(0.04)	**(0.06)**	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)
5 year	-0.01	0	-0.03	0.02	0.05***	**-0.01**	0.04	0.00	-0.04*	0.00	-0.04**	0.04	0.05	0.03	0.07	0.04	**0.23*** **	0.02	-0.04	0.00	0.03	-0.03
	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)	**(0.03)**	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.04)	(0.05)	(0.04)	(0.06)	(0.03)	**(0.06)**	(0.04)	(0.05)	(0.04)	(0.03)	(0.04)
10 year	-0.01	0	-0.04*	0	0.03**	**-0.04***	0.06***	0.01	-0.03	-0.00	-0.03	0.02	0.05	0.01	0.06	0.02	**0.09***	0.02	-0.03	0.02	0.02	-0.01
	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	**(0.02)**	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)	(0.04)	(0.04)	(0.05)	(0.03)	**(0.04)**	(0.06)	(0.04)	(0.04)	(0.03)	(0.04)
30 year	0	0.01	-0.04*	-0.01	0.03*	**-0.07***	0.07***	0.02	-0.01	-0.01	-0.02	0.03	0.07	0.01	0.03	0.01	**0.02**	-0.01	-0.03	0.02	0.02	0.03
	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	**(0.04)**	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)	(0.05)	(0.03)	(0.04)	(0.03)	**(0.06)**	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)

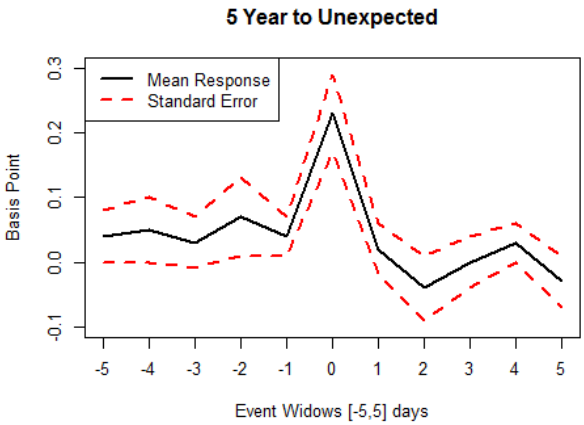
*Notice: the code *** denote the significance level of α<0.01; ** α<0.05; * α<0.1*

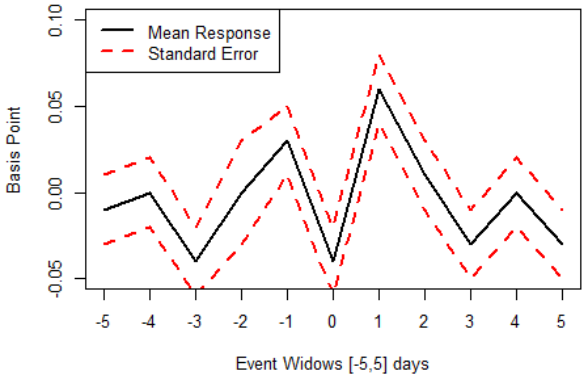
Table 8 reports the results of extended horizon regression: $R_{t+i} = \gamma_{0i} + \gamma_{1i}\Delta FFR_t^{expected} + \gamma_{2i}\Delta FFR_t^{unexpected} + \varepsilon_{t+i}, i \in [-5, 5]$ which are event days in the regression. The bracket reports the robust standard error. We estimate the coefficients of effects from expected and unexpected components of the monetary policy shock by using OLS.

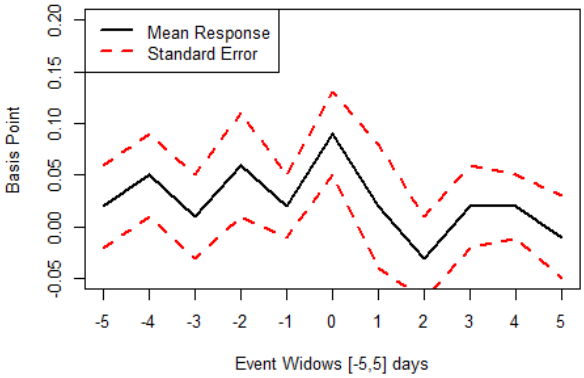
Figure 6: The Coefficients of the Monetary Policy Shock to each Yield of Treasury Bonds

