The asymmetric effects of monetary policy on stock market returns; state dependency asymmetries and directional asymmetries.

ERASMUS UNIVERSITY ROTTERDAM
Erasmus School of Economics
Department of Financial Economics

Supervisor: Prof. Kan Ji
Second reader: Prof. Haanappel, H.T.
Name: Elward Hugo Valstein
Student number: 318300
E-mail address: evalstein@hotmail.com

Abstract

There is somewhat of a consensus among economist that monetary policy changes impact stock market returns. However, there is no such broad consensus with respect whether there exists an asymmetric relationship between monetary policy and stock returns. This paper adds to the literature by testing two specific forms of asymmetry namely, state dependency asymmetries and directional asymmetries. The paper finds no evidence in support of the former asymmetry. With respect to the latter asymmetry the paper finds that monetary policy is more effective when the direction of previous monetary policy changes is reversed. Another finding, is that the evidence in favor of state dependency asymmetric effects seems to be driven by endogeneity biases. The findings suggest that the use of daily data is problematic with respect to estimating state dependency asymmetries and directional asymmetries. However, it is less problematic for the latter case.

Contents

I. Introduction

There is a relatively large literature which investigates the effect of monetary policy on stock returns. Within this literature there exists a scholarly consensus that monetary policy impacts the stock market. Yet, the possible *asymmetric properties* of monetary policy have been less investigated and are not subject to such a consensus. A common form of asymmetry is *state dependency asymmetry*. This form of asymmetry indicates that the effectiveness of monetary policy depends on the state of the economy. This form of asymmetry relates to the events that unfolded during the "The Great Depression". Ironically, in the run up to "The Great Depression", there were high hopes the US had embraced on a new era of unprecedented financial stability, due of the inception of the Federal Reserve Bank (Fed), which was called into being in 1913. Unfortunately, these hopes were painfully destroyed by the apparent inability of the Federal Reserve Bank to make an end to the Great Depression of 1929. Having lived through "The Great Depression", most economists in that time believed that monetary policy could effectively slow down economic growth but not increase it. This idea is reflected in Milton Friedman's Presidential Address at the 88th meeting of the American Economics Association. Friedman (1960, p. 1) stated that; "monetary policy was a string. You could pull on it to stop inflation but you could not push on it to halt recession. You could lead a horse to water but you could not make him drink." I investigate whether this in true in the context of the stock market. Is monetary policy equally effective at increasing stock returns during a recession compared to decreasing stock returns during an expansion? This is in essence a question of whether or not the relationship between monetary policy and stock returns has state dependency asymmetries.

The second type of asymmetry, namely directional asymmetry, relates to more modern times. More specifically, the years following the end of financial crisis of 2007 – 2009. During this period, most of the Eurozone economies fell in and out of multiple recession and some have even flirted with deflation. The weak economic performance stands in face of exceptionally loose monetary policy by the European Central Bank. This situation is reminiscent of "The Great Depression" but it is still fundamentally different. During "The Great Recession" the US economy was in recession, as I will point out this could be why it under performed. In contrast, following the end of the financial crisis, the Eurozone economies have been in situations where there was no recession and the ECB was still conducting expansionary policy. Yet, these economies have kept growing at unimpressive rates. This give weight to the idea that expansionary monetary policy is in and of itself not as effective as contractionary policy. Thus the fundamental question in more modern times is whether or not expansionary monetary policy is less effective compared to contractionary monetary policy. More generally, does the direction of monetary policy dictate its effectiveness? As most of the western world (and Japan) tries to understand how to optimally combat recessionary and deflationary pressures of the last decade(s), an accurate understanding of the possible asymmetric effects of monetary policy is becoming increasingly important. Most of the literature investigating the asymmetric effect of monetary policy has focused on the asymmetric relationship between monetary policy and output. Citing this literature, the paper zooms in by focusing on the asymmetric relationship between monetary policy and stock market returns. In summary I try to answer the following questions;

a. Is the effect of monetary policy state dependent?
b. Does the direction of monetary policy indicate its effectiveness?

The evidence suggests that the answer to the first question is "no". More specifically, the findings suggest that the effect of monetary policy is not state dependent. In other words, the effect does not dependent on whether or not the economy is in recession. In my paper I also find that monetary policy is even more effective during crises[1]. The second hypothesis is only accepted for a certain form of directional asymmetry. More explicitly, the results suggest that monetary policy is equally effective during recessions and expansions. However, monetary policy is more effective when the direction of previous monetary policy changes is reversed.

A contribution is made to the literature by focusing on the asymmetric effects of monetary policy on stock returns. Most literature on the asymmetric effects of monetary policy focuses on the real

[1] A crisis is defined as an extreme recession, this in regards to the last financial crisis. During "normal recession" endogeneity biases are expected to be small. However, during crises, endogeneity problems are expected to be very large. See literature review and, or appendix B for more details.

economy. Other studies investigating the asymmetric effect of monetary policy do so only as an afterthought. Furthermore, some highlights of this study are the use of daily data alongside intra-data. This is done to assess to which extent the use of daily data complicates identification of the effect. The findings suggest that the use of daily data is problematic with respect to estimating state dependency asymmetries and directional asymmetries. However, the evidence in support of a specific type of directional asymmetry is robust to the use of daily data.

The paper is organized as follows, section II reviews the relevant literature, section III outlines the theoretical framework that is employed, section IV describes the data, section V presents the results, section VI presents the conclusion.

II. Literature Review

The empirical relationship between monetary policy and the stock market has been extensively studied by economists. To empirically investigate the effect of monetary policy, studies in the early 70's used money supply data (Sellin, 2001). Using M1 as proxy for monetary policy, most of these studies found that monetary policy change impact stock market returns. A weakness of these types of studies is that it is not clear whether the money supply data is not actually money demand data[2]. More specifically, if velocity correlates with stock returns then the findings of these papers are difficult to interpret. This ambiguity could result in multiple interpretations of the estimated effect. In other words, the estimates of these types of regressions could suffer from the reverse causality bias. This is probably why more recent literature makes use of the event study methodology which involves looking at the effect of monetary policy immediately after a monetary policy announcement (Sellin, 2001).

Preliminary studies using this methodology were conducted almost exclusively on quarterly or monthly data for US. One can argue that the use of high frequency data could solve a few of the aforementioned endogeniety problems. As result, researchers started using higher frequency data

[2] The findings of these aforementioned studies were disputed, among others, by Cooper (1974) and (Rogalski & Vinso, 1977).

such as daily or weekly data on money supply announcements, discount rate changes, changes in the Fed funds target rate and open market operations. An example of such a study is Berkman (1978), the author uses data on money supply announcements and finds evidence which suggest that stock returns are negatively related to money supply announcements. The author also argues that stock returns only respond to unexpected changes in monetary policy. This is to be expected when stock market actors are forward looking.

In related work, Kuttner (2001) distinguishes between expected monetary policy changes and unexpected monetary policy changes by using federal funds future instead of money supply announcements. To achieve this goal Kuttner constructs a proxy which measures expected and unexpected monetary policy changes using federal funds futures data. The author then presents evidence which suggests *unexpected* monetary policy changes impact bonds, bills and treasury securities whereas change in *expected* monetary policy change do so to a much lesser extent. Following Kuttner (2001), most of the recent relevant studies use changes in the federal funds futures settlement prices as a measure of unexpected changes in monetary policy.

A widely cited example of such a study is Bernanke and Kuttner (2005), the authors conducted an event study analysis for period from 1989 till 2002. The paper presents evidence which suggests that that there is a negative relationship between monetary policy and stock returns. Another example of such a study is Thorbecke (1997), the authors employ a vector autoregressive model and subsequently find evidence that suggests that monetary policy and stock market returns are inversely related. Similar to Bernanke and Kuttner, Bredin et al. (2007) conduct an event study using federal funds future data and estimate the effect of monetary policy on aggregate and sectoral stock returns in the United Kingdom. They find evidence in line with the two previously mentioned studies, more explicitly, they find evidence of a negative relationship between monetary policies and stock market returns.

Many papers that study the effect of monetary policy on stock returns use daily data. However, one could argue that the use of daily data results in estimates that suffer from multiple endogeneity biases[3]. Specifically, there are two main identification issues that plague this strain of economic literature. First, as shown by Leitem and Bjornland (2009), and Rigobon and Sack (2001), the causality can run both ways. In other words, monetary policy could be implemented in response to developments in the stock market, instead of the other way around[4]. Secondly, as pointed out by Bernanke and Kuttner (2005), using daily data could also result in biased estimates due to omitted variable biases.

Some papers have argued that using intra-day data instead of daily data can remedy these aforementioned endogeneity problems. Interestingly, most of these studies also find that there is a negative relationship between monetary policy and stock market returns. For example, using intra-day data Gurkaynak, Sack and Swanson (2004) investigates the period from 1990 to 2004. The authors find evidence which suggests that there is a negative relationship between monetary policy and stock market returns. They also present evidence which suggests that FOMC statements have a greater effect on stock prices than the respective current monetary policy stance. Most papers using intra-day data have generally found the same results as studies using daily data. This suggests that the endogeneity bias is not likely to be the significant driver of negative relationship found in the literature. Likewise, Rigobon and Sack (2004) argues that the results of event studies using daily data will probably not significantly differ from the results of studies using intra-day data. Yet, Kurov and Gu (2016) argue that these biases can become larger during crisis periods. This will be discussed in greater detail in a later part of this paper.

Other studies have tried using other statistical methods to solve the endogeneity problems. Rigobon and Sack (2002) develop a new estimator that uses the heteroscedasticity that exists in high frequency data to get consistent estimates of the effect of monetary policy. Martin and Crain (2003) specify a more general model using daily data and a more efficient estimator. Both these studies find results that are similar to those obtained using event study analysis.

[3] A more detailed review of these issues is given under the data section.

[4] However, Bernanke and Gettler (1999) argue that central banks should not respond to changes in asset prices.

Up until this point, most of the papers, that I have mentioned, focus on finding the effect of monetary policy on stock returns while assuming a "*symmetrical"* relationship between monetary policy and stock returns. However, there has been surprisingly little empirical and theoretical work done on the possible "*asymmetric"* effects of monetary policy on stock returns[5]. Nevertheless, there are two commonly proposed asymmetrical relationships between monetary policy and stock returns, namely directional asymmetries and state dependency asymmetries. The former states, that the effectiveness (magnitude) of a monetary policy action depends on the direction of the monetary policy change. The latter states that, the effectiveness of monetary policy is dependent on the state of the economy. In other words, the effectiveness of monetary policy depends on whether or not the economy is in expansion, recession. As we will see some papers even distinguish between a third state, called crisis. Note that these definitions do not account for the fact that expansionary monetary policy is mostly conducted during recessions. Furthermore, the results regarding these two categories of asymmetries are mixed.

First, with respect to directional asymmetries, studies using monthly, daily and intra-day data all find mixed results. For example, Lim, Sum, and Khun (2012) use daily data to investigates if the stock returns of the 14 largest bank holding companies in the United States respond asymmetrically to monetary policy. The authors present evidence which suggests that the relationship between monetary policy and stocks returns is negative and *not* directionally asymmetric. In contrast, other studies find evidence in line with an asymmetrical relationship. For example, Bernanke and Kuttner (2005) investigate the case of directional asymmetric effects using monthly data and daily data. Using monthly data, the authors *do not* find evidence in line with the existence of asymmetries. However, when the authors re-do the analysis using daily data they *do* find evidence that suggests there is an asymmetric relationship but this evidence is rather "weak". This suggests that not employing high frequency data could bias the results towards concluding that there are no asymmetric effects. This line of thinking is supported by the findings of recent papers that use

[5] Most papers only vaguely touch upon this topic and the few papers that do research this topic are mostly investigating the possible asymmetric relationship between monetary policy, on one hand, and GDP and/or inflation, on the other hand.

intra-day data. For example, Chulia et al. (2010) use intra-day data and firm-level data and finds evidence which suggest that, in absolute terms, expansionary policy has a bigger impact on stock returns compared to contractionary monetary policy.

Another example study that uses intraday data and finds similar results is Nakazono and Ikeda (2016). This paper that uses intra-day data to investigate directional asymmetric effects of unconventional monetary policy in Japan. More specifically, Nakazono and Ikeda (2016) focuses on the effect of unconventional monetary policy conducted by the Bank of Japan from 2001 to 2006. The authors distinguish between monetary policy tightening and monetary policy loosening and presents evidence which suggests that the effect of monetary policy loosening on stock returns is positive. However, rather surprisingly, the paper also presents evidence which suggests that the effect of unconventional monetary policy tightening on the stock returns is also positive. Ultimately, with respect to the existence of directional asymmetries even the results of papers using intra-day data are mixed.

As, mentioned earlier, state dependency is the second common form of asymmetry that is proposed by the literature. Interestingly, with respect to state dependency asymmetries, studies using monthly, daily and intra-day data also find mixed results. For example, Chen (2007) uses multiple monetary policy proxies at a monthly data frequency to argue that monetary policy has a greater effect during bear markets compared to bull markets. Other papers distinguish between expansions (economic booms), recessions (economic busts) and crisis. These papers tend to argue that during economic booms and economics busts the relationship between monetary policy and stock market returns is negative but during crisis it become positive. For example, Kontonikas, MacDonald and Saggu (2013) conduct an event study analysis using daily data and find evidence which suggests that, during the global financial crisis of 2007 and 2008, the relationship was positive. The explanation that the authors provide for this sign reversal is that during periods of crisis an unexpected federal funds rate cut is actually seen as bad news by the investors. This triggers a flight to safety mechanism where investors are less likely to prefer risky assets and thus invest less in stocks. Thus the net result is that a rate cut eventually leads to lower stock prices. Florackis, Kontonikas and Kostakis (2014), Gregoriou, Kontonikas, MacDonals and Montagnoli, (2009) use data from on the United Kingdom and find similar evidence.

These aforementioned findings on the state dependency of monetary policy have been disputed by Kurov and Gu (2016). The authors present evidence which suggests that there is a *stronger* negative relationship during crisis periods compared to normal times. The authors argue that the apparent sign reversal found in studies using daily data is probably caused by an increase in the presence of reverse causality and omitted variable biases during a crisis.

First, the case for state dependency is investigated. Second, the case for directional asymmetries is investigated. Third, in light of the fact that Bernanke and Kuttner (2005) finds evidence of asymmetries when using daily data but this evidence evaporates when monthly data is used. This paper investigates whether, better identification in the form of high frequency data (i.e. intra-day data) leads to more evidence in support of an asymmetric relationship between monetary policy and stock returns.

III. The Mechanisms of Asymmetric Impacts of Monetary Policies on Stock Returns

In the following section, I will present a variety of ways in which monetary policy can influence stock returns. There are numerous theoretical models that try to explain the way in which monetary policy can impact the stock market (Sellin, 2001). Nevertheless, I focus on the possible asymmetric effects of monetary policy on stock returns. Within the literature there are four commonly proposed mechanisms through which the effect of monetary policy on output can exhibit asymmetric properties[6].