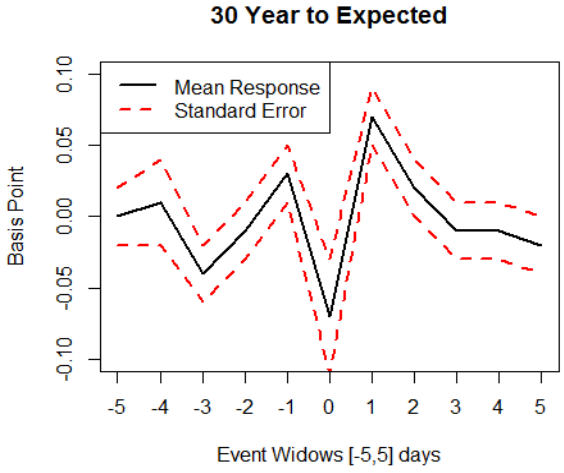



5 Year to Expected
Mean Response
Standard Error
Basis Point
0.10
0.05
0.00
-0.05
-0.10
-5 -4 -3 -2 -1 0 1 2 3 4 5
Event Widows [-5,5] days


5 Year to Unexpected
Mean Response
Standard Error
Basis Point
0.3
0.2
0.1
0.0
-0.1
-5 -4 -3 -2 -1 0 1 2 3 4 5
Event Widows [-5,5] days


10 Year to Expected
Mean Response
Standard Error
Basis Point
0.10
0.05
0.00
-0.05
-5 -4 -3 -2 -1 0 1 2 3 4 5
Event Widows [-5,5] days


10 Year to Unexpected
Mean Response
Standard Error
Basis Point
0.20
0.15
0.10
0.05
0.00
-0.05
-5 -4 -3 -2 -1 0 1 2 3 4 5
Event Widows [-5,5] days


30 Year to Expected
Mean Response
Standard Error
Basis Point
0.10
0.05
0.00
-0.05
-0.10
-5 -4 -3 -2 -1 0 1 2 3 4 5
Event Widows [-5,5] days

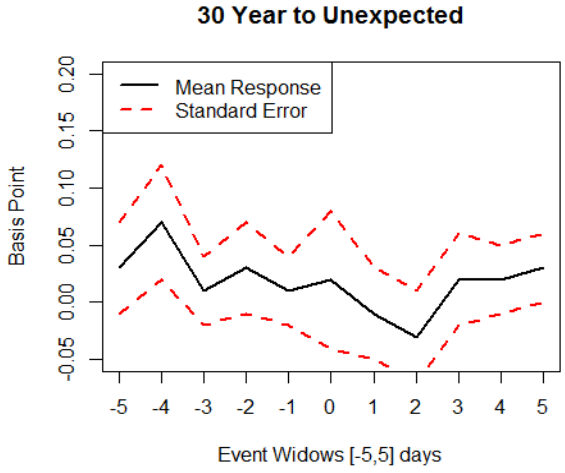

30 Year to Unexpected
Mean Response
Standard Error
Basis Point
0.20
0.15
0.10
0.05
0.00
-0.05
-5 -4 -3 -2 -1 0 1 2 3 4 5
Event Widows [-5,5] days

Table 9: Exchange Rate's Response to Monetary Policy Surprises: Response of Interest Rates to Expected and Unexpected Component of Federal Fund Target Surprises (1989-2008), Extended Estimation Windows.