Firstly, it is plausible that during recessions firms and consumer lose trust in the economy, or in parts of it like the stock market. In other words, it is possible that firms and consumers become more pessimistic during recessions. The implication of this is that firms keep on divesting in the face of monetary policy. However, this idea loses weight in light of the fact that it is also possible

[6] For a more detailed account of these mechanisms see Donald (1993) and Florio (2004).

for firms and consumers to become more optimistic during expansions. The implication of this is that it is also possible that firms keep investing in the face of tight monetary policy. Given these two possibilities, the mechanism would only predict asymmetric response to monetary policy if people are more pessimistic during expansions than they are optimistic during recessions. Except for some behavioral arguments, it is difficult to argue why this would be the case.

Secondly, a possible mechanism through which monetary policy could have asymmetric effects is based on theory regarding the term structure of interest and expected inflation. In keeping with the theory of expectations of the term structure of interest, we get the following relationship,

$$i_{n,t} = \frac{1}{n+1}\sum_{i=0}^{n} E_t i_{t+i} \qquad (1)$$

Where $i_{n,t}$ is the n period interest rate and is equal to the average of the spot rate and the n period future short term rates. Following, Fishers identity we get the following equation by adding inflation expectations to the previous equation,

$$i_{n,t} = \frac{1}{n+1}\sum_{i=0}^{n} E_t r_{t+i} + \frac{1}{n+1}\sum_{i=0}^{n} E_t \pi_{t+i} \qquad (1.1)$$

Equation (1.1) represents the n period nominal interest rate on a bond, where similarly to equation (1), $E_t r_{t+i}$ is the expected interest rate at t+n at time t. If we assume rational expectations then, on average, the investments done by firms increase their income. Furthermore, firms their investment decisions are based, in part, on long-term rates. From equation (1.1) we see that long-term rates depend on short-term rates and on inflation expectations. Evidently, a change in the short term rate by a central bank can fall short of achieving a change in the long term rate. For example, a significant reduction in the federal funds rate, to raise output, might fail to decrease long term rates because of inflation expectations. On the other hand, an increase in the federal fund rate, to tame inflation, immediately increases long term rates and thus decreases stock returns if it is credible commitment to reducing inflation. If it is not a credible commitment to taming inflation, then an increase would not impact inflation expectation and thus inflation would remain high or increase.

The prediction of this theoretical model makes hinges on a critical assumption about inflations expectations. More specifically, there is a principle difference between the inflation expectations under loose monetary policy and tight monetary policy. It assumes that when central banks cut rates, inflation expectations adapt quicker in comparison to rate hikes. However, this is not self-evident.

Thirdly, one of the more compelling arguments in support of asymmetric monetary policy effects, hinges on the assumption of a convex supply curve. If this assumption is valid then aggregate demand shocks of the same magnitude, but of a different sign, would affect output in different magnitudes.

In contrast to the previous mechanisms there are relatively sound macro- and micro-economic theoretical foundations for assuming a convex supply curve. For example, the convex aggregate supply curve is a prediction of Keynesian macro-economic models of downwardly rigid but upwardly flexible wages and prices. Further support for the existence of a convex supply curve is found in the widely accepted macro-economic and micro-economic concept of decreasing marginal productivity. Other micro-economic justification for assuming convex supply curves are based on the existence of trend inflation and menu cost. These make it costly for the firms to adjust prices to the desired level. In this sticky price environment, the effect of monetary policy is asymmetric because positive trend inflation makes price increases more likely, than price decreases. For example, if there is an increase in the central bank's policy rate, then firms are less inclined to increase the price and more likely to decrease the quantity (output). In contrast, if there is a reduction in the policy rate, the firms are more inclined to adjust prices and less inclined to adjust quantity.

Fourthly, one could argue that the existence of credit market imperfections is another reason why there should be an asymmetric relationship between monetary policy and output growth. To illustrate this in more detail I examine the credit channel. This channel assumes that there are credit market imperfections which result in external funds being costlier than internal funds. This discrepancy in funding costs is explained by the existence of agency costs which cause the prices of external funds to contain external finance premiums. The credit channel can be sub-divided into two channels, namely, the *bank lending channel* and the *balance sheet channel*. Both effects operate separate from one another, thus the sum of both effects reflects the total effect of the credit channel. The *bank lending channel* is the more traditional mechanism through which monetary policy is affects output. In this channel a monetary policy tightening will result in a reduction of the supply of credit. As a result, some firms (mostly small and/or credit constrained firms) will not be able to get credit and thus will be force to reduce their investments (or go bankrupt). This reduction in investments will ultimately translate into lower output. The opposite holds true for a monetary loosening. The *balance sheet channel* is formalized, among others, by Bernanke and Gertler (1989). It is based on the existence of credit market imperfections, more specifically, asymmetric information which give rise to agency costs. These market failures result in external funds being costlier than internal funds. More specifically, the prices of external funds contain external finance premiums due to the agency costs. Furthermore, the relationship between agency costs and a firm's market value is negative. In other words, a high (low) market value reduces (increases) the agency costs because the market value acts as collateral. If we then assume that market values are pro-cyclical, this would imply that agency costs (and thus external finance premiums) increase during economic busts (recessions) and decrease during economic booms (expansions). Thus the effectiveness monetary policy depends on the phase of the business cycle. Within the literature there is some discussion on the whether monetary policy is more effective in expansions or recessions. Similar to, Kakes (1998) and Basistha and Kurov (2008), some papers argue that the effect of monetary policy is more effective during recessions compared to expansions. These papers argue that, during expansions, firms their funding needs will tend to be satisfied with internal funds (retained earnings). In expansions balance sheets will probably be strong and thus the external finance premium will be relatively low. As a result, the effect of monetary policy through this external finance premium will also be small. During recessions, retained earnings tend to be low, so firms will become more dependent on external finance. This would suggest that monetary policy is more effective during recessions compared to expansions.

Other papers, like Florio (2004), argue that firms will be less dependent on external finance during recession and more dependent on external finance during expansions. Under this assumption monetary policy will be less effective during recessions. Florio argues that during expansions, there are plenty of profitable investment opportunities and the demand for credit is high. If the amount of investment opportunities is good in relation to liquid assets, firms will tend to be constrained by their respective internal funds. In such a situation, monetary policy is going to be more effective because the credit constraint is more likely to be binding. As a result, a monetary contraction (tightening), to decrease output, will be effective. In contrast, a monetary expansion (loosening), in a recession, would not be as effective. During a recession, there are less profitable investment opportunities and the demand for credit is low. Thus the credit constraint is less likely to be binding. Monetary policy will thus not be as effective during recessions compared to expansions.

There is somewhat of a consensus in the literature that the third and the fourth proposed mechanisms are the most plausible. It should be noted that the third mechanism relates to directional asymmetries and the fourth mechanism relates to state dependency asymmetries. All of the aforementioned mechanisms relate to the effect of monetary policy on aggregate output. However, stock prices are the discounted value of all future dividends. In turn future dividends depend, among other things, on the output (sales) of a firm. Thus, in general, if monetary policy has asymmetric effects on output then it has asymmetric effects on the stock market (Sellin, 2001). This twin relationship is reflected by the fact that both the literature on the asymmetric effects on output as well as the literature on the asymmetric effects on the stock market, cite previously mentioned model of asymmetric information by Bernanke and Gertler (1989). A formal theoretical representation of this is beyond the scope of my paper. My paper focuses on assessing whether or not there is empirical evidence in support of an asymmetric relationship between stock returns and monetary policy.

This is done by testing the following null-hypotheses;

a. The effect of monetary policy is not state dependent.
b. The direction of monetary policy changes does not indicate its effectiveness.

IV. Data and Methodology

To investigate the effect of monetary policy on the stock market I employ an event study analysis using daily and intra-day data. The event study is conducted using OLS in combination with the so-called Huber-White sandwich estimators (White (1980), Huber (1973)). The time horizon that is investigated runs from 4th of February 1994 till the 16th of December 2008. The sample period begins at this specific day because this was the moment when the Federal Open Market Committee (FOMC) started its current policy of announcing monetary policy decisions immediately after the meeting. Pre-1994, these decisions had to be inferred from the open market operations that followed in the wake of the FOMC meetings. Prior to this day the market only became aware of a change in the federal fund target rate when it was implemented by the Open Market Desk. This implementation was usually done one day after the target rate change[7]. The choice to exclude rate changes pre-1994 will probably not influence my findings as Bernanke B. and Kuttner N. (2005) shows that adding this period to the sample had not led to significantly different results. The full sample consist of 129 FOMC announcements which consist of 31 rate hikes, 28 rate cuts and 70 instances where the rate was not changed. Of these FOMC announcements 9 were not unscheduled.

Daily and intra-day stock market returns are measured as continuously compounded returns. In accordance with Gürkaynak, Sack and Swanson (2005), the event window with respect to the intra-day data starts 10 minutes before the monetary policy announcement and ends 20 minutes after the announcement. Measuring the stock market returns using the regular S&P 500 futures for the whole time horizon is problematic because two unscheduled FOMC announcements happened at a time of day where these futures are not traded. To remedy this problem, the E-mini S&P 500 futures are used, as the E-mini S&P 500 futures are electronically traded almost every second of the day. However, a downside of the E-mini futures is that these contracts were introduced in the fall of 1997 so the data does not encompass the whole time horizon. As a result I calculate the

[7]Yet there are several deviations from this for more details see Kuttner (2003)

stock market returns using the regular S&P 500 futures before October 1997 and the E-mini S&P 500 futures thereafter[8].

Similar to Kuttner (2001), daily and intra-day data on Federal Funds Futures contracts will be used to measure the unexpected Federal Funds Rate changes. More formally, the unexpected monetary policy changes are measured as,

$$\Delta i_t^u = \frac{D}{D-d}(f_t - f_{t-1})/f_t \qquad (1)$$

where Δi_t^u is the unexpected change in the Federal Funds Rate for the day t and f_t is the implied daily Federal Future Rate for date t, and D is the number of days in the month. The term "$\frac{D}{D-d}$" in equation (1) is a scaling factor that is added because the Fed Funds Futures settlement prices are based on the average Fed Funds Rate during the contract's month[9].

It should be noted that, the FOMC monetary policy decisions are announced before the close of the futures market so the end of the day futures settlement price includes the information on Federal Funds Rate changes[10].

If we know the (raw) change in the Federal Funds Rate and the unexpected change in the Federal Funds Rate then we can compute the expected change in the Federal Funds Target Rate as follows,

$$\Delta i_t^e = \Delta i_t + \Delta i_t^u \qquad (2)$$

where "Δi_t^e" is the expected change in the Federal Funds Rate, "Δi_t" is the raw change in the (target) Federal Funds Rate and all other variables remain as previously specified.

---

[8] For all futures data the contract settlement price is used.

[9] As pointed out by Kuttner (2003), there is some month-end noise in this proxy due to the fact that future prices are measured as discrete variables. In line with (Kurov & Gu, 2016), the change in the rate implied in next-month's contract is used as the measure of the unexpected target rate change if the FOMC meeting occurs in the last seven days of the month.

[10] The first unscheduled announcement after the 15th of October 1998 will be excluded from my analysis because the rate change was announced after the close of the futures market. The Full sample also excludes the unscheduled rate cut of the 17th of September 2001 because this day's rate cut happened on the first day of trading in the wake of the September 11th terrorist attacks.

A popular business cycle indicator is the NBER, however, this business cycle indicator is not available in real-time. As the recessions are only identified months after they have started and ended. This implies that investors could not have reacted to this information at the time the recession began[11] [12]. Following, Bashista and Kurov (2008), I employ a more real-time business cycle indicator called the Chicago national Activity Index (CFNAI). The index is a principal component of 85 economic indicators, which is published monthly by the Federal Bank of Chicago. The Chicago Fed proposes using a 3-month moving average as indicator of business cycle turning points. More specifically, they suggest that, a drop in the 3-month moving average of the CFNAI below -0.7 indicates a high probability that the US economy has gone into recession. Similarly, when the 3-month moving average of the CFNAI goes above 0.2 there is a significant probability that the recession has ended.

V. Results

Figures 1 and 2, plot the stock market returns against the unexpected change in the Federal Funds Rate for respectively the daily and intra-day data. The graphs also graphically denote the characteristics of the observation in the sub-sample. More specifically, the graphs distinguish between unscheduled announcements, outliers and reversals. Unscheduled announcements are all announcements which take place on days that are not traditionally FOMC meeting days. Within the literature it is common to distinguish between scheduled and unscheduled meetings because the latter is expected to suffer more from endogeneity biases. Next, the outliers are identified by calculating influence statistic as proposed by Cook (1977). More specifically, an observation is classified as an outlier if it has a cook's D higher than 4/n.[13] [14] Nine outliers are identified for respectively, the daily data set and the intra-day data sets. A list of these specific dates can be

[11] Furthermore, the correlation between the CFNAI and the NBER is 0.57.

[12] Results computed using the NBER do not seem to significantly influence the findings but they are available upon request.

[13] The outliers are identified by calculating cook's D influence statistics for model 3, as we will see that this model this model has the most explanatory power.

[14] Cook (1977) proposes classifying all observations higher than 1 as outliers. In contrast, I use a common alternative cut-off point, more specifically, "4/n" (4/129≈0.031). Where n is the total number of observations in the full sample. The use of 1 as cut-off point does not significantly change the results.

found in Appendix A.2. Reversals are more relevant at a later stage of the analysis. Nevertheless, they represent the changes in the direction of the Federal Funds Rate movements.

Figure 1: Stock returns against unexpected Federal Funds Rate Changes, daily data.

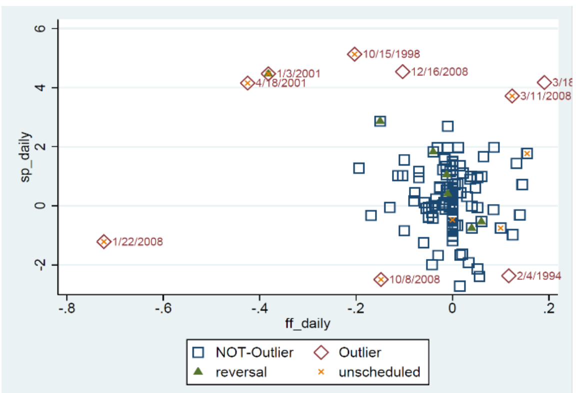

Figure 1: This figure is a scatterplot of the 1-day stock returns against the unexpected 1-day changes in the Federal Funds Rate (unexpected monetary policy change). All observations are FOMC announcements but I distinguish between unscheduled announcements, outliers (cook's D higher than 4/n) and reversals (changes in the direction of Federal Funds Rate movements).

Figure 2: Stock returns against unexpected Federal Funds Rate changes, intra-day data.