Currencies	*Expected Policy Effect*											*Unexpected Policy Effect*										
	Event Days											*Event Days*										
	-5	-4	-3	-2	-1	0	1	2	3	4	5	-5	-4	-3	-2	-1	0	1	2	3	4	5
EUR	0.24***	-0.09	-0.07	-0.03	-0.03	**0.02**	-0.13	0.08	0.04	0.06	0.07	-0.01	0.08	0.07	0.12	0.12	**-2.11***	-0.35*	0.10	0.28*	-0.24	0.37*
	(0.08)	(0.11)	(0.11)	(0.09)	(0.09)	**(0.07)**	(0.12)	(0.11)	(0.10)	(0.10)	(0.10)	(0.15)	(0.19)	(0.19)	(0.17)	(0.17)	**(0.13)**	(0.22)	(0.21)	(0.19)	(0.18)	(0.18)
GBP	0.10	-0.20**	-0.12	0.11	-0.05	**-0.18****	0.05	0.27**	-0.10	0.09	0.06	0.03	0.17	0.09	-0.08	-0.29	**-0.38****	-0.50***	0.08	0.24	0.05	0.41**
	(0.09)	(0.08)	(0.09)	(0.09)	(0.13)	**(0.09)**	(0.09)	(0.10)	(0.09)	(0.08)	(0.09)	(0.17)	(0.16)	(0.17)	(0.16)	(0.23)	**(0.18)**	(0.16)	(0.19)	(0.17)	(0.12)	(0.17)
JPY	-0.02	0.02	0.05	0.01	0.01	**0.01**	-0.12	-0.21	0.07	-0.13	-0.07	0.27	-0.19	0.07	0.09	0.09	**0.65*****	-0.22	0.14	-0.03	0.00	-0.19
	(0.11)	(0.10)	(0.11)	(0.09)	(0.09)	**(0.10)**	(0.11)	(0.10)	(0.09)	(0.08)	(0.12)	(0.21)	(0.19)	(0.20)	(0.17)	(0.17)	**(0.17)**	(0.21)	(0.18)	(0.17)	(0.14)	(0.21)
CAD	-0.11	0.18***	0.02	-0.02	-0.02	**0.05**	-0.06	0.06	0.03	-0.05	-0.00	-0.48***	-0.03	0.02	-0.10	-0.10	**0.06**	0.37**	-0.18	0.12	0.23*	-0.02
	(0.09)	(0.06)	(0.07)	(0.05)	(0.05)	**(0.08)**	(0.08)	(0.08)	(0.08)	(0.08)	(0.06)	(0.16)	(0.12)	(0.13)	(0.09)	(0.09)	**(0.07)**	(0.15)	(0.15)	(0.14)	(0.14)	(0.12)
CHF	-0.15	0.16	-0.03	0.09	0.09	**0.19**	0.18	-0.23**	-0.03	-0.02	-0.08	0.24	-0.13	0.04	-0.02	-0.02	**0.53*****	0.11	0.10	-0.23	0.11	-0.42**
	(0.10)	(0.12)	(0.10)	(0.11)	(0.11)	**(0.13)**	(0.14)	(0.11)	(0.11)	(0.07)	(0.11)	(0.18)	(0.21)	(0.19)	(0.19)	(0.19)	**(0.24)**	(0.26)	(0.20)	(0.21)	(0.14)	(0.20)
NOK	-0.21	0.20	-0.01	-0.03	0.17	**0.10*****	0.21*	-0.36**	-0.01	-0.10	-0.04	-0.03	0.12	0.14	0.01	0.65***	**0.61*****	0.45*	0.06	-0.27	0.01	-0.44**
	(0.12)	(0.13)	(0.11)	(0.10)	(0.10)	**(0.00)**	(0.14)	(0.13)	(0.11)	(0.08)	(0.10)	(0.22)	(0.24)	(0.21)	(0.18)	(0.19)	**(0.20)**	(0.25)	(0.23)	(0.21)	(0.15)	(0.19)