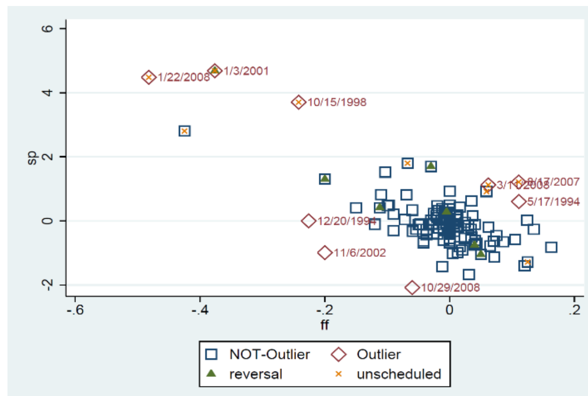

Figure 2: This figure is a scatterplot of the intra-day stock returns against the unexpected intra-day changes in the Federal Funds Rate (unexpected monetary policy change). All observations are FOMC announcements but I distinguish between unscheduled announcements, outliers (cook's D higher than 4/n) and reversals (changes in the direction of Federal Funds Rate movements).

Baseline results

In this section, the effect of monetary policy on stock returns is estimated under the assumption of a linear relationship (assuming no asymmetries). More specifically, I test whether or not the stock market responds to expected and/or unexpected Federal Funds Rate changes without allowing for possible state dependency asymmetries and directional asymmetries. More formally, the following models are estimated,

$$R_t = \alpha_t + \beta I_t + \varepsilon_t \qquad (2)$$

where R_t are the stock returns, I_t is a vector of explanatory variables containing the (raw) change in the Federal Funds Rate (Δi_t), the expected change in the Federal Funds Rate (Δi_t^e) and the unexpected change in the Federal Funds Rate (Δi_t^u). Furthermore, α is a constant, ε_t is an error term and t denotes a daily or an intra-day time-window. Table 1 shows the results of these estimations for various samples. More explicitly, the table distinguishes between the three samples. First, the full sample that is used in Part A, which include all scheduled and unscheduled FOMC meeting from 1994 till 2008. Second, a sample excluding the outliers. Third, a sample which consists of all scheduled FOMC announcements from 1994 till 2008.

The results obtained using daily data do not indicate a relationship between stock market returns and the Federal Funds Rate. This is somewhat surprising because the majority of the literature use daily data and finds a negative effect between stock market returns and monetary policy. Later in this section evidence is presented which could potentially reconcile these two discrepancies. Now the analysis turns to the results obtained using intra-day data. In contrast to the daily data results, the results obtained using intra-day data appear to be in line with the literature. They indicate a negative relationship between changes in the Federal Funds Rate and stock market returns. More specifically, they suggest that market participants only respond to unexpected changes in the Federal Funds Rate.

Further evidence in line with this conclusion is that, the significance level of the unexpected change in the Federal Funds Rate is greater than the significance level of the raw change in the Federal Funds Rate. This is to be expected when, as assumed, the raw change in the Federal Funds Rate is the sum of the *expected* change plus the *unexpected* change and stock returns only react to the unexpected change component. Thus the estimated effect of the raw change will suffer from measurement error bias, due to the expected change component. In other words, if the expected monetary policy change is removed from the raw Federal Funds Rate change then the resulting variable, namely the unexpected monetary policy variable, should have a relatively higher significance level. From table 1 we see that this is in fact the case. The raw change in the Federal Funds Rate is significant at a 5% level but the unexpected change in the Federal Funds Rate is significant at a 1% level. A notable mention is that intra-day data seems to have, substantially, higher explanatory power compared to daily data. This is also in line with expectations as higher data frequency improves identification.

Table 1 : Baseline results									
Variables		All announcements			Excluding Outliers			Scheduled Announcements Only	
Panel A:									
Constant	.36***	.38***	-.35***	.24**	.23**	.24***	.28***	.29***	.28**
	(.11)	(.12)	(.12)	(.10)	(.10)	(.09)	(.10)	(.11)	(.11)
Raw change	-.91			-.35			-.71		
	(.68)			(.49)			(70)		
Expected change		-.79			-.54			-.70	
		(.77)			(.53)			(.79)	
Un-expected change			-2.04			-1.64			-1.82
			(2.43)			(1.95)			(.2.99)
R^2	.03	.02	.02	.01	.01	.01	.02	.02	.01
Panel B:									
Constant	-.00	-.02	-.09	-.09	-.08	-.12***	-.14***	-.14***	-.16***
	(.07)	(.08)	(.06)	(.06)	(.06)	(.05)	(.05)	(.05)	(-3.15)
Raw change	-1.05**			-.65*			-.05		
	(.50)			(.35)			(.35)		
Expected change		-.33			-.27			.15	
		(.41)			(.37)			(.38)	
Un-expected change			-6.87***			-5.92***			-3.15***
			(1.25)			(.67)			(1.11)
R^2	.09	.01	.44	.07	.01	.39	.00	.00	.11
N	129	129	129	120	120	120	120	120	120

Panel A and panel B represent, estimates obtained using daily and intraday data, respectively. The regression model that is used is; $R_t = \alpha_t + \beta I_t + \varepsilon_t$, where R_t is the return of stock futures, I_t is a vector of explanatory variables containing Federal Funds Rate (Δi_t), the expected change in the Federal Funds Rate (Δi_t^e) and the unexpected change in the Federal Funds Rate (Δi_t^u), and D_t^{crisis} is a dummy variable that takes the value of 1 for FOMC announcements that are within the crisis period and a 0 otherwise. The intra-day event window is from 10 minutes before to 20 minutes after the announcement. Panel C represents the out of event window data. The columns named "All Announcements", "Excluding Outliers" and "Scheduled Announcements Only", respectively represents, the full-sample, the full-sample excluding outliers, the full-sample excluding unscheduled announcements. The full-sample starts the 4th of February 1994 and ends the 16th of December 2008 it contains 129 FOMC meetings, including, respectively, 9 outliers and 9 unscheduled meetings. The regressions are estimated using OLS in combination with the so-called Huber-White sandwich estimators (White (1980), Huber (1973)). Standard errors are shown in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively. Furthermore, all estimates are rounded to two decimals.

It is interesting that when using daily data, the results suggest that unexpected Federal Fund Rate changes do not affect stock returns. This is especially strange given the fact that, similar to Bernanke and Kuttner (2005), most papers that employ daily data find evidence in support of a negative relationship. A plausible explanation for these apparent contradictions is proposed by Kurov an Gu (2016). The authors point out that daily data is more sensitive to some specific endogeniety biases compared to intra-day data. These endogeneity biases are small and not problematic for non-crisis periods. However, during crisis periods these biases increases substantially and as a result it does become problematic. The results from earlier daily data studies, like Bernanke and Kuttner (2005), do not suffer significantly from these biases because there were no substantial crisis in their respective time horizons. In contrast, my time horizon includes the financial crisis of 2007 and 2008. The inclusion of this crisis period results in more severely biased estimated for daily data. Appendix B outlines this problem more formally. To test whether or not this is the case, I split my sample into a normal (non-crisis) period and a crisis period. Structural break tests are used to identify the normal (non-crisis) period and the crisis period. The start of the crisis period is estimated using the Bai and Perron (1998) and Andrews (1993) structural breaks tests on daily and intra-day data for the following model[15];

$$R_t = \alpha + \beta \Delta i_t^u + \varepsilon_t \qquad (3)$$

The test results obtained using daily data seem to indicate a structural break at 31st of January 2007[16]. The test results with respect to the intra-day data do not indicate that there is a structural break. Note that, following my earlier results, model (3) only considers the effect of unexpected change in the Federal Funds Rate.

Subsequently, the crisis period is, defined as, the period from 31st of January 2007 till the 16th of December 2008[17]. Using this distinction, a variation of model 2 from Table 1 is estimated. More formally, I estimate the following model;

$$R_t = (\alpha_1 + \beta_1 \Delta i_t^u)\left(1 - D_t^{crisis}\right) + (\alpha_2 + \beta_2 \Delta i_t^u)\left(D_t^{crisis}\right) + \varepsilon_t \qquad (4)$$

where D_t^{crisis} is a dummy variable that takes the value of 1 for FOMC announcements that are within the crisis period and a 0 otherwise. Furthermore, all variables remain as previously

[15] The Bai-Perron test is conducted using max break point restrictions ranging from 1 to 5. The Qaund-Andrews test is conducted using a 15% data trim level.

[16] However, when I conduct the tests with intra-day data the tests show no evidence of a structural break. For more details, see Appendix A1.

[17] This finding is rather strange as there is somewhat of a consensus that the financial crisis started when Lehman Brothers collapsed. Later, I will show that the results of these tests are likely biased due to use of daily data and the increase in endogeneity bias around the onset of the last financial crisis.

specified. The results with respect to this estimation are reported in Table 2. The results seem to confirm that there is a structural break in the daily data. For example, the estimated effect of an unexpected 1% change in the Federal Funds Rate is a reduction in stock returns of 7.85% in the normal period. This same effect would lead to an increase in stock returns of 4.24 in the crisis period. In contrast, the results obtained using intra-day data show that there is a negative relationship during normal times and that this relationship becomes even more negative during crisis periods. Under the assumption that intra-day data eliminates a substantial part of the endogeneity concerns. This suggests that the structural break in the daily data is driven by increases in endogeneity biases during crisis. Of course this rests on the reasonable assumption that the intraday data increases improve identification. Some evidence which suggest that this assumption is valid is that the R-squared is higher by, approximately a factor of 2, for the most intra-day regressions. For example, for the full sample in the R-squared is 27% and 14% for the respective normal and crisis period in Panel A. In contrast, Panel B shows an R-squared of 44% for both respective periods. The fact that the R-squared remains stable throughout the normal period and the crisis period is further indication that the intra-day estimates do not get significantly biased during crisis periods. Taken together these results suggest that the endogeneity bias in the estimates, obtained using daily data, increases during the crisis periods. Apparently this increase is very large and can have a very detrimental effect on the validity of the results. A testament to this is the fact for daily data the sign of the effect changes from negative (in the normal period) to positive (in the crisis period).

A necessary condition for the existence endogeneity biases, more specifically reverse causality, is that the Fed responds to stock market returns. Empirical evidence in favor of this assertion is provided by Rigobon and Sack (2001).

Table 2: Normal, Crisis						
	All announcements		Excluding Outliers		Scheduled Announcements Only	
	Normal	Crisis	Normal	Crisis	Normal	Crisis
Panel A:						
Constant	.21**	.97**	.19**	2.00	.18*	1.03*
	(.10)	(.42)	(.09)	(6.91)	(.10)	(.49)
Un-expected change	-7.85***	4.24**	-2.42	.54	-3.09*	3.50
	(1.66)	(1.71)	(1.74)	(.37)	(1.94)	(8.63)
R^2	.27	.14	.03	.01	.03	.11
Panel B:						
Constant	-0.13**	.12	-.16***	-.03	-0.15***	-.31
	(.05)	(.26)	(.04)	(.26)	(.04)	(.21)
Un-expected change	-6.48***	-7.44***	-2.17*	-2.09	-2.00*	-8.45**
	(1.63)	(1.68)	(1.11)	(3.87)	(1.02)	(2.04)
R^2	.44	.44	.09	.02	.06	.34
N	108	21	104	16	104	16

The table presents the OLS estimates for the following regression model; $R_t = (\alpha_1 + \beta_1 \Delta i_t^u)(1 - D_t^{crisis}) + (\alpha_2 + \beta_2 \Delta i_t^u)(D_t^{crisis}) + \varepsilon_t$, where R_t is the return of stock futures, Δi_t^u is the un expected change in the Federal Funds Rate and D_t^{crisis} is a dummy variable that takes the value of 1 for FOMC announcements that are within the crisis period and a 0 otherwise. Panel A, Panel B and Panel C represent the estimates obtained using daily data, intra- day data and "out of event window" data, respectively The intra-day event window is from 10 minutes before to 20 minutes after the announcement. The columns named "All Announcements", "Excluding Outliers" and "Scheduled Announcements Only", respectively represents, the full-sample, the full-sample excluding outliers, the full-sample excluding unscheduled announcements. The full-sample starts the 4th of February 1994 and ends the 16th of December 2008 it contains 129 FOMC meetings, including, respectively, 9 outliers and 9 unscheduled meetings. The sub-columns named "normal" and "crisis" present the estimates for respectively, the normal time period and the period during the 2007-2008 financial crisis. The regressions are estimated using OLS in combination with the so-called Huber-White sandwich estimators (White (1980), Huber (1973)). Standard errors are shown in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively. Furthermore, all estimates are rounded to two decimals.

Further evidence that the daily data estimates have large endogeneity biases, emanates from the results presented in Table 3. The table shows the mean and the variance of the daily and intra-data during normal periods and crisis periods. In addition, the table also shows the mean and variance for the out of event window data. Similar to Kurov and Gu (2016), these "out of event window" returns and rates changes are calculated by subtracting the daily data values from the intra-day values. For scheduled meetings, the out of event window stock returns and rate changes roughly corresponds to the period from, the previous day's, market close to 10 minutes before the monetary

Table 3 : Descriptive statistics for the Normal period and the Crisis period

	All Announcements				Excluding Outliers				Scheduled Announcements only			
	Normal		Crisis		Normal		Crisis		Normal		Crisis	
	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
Panel A:												
R_t	.30	1.20	.81	2.03	.29	1.20	1.02	1.49	.18	.97	.98	1.93
Δi_t^u	-1.15	.62	-3.75	3.24	-1.17	.64	-4.11	4.28	-.32	.29	-1.22	.60
Panel B:												
R_t	-.05	.80	.37	1.42	-.05	.81	.50	1.34	-.14	.46	-.11	1.03
Δi_t^u	-1.23	.68	-3.29	1.59	-1.25	.70	-3.68	2.12	-.40	.33	-2.33	.50
Panel C:												
R_t	.35	.84	.44	2.45	.34	.85	.53	2.44	.33	.84	1.10	1.72
Δi_t^u	.09	.03	-.47	.46	.08	.04	-.43	.58	.08	.03	1.10	0.11
N	108		21		105		15		104		16	

The table shows the means and variance of stock market returns and Federal Funds Future rate changes. The means (μ) and variances (σ)of the Federal Funds Future rate changes are multiplied by a 100. Panel A, Panel B and Panel C represent the estimates obtained using daily data, intra- day data and "out of event window" data, respectively. R_t and Δi_t^u are respectively, the stock market returns and unexpected monetary changes for period t. and respresent the mean and the variance of the data in question. The intra-day event window is from 10 minutes before to 20 minutes after the announcement. The columns named "All Announcements", "Excluding Outliers" and "Scheduled Announcements Only", respectively represents, the full-sample, the full-sample excluding outliers, the full-sample excluding unscheduled announcements. The full-sample starts the 4th of February 1994 and ends the 16th of December 2008 it contains 129 FOMC meetings, including, respectively, 9 outliers and 9 unscheduled meetings. The sub-columns named "normal" and "crisis" present the means and variance statistics for respectively, the normal time period and the period during the 2007-2008 financial crisis. The regressions are estimated using OLS in combination with the so-called Huber-White sandwich estimators (White (1980), Huber (1973)). Standard errors are shown in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively. Furthermore, all estimates are rounded to two decimals.

policy announcement [18]. As a result, these values cannot be determined by the FOMC announcement because the announcements takes place at a later point in time.