SEK	-0.25	0.24**	0.07	-0.08	-0.08	**0.29*****	0.18	-0.25**	-0.03	-0.13	-0.02	0.15	-0.11	0.05	-0.13	-0.13	**0.63*****	0.41*	0.01	-0.34	-0.06	-0.35*
	(0.11)	(0.11)	(0.13)	(0.10)	(0.10)	**(0.09)**	(0.14)	(0.10)	(0.10)	(0.11)	(0.11)	(0.20)	(0.20)	(0.24)	(0.18)	(0.18)	**(0.24)**	(0.26)	(0.19)	(0.19)	(0.20)	(0.20)
AUD	0.19*	-0.10	-0.14	-0.08	-0.08	**0.01**	-0.13	0.02	-0.07	-0.08	0.19*	0.04	-0.05	0.34	0.18	0.18	**0.14**	-0.34	0.15	0.38**	-0.06	0.01
	(0.10)	(0.10)	(0.17)	(0.11)	(0.11)	**(0.16)**	(0.14)	(0.11)	(0.10)	(0.11)	(0.11)	(0.19)	(0.19)	(0.31)	(0.20)	(0.20)	**(0.28)**	(0.26)	(0.20)	(0.18)	(0.20)	(0.20)
NZD	0.15	-0.11	-0.14	-0.08	-0.08	**-0.05**	-0.21	-0.07	0.03	-0.02	0.08	0.14	-0.12	0.46	0.13	0.13	**0.05**	-0.64**	0.22	0.14	0.20	0.31**
	(0.12)	(0.10)	(0.17)	(0.11)	(0.11)	**(0.16)**	(0.13)	(0.12)	(0.10)	(0.11)	(0.08)	(0.21)	(0.19)	(0.31)	(0.20)	(0.20)	**(0.36)**	(0.24)	(0.21)	(0.18)	(0.21)	(0.15)
RUB	-0.25	0.13*	-0.06	0.06	-0.02	**-0.30**	0.02	-0.21	-0.17	0.01	0.05	0.00	-0.30	-0.24	-0.12	0.00	**0.56****	0.14	0.12	0.01	-0.00	-0.09
	(0.25)	(0.08)	(0.18)	(0.12)	(0.14)	**(0.19)**	(0.10)	(0.29)	(0.22)	(0.08)	(0.05)	(0.63)	(0.21)	(0.47)	(0.30)	(0.35)	**(0.19)**	(0.26)	(0.72)	(0.55)	(0.20)	(0.14)
ZAR	-0.04	0.07	-0.04	-0.09	-0.10	**0.01**	-0.07	0.21	-0.22	-0.08	-0.14	-0.84**	0.30	0.20	0.23	0.53*	**0.45*****	0.19	0.31	-0.38	0.08	-0.24
	(0.19)	(0.16)	(0.12)	(0.10)	(0.16)	**(0.10)**	(0.14)	(0.16)	(0.15)	(0.15)	(0.11)	(0.35)	(0.30)	(0.21)	(0.19)	(0.29)	**(0.11)**	(0.25)	(0.30)	(0.28)	(0.27)	(0.20)
PLN	-0.24	0.12	0.21*	-0.11	0.04	**0.17***	0.02	0.05	0.01	0.03	-0.01	-0.45	-0.55	0.19	-0.35	0.81	**0.33**	0.23	0.04	-0.60**	0.15	-0.12
	(0.14)	(0.11)	(0.11)	(0.10)	(0.18)	**(0.09)**	(0.13)	(0.14)	(0.12)	(0.14)	(0.11)	(0.35)	(0.28)	(0.28)	(0.25)	(0.46)	**(0.25)**	(0.34)	(0.34)	(0.30)	(0.35)	(0.27)
RON	-0.06	-1.71	0.02	-0.29	-0.01	**-0.08**	0.08	0.04	0.02	0.04	-0.04	-2.87	-6.03	0.25	-2.60**	0.30	**0.04**	0.30	-0.41	-0.45	0.25	-0.18