The results from Table 3 indicate that the variance of stock returns out of event window is 2-3 times larger during the crisis period. This variance can be interpreted as the part of the stock return variance that is caused by economic news z_t and stock return η_t. Similary, the variance of Federal Funds Futures Rate changes is 3-10 times larger during the crisis period. In light of the theoretical results formulated in Appendix B, these findings suggest that the endogeneity bias greatly increase

[18] The scheduled FOMC announcements in the sample are normally announced at :15 ET. As a results, the intraday event window is from 2:05 p.m. to 2:35 p.m. Furthermore, the settlement price of the Fed funds future is determined at 3:00 p.m.

during crisis periods. As a result, all regressions models, after Table 3, exclude FOMC announcements made during the financial crisis of 2007 - 2008. Another implication of my findings is that the previously conducted structural break tests also suffer from endogeneity biases. This would explain why a seemingly incorrect date was identified as the start of the financial crisis.

State dependency asymmetries

The previous section indicates that the stock returns only respond to unexpected monetary policy changes. An implicit assumption in the previously used regression models is that there is a *symmetric* relationship between stock returns and monetary policy. In this section, I relax this assumption. More specifically, the case for state dependency is investigated. As outlined in the hypothesis section, from a theoretical point of view it is not clear whether monetary policy is more effective during recessions or less effective during recessions. More formally, I estimate the following model;

$$R_t = (\alpha_1 + \beta_1 \Delta i_t^u)\left(1 - D_t^{recession}\right) + (\alpha_2 + \beta_2 \Delta i_t^u)\left(D_t^{recession}\right) + \varepsilon_t \qquad (5)$$

Where $D_t^{recession}$ is a dummy variable that take the value of 1 for periods when the economy is in recession and 0 otherwise. The estimation results are reported in Table 4. The table, also, simultaneously reports the estimates obtained using daily and intraday data frequencies. Similar to the previous section I compare the daily data estimates to the intra-day estimates.

The comparison of daily data estimates to the intra-day estimates is fruitful as it will reveal whether or not higher data frequencies lead to more (or less) evidence in support of asymmetric effects. As mentioned in the literature review Bernanke and Kuttner (2005) find no evidence of asymmetries at monthly data intervals. However, when the authors increase the data frequency by using daily data they find weak evidence in support of asymmetries. Using daily data others, like Basistha and Kurov (2008), even find relatively strong evidence in support of state dependency asymmetries. More specifically, the authors find that monetary policy is more effective during recessions.

With respect to daily data the results indicate that, throughout the majority of the samples, the difference between β_1 and β_2 is statistically insignificant. This suggests that there is no difference between the effect of monetary policy in recessions and expansions. Yet, there is some evidence which suggest the opposite. For example, when only scheduled meetings are considered, there is a statistically significant difference between both coefficients. More specifically, this evidence suggest that monetary policy is more effective during recessions. This findings is in line with, among others, Basistha and Kurov (2008). Somewhat weaker evidence that suggests this is the fact that, for daily data, the absolute value and the significance level of the coefficient "β_2" (effect during recessions) is higher than that of the coefficient "β_1" (effect during expansions) throughout all samples. However, when intra-day data is used, the results overwhelmingly reject the hypothesis that monetary policy is more effective during recessions. A testament to this statement is the fact that the difference between β_1 and β_2 is statistically insignificant throughout all samples. Rather interesting, is the fact that the intra-day estimates even vaguely suggest that monetary policy is more effective during expansionary periods. Indeed, in contrast to daily data estimates, the estimated effect of monetary policy is more significant and has a higher absolute value during expansions, compared to recessions. The fact that there is appears to be a stark difference between estimates obtained using daily data and intra-day data suggest that the daily data results are driven by endogeneity biases. To investigate this hypothesis, I conduct, roughly, the same analysis as in the previous section because, as outlined in appendix B, a crisis can be interpreted as extreme case of recession. Thus, the dynamics outlined with respect to the development of bias is daily data estimates during crisis periods can also apply to recessionary periods[19]. This idea gains weight in light of the fact that others like Andersen et al (2007) have found evidence which suggest that the volatilities of stock returns increase during recessions. Similar to the analysis in the previous section, Table 5 presents the means and variances of stock returns and monetary policy rate changes during the recessionary periods and the expansionary periods.

---

[19] For more information, with respect to this, please visit Appendix B.

The results from Table 5 indicate that the variance of stock returns "out of event window" is approximately 40% larger during the recessionary period. Although the variance increase is less than during crisis period, the increase could still lead to a substantial increase in the reverse causality bias. The results indicate relatively less substantial increases in the variance of stock returns and the variance of Federal Funds Futures rate changes, during recessionary periods. Nevertheless, in the majority of the instances, both of the respective variances are still higher in the recessionary periods compared to the expansionary periods. However, the results are somewhat more ambiguous, compared to the previous section, due to the fact that the variance statistic of Federal Funds Futures is approximately 30% larger during the expansionary period. On a whole the "out of event window" variance differences do not resoundingly point to a large increase in endogeneity biases during recessionary periods. Thus an increase in endogeneity bias does not appear to be driving the difference between the daily data and intra-day data estimates. Yet, is possible if the Fed's response ("β" in Appendix B) to the stock market increases during recessions. Some evidence which suggests this is provided by (Furlanetto, 2004). The author finds that the reaction of the Federal Reserve to the high tech bubble (expansionary period) was 3 times lower compared to normal other periods. This somewhat implies that the reaction of monetary policy to the stock market returns is higher during recessions. Thus the, previously documented, small increase in the variance of stock returns combined with an increase in the higher (β) could still lead to an increase in endogeneity biases in daily data estimates, during a recession.

Table 4: Business Cycle			
Variables	All Announcements	Excluding Outliers	Scheduled Announcements Only
Panel A:			
Expansion (α_1)	.22*	.21*	.18*
	(.11)	(.11)	(.10)
Expansion (β_1)	-6.92**	-6.89**	-.44
	(2.94)	(2.85)	(2.07)
Recessions (α_2)	.18	.18	.18
	(.24)	(.24)	(.24)
Recession (β_2)	-9.27***	-9.27***	-9.11***
	(1.09)	1.09	(2.50)
$\alpha_1 - \alpha_2$	-.04	-.03	-.00
	(.26)	(.26)	(.23)
$\beta_1 - \beta_2$	-2.35	-2.38	-8.67**
	(3.02)	(3.04)	(3.74)
R^2	.27	.28	.08
Panel B:			
Expansion (α_1)	-.10*	-.10	-.12**
	(.06)	(.06)	(.05)
Expansion (β_1)	-7.76***	-7.65***	-2.46**
	(2.21)	(2.22)	(1.08)
Recessions (α_2)	-.24**	-.24**	-.28***
	(.10)	(.10)	(.09)
Recession (β_2)	-4.76**	-4.76**	-.96
	(1.93)	(1.93)	(1.96)
$\alpha_1 = \alpha_2$	-.14	-.14	-.16
	(.11)	(.11)	(.10)
$\beta_1 - \beta_2$	2.90	2.88	1.58
	(2.91)	(2.91)	(2.19)
R^2	.47	.47	.07
N	108	105	104