	(1.08)	(2.40)	(0.14)	(0.70)	(0.14)	**(0.08)**	(0.12)	(0.17)	(0.32)	(0.20)	(0.11)	(1.84)	(4.07)	(0.23)	(1.19)	(0.24)	**(0.22)**	(0.22)	(0.32)	(0.55)	(0.34)	(0.18)
HUF	-0.18	0.17	0.08	-0.07	0.22	**0.13**	0.10	-0.00	-0.12	-0.08	-0.17*	-0.44	-0.40	-0.03	0.05	0.70*	**-0.03**	0.66**	0.13	-1.03**	-0.00	-0.14
	(0.12)	(0.11)	(0.12)	(0.10)	(0.15)	**(0.17)**	(0.13)	(0.13)	(0.11)	(0.13)	(0.10)	(0.31)	(0.28)	(0.31)	(0.25)	(0.39)	**(0.38)**	(0.33)	(0.32)	(0.27)	(0.34)	(0.24)
CZK	-0.12	0.14	0.17	-0.07	0.07	**0.24****	-0.07	-0.04	-0.06	-0.01	-0.11	-0.60**	0.29	0.12	-0.18	0.62*	**0.84*****	-0.06	0.04	-0.94***	0.14	-0.30
	(0.12)	(0.15)	(0.12)	(0.10)	(0.13)	**(0.10)**	(0.14)	(0.10)	(0.10)	(0.14)	(0.11)	(0.31)	(0.39)	(0.30)	(0.26)	(0.33)	**(0.13)**	(0.34)	(0.26)	(0.26)	(0.35)	(0.29)
CLP	0.08	0.14	0.07	0.08	-0.01	**0.13**	-0.07	-0.13	-0.09*	-0.02	0.09	-0.50**	0.29	0.16	-0.18	-0.01	**-0.43***	0.50***	-0.02	0.09	0.19	0.04
	(0.11)	(0.15)	(0.13)	(0.10)	(0.10)	**(0.18)**	(0.08)	(0.11)	(0.05)	(0.09)	(0.08)	(0.21)	(0.39)	(0.25)	(0.18)	(0.17)	**(0.24)**	(0.15)	(0.20)	(0.10)	(0.16)	(0.15)
INR	-0.04	0.08**	0.09	-0.03	-0.02	**-0.05**	0.03	0.06*	-0.03	-0.07	-0.06	-0.11*	-0.13	-0.03	-0.10	0.03	**-0.09****	0.06	0.00	0.03	0.04	-0.14
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	**(0.07)**	(0.03)	(0.04)	(0.07)	(0.06)	(0.05)	(0.07)	(0.07)	(0.07)	(0.07)	(0.08)	**(0.04)**	(0.06)	(0.07)	(0.13)	(0.11)	(0.10)
MXN	0.00	0.14	-3.83	0.01	0.01	**-0.01*****	0.00	0.01	0.01	0.01	0.01	0.00	0.29	-18.98	0.02***	0.01	**0.01***	-0.00	0.02**	0.02	-0.01	0.02**
	(0.01)	(0.15)	(13.10)	(0.00)	(0.00)	**(0.00)**	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)	(0.02)	(0.39)	(24.02)	(0.01)	(0.01)	**(0.00)**	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)
BRL	0.02	0.14	0.39**	-0.17	0.03	**-0.23**	-0.05	-0.01	0.16	-0.14	0.20	-0.76*	0.29	0.36	-0.20	0.55	**-0.27**	0.17	-0.73	-0.47	-0.22	0.22
	(0.18)	(0.15)	(0.15)	(0.21)	(0.16)	**(0.17)**	(0.16)	(0.20)	(0.13)	(0.17)	(0.18)	(0.43)	(0.39)	(0.36)	(0.50)	(0.37)	**(0.75)**	(0.37)	(0.46)	(0.29)	(0.40)	(0.41)

*Notice: the code *** denote significance level of $\alpha<0.01$; ** $\alpha<0.05$; * $\alpha<0.1$*

Table 10: Equity and Commodities' Response to Monetary Policy Surprises: Response of Interest Rates to Expected and Unexpected Component of Federal Fund Target Surprises (1989-2008), Extended Estimation Windows

Treasuries	*Expected Policy Effect*											*Unexpected Policy Effect*										
	Event Days											*Event Days*										
	-5	-4	-3	-2	-1	0	1	2	3	4	5	-5	-4	-3	-2	-1	0	1	2	3	4	5
S&P 500	-0.23	-0.17	0.11	0.26*	0.33	**-0.03**	0.33	0.17	-0.38	0.10	0.11	0.62*	0.13	0.27	-0.05	-0.72	**0.28**	-0.72	-0.65*	-0.01	-0.43	-0.19
	(0.18)	(0.16)	(0.19)	(0.17)	(0.25)	**(0.03)**	(0.25)	(0.21)	(0.27)	(0.18)	(0.25)	(0.33)	(0.31)	(0.36)	(0.32)	(0.50)	**(0.46)**	(0.50)	(0.41)	(0.46)	(0.31)	(0.45)
FTSE 100	-0.23	-0.25	-0.02	0.50	0.43**	**-0.11**	0.43**	0.02	-0.16	0.19	0.08	0.66**	0.67*	0.15	0.40	0.56	**-0.24**	0.55*	-0.36	0.01	-0.66	-0.15
	(0.17)	(0.19)	(0.18)	(0.38)	(0.20)	**(0.20)**	(0.20)	(0.19)	(0.23)	(0.23)	(0.23)	(0.31)	(0.34)	(0.35)	(0.67)	(0.38)	**(0.40)**	(0.38)	(0.34)	(0.40)	(0.40)	(0.39)
DAX	0.09	-0.43	-0.14	0.21	0.34	**-0.06**	0.34	0.13	-0.07	0.01	0.12	0.43	0.64	0.31	-0.32	0.43	**-0.09**	0.43	0.38	0.25	-0.67	-0.46
	(0.23)	(0.27)	(0.20)	(0.25)	(0.33)	**(0.19)**	(0.33)	(0.25)	(0.32)	(0.24)	(0.25)	(0.41)	(0.49)	(0.38)	(0.46)	(0.61)	**(0.42)**	(0.61)	(0.46)	(0.56)	(0.42)	(0.44)
Hang Seng	-0.32	-0.65**	0.10	0.50	-0.00	**0.15**	-0.00	-0.54	0.21	0.18	0.04	0.26	0.73	0.59	0.40	-0.47	**0.77**	-0.47	-2.84***	-1.04	0.67	-0.66
	(0.29)	(0.29)	(0.36)	(0.38)	(0.36)	**(0.88)**	(0.36)	(0.42)	(0.33)	(0.25)	(0.29)	(0.51)	(0.52)	(0.66)	(0.67)	(0.66)	**(0.97)**	(0.66)	(0.75)	(0.57)	(0.43)	(0.48)
Nikkei 225	-0.03	-0.21	-0.06	0.90***	-0.14	**0.21**	-0.14	-0.34	0.15	-0.45	-0.34	-0.27	0.43	1.42**	0.21	-0.08	**0.62***	-0.08	-1.54**	-0.52	-0.25	-0.23
	(0.28)	(0.24)	(0.32)	(0.26)	(0.32)	**(0.21)**	(0.32)	(0.31)	(0.26)	(0.35)	(0.29)	(0.55)	(0.43)	(0.57)	(0.46)	(0.57)	**(0.36)**	(0.57)	(0.56)	(0.49)	(0.64)	(0.51)
Ibovespa	0.60	-0.38	-0.19	0.15	0.55	**-0.57**	0.55	0.67	-0.87	-0.69	-0.26	1.35	1.52*	1.61	-2.91**	0.10	**-1.42**	0.10	0.42	-2.65	-1.69	1.77
	(0.86)	(0.49)	(0.57)	(0.58)	(0.43)	**(0.61)**	(0.43)	(0.52)	(0.92)	(0.55)	(0.91)	(1.56)	(0.86)	(1.01)	(1.04)	(0.78)	**(3.29)**	(0.76)	(1.01)	(1.71)	(1.04)	(1.66)
Gold Price	0.15	-0.14	-0.23*	-0.19	-0.09	**-0.14**	-0.09	0.23	-0.06	-0.09	-0.04	0.40	-0.15	0.30	0.12	-0.01	**-0.47***	-0.01	-0.64**	0.44**	-0.48*	0.30
	(0.15)	(0.18)	(0.12)	(0.14)	(0.16)	**(0.14)**	(0.16)	(0.16)	(0.12)	(0.15)	(0.15)	(0.27)	(0.33)	(0.22)	(0.26)	(0.29)	**(0.05)**	(0.29)	(0.29)	(0.22)	(0.27)	(0.28)
WTI Crude	0.89*	-0.59*	-0.49	0.33	0.87**	**-0.02**	0.87**	1.09***	0.01	-1.50***	0.26	1.92**	0.15	-0.34	1.00	-0.20	**0.27**	-0.20	0.74	-0.08	-0.03	1.03
	(0.46)	(0.34)	(0.38)	(0.49)	(0.36)	**(0.37)**	(0.36)	(0.36)	(0.47)	(0.50)	(0.47)	(0.85)	(0.62)	(0.72)	(0.92)	(0.74)	**(0.91)**	(0.74)	(0.69)	(0.82)	(0.86)	(0.86)

*Notice: the code *** denote significance level of $\alpha<0.01$; ** $\alpha<0.05$; * $\alpha<0.1$*