The table presents the OLS estimates for the following regression model; $R_t = (\alpha_1 + \beta_1 \Delta i_t^u)(1 - D_t^{recession}) + (\alpha_2 + \beta_2 \Delta i_t^u)(D_t^{recession}) + \varepsilon_t$, where R_t is the return of stock futures, Δi_t^u is the un expected change in the Federal Funds Rate and $D_t^{recession}$ is a dummy variable that takes the value of 1 for FOMC announcements that are within the crisis period and a 0 otherwise. Panel A, Panel B and Panel C represent the estimates obtained using daily data, intra- day data and "out of event window" data, respectively The intra-day event window is from 10 minutes before to 20 minutes after the announcement. The columns named "All Announcements", "Excluding Outliers" and "Scheduled Announcements Only", respectively represents, the full-sample, the full-sample excluding outliers, the full-sample excluding unscheduled announcements. The full-sample starts the 4th of February 1994 and ends 31st of January 2007 it contains 108 FOMC meetings, including, respectively, 3 outliers and 3 unscheduled meetings. The sub-columns named "normal" and "crisis" present the estimates for respectively, the normal time period and the period during the 2007-2008 financial crisis. The regressions are estimated using OLS in combination with the so-called Huber-White sandwich estimators (White (1980), Huber (1973)). Standard errors are shown in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively. Furthermore, all estimates are rounded to two decimals.

Table 5 : Descriptive statistics for the Expansions (Booms) and Recessions (Busts)

	All Announcements				Excluding Outliers				Scheduled Announcements only			
	Expansion		Recession		Expansion		Recession		Expansion		Recession	
	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
Panel A:												
R_t	.28	1.13	.37	1.45	.27	1.13	.37	1.45	.18	.89	.20	1.22
Δi_t^u	-.90	.47	-2.05	1.19	-.92	.49	-2.05	1.19	-.34	.25	-.21	.43
Panel B:												
R_t	-.02	.82	-.15	.76	-.02	.83	-.15	.76	-.11	.47	-.28	.42
Δi_t^u	-1.04	.52	-1.93	1.30	-1.06	.54	-1.93	1.30	-.48	.28	-.09	.54
Panel C:												
R_t	.30	.77	.52	1.07	0.29	.77	.52	1.07	.29	.77	.48	1.08
Δi_t^u	.14	.04	-.12	.03	.13	.04	-.12	.03	.14	.04	-.13	.03
N	85		23		82		23		82		22	

The table shows the means and variance of stock market returns and Federal Funds Future rate changes. The means (μ) and variances (σ)of the Federal Funds Future rate changes are multiplied by a 100. Panel A, Panel B and Panel C represent the estimates obtained using daily data, intra- day data and "out of event window" data, respectively. R_t and Δi_t^u are respectively, the stock market returns and unexpected monetary changes for period t. and respresent the mean and the variance of the data in question. The intra-day event window is from 10 minutes before to 20 minutes after the announcement. The columns named "All Announcements", "Excluding Outliers" and "Scheduled Announcements Only", respectively represents, the full-sample, the full-sample excluding outliers, the full-sample excluding unscheduled announcements. The full-sample starts the 4th of February 1994 and ends the 31st of January 2007 it contains 108 FOMC meetings, including, respectively, 3 outliers and 3 unscheduled meetings. The sub-columns named "normal" and "crisis" present the means and variance statistics for respectively, the normal time period and the period during the 2007-2008 financial crisis. The regressions are estimated using OLS in combination with the so-called Huber-White sandwich estimators (White (1980), Huber (1973)). Standard errors are shown in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively. Furthermore, all estimates are rounded to two decimals.

Directional asymmetries

In the previous section, I investigate the case for state dependency asymmetries. In this section, a different type of asymmetry is estimated, namely directional asymmetries. Similar to Bernanke and Kuttner (2005), the following regression model is used;

$$R_t = \alpha + \beta \Delta i_t^u + \beta \Delta i_t^u D_t + \varepsilon_t$$

where D_t is one of two dummy variables, which capture the additional effect of directional asymmetries. The first form of directional asymmetries relates to whether or not the stock market reacts differently to positive shocks and negative shocks. The first interaction variable uses a dummy variable that takes a value of 1 for all unexpected rate changes that are *non-negative* (no change and positive rate changes) and takes a value of 0 for all unexpected rate changes that are *negative* (negative rate changes). The daily and intra-day estimation results are reported in Table 4. In line with previous studies, like Bernanke and Kuttner (2005), I find weak evidence in favor of this asymmetry using daily data. More specifically, the evidence hinges on whether or not the outliers are truly exceptional observations or not and on whether the unscheduled meetings complicate identification. However, similar to the previous section, this evidence evaporates when the data frequency is increased. This suggests that the evidence is driven by endogeneity biases in the daily data.

The second form of directional asymmetries relates to whether or not the stock market reacts differently to a change in the direction of monetary policy. The second interaction variable uses a dummy variable that takes a value of 1 for all rate changes that are in an opposite direction of the preceding rate changes and a 0 otherwise. The results with respect to the daily data provide strong evidence in support of this type of directional asymmetry. A notable mention is that the magnitude of the effect in the two last samples ("excluding outliers" and "scheduled meetings only") seems implausible, respectively -20.80 and -20.00. This suggest that a 1% reduction in the policy rate results in an additional 20% (approximately) increase in daily stock market returns if the reduction was a change in direction of monetary policy. As mentioned, this type of magnitude is highly unlikely. However, Bernanke and Kuttner (2005) finds similarly implausible coefficients, namely, that a 1% reduction of the policy rate results in an 17.62% increase in daily stock market returns. The authors attribute these implausible estimates to the existence of extreme market reaction to policy reversals. A different explanation can be given when taking the intra-day results into account. If the intra-day data is used the coefficient estimate drops from approximately 20% to 9%. This large drop suggests that the implausible coefficients are caused by endogeneity biases in the daily data estimates. Furthermore, it should be noted that the intra-day results also indicate strong support for this specific form of directional asymmetry. More specifically, the reversal coefficient is significant throughout all the samples, albeit that, the magnitude of the asymmetric effects depends on whether or not the outliers are correctly identified and whether or the unscheduled meetings hinder identification. Furthermore, the OLS bias in the daily estimates is relatively less problematic when it comes to detecting this asymmetry as the estimated sign of the coefficient is still correct when daily data is used.

Table 6: Monetary Expansion vs Monetary Contraction

Variables	All Announcements		Excluding Outliers		Scheduled announcements only	
Panel A:						
Constant	.08	.21**	.17	.20**	.18*	.18*
	(.10)	(.10)	(.11)	(.09)	(1.10)	(.10)
Un-expected change	-9.58***	-6.74***	-3.16	-1.91	-3.03	-2.6
	(.21)	(2.07)	(2.12)	(1.76)	(2.12)	(1.98)
Positive	7.11*		-1.63		-.15	
	(4.07)		(4.52)		(4.69)	
Reversal		-4.95**		-20.80***		-20.00***
		(2.15)		(7.16)		(7.39)
R^2	.29	.28	.02	.05	.03	.06
Panel B:						
Constant	-.21***	-.14	-.10*	-.16***	-.10*	-.16***
	(.06)	(.05)	(.05)	(.04)	(.05)	(.04)
Un-expected change	-7.56***	-4.84***	-.74	-1.70	-.79	-1.53
	(2.02)	(1.54)	(1.37)	(1.11)	(1.36)	(1.01)
Positive	4.55		-3.62		-2.93	
	(2.86)		(2.64)		(2.32)	
Reversal		-7.75***		-9.14*		-9.29*
		(.05)		(5.11)		(5.11)
R^2	.47	.55	.10	.13	.08	.13
N	108	108	104	104	104	104

The table presents the OLS estimates for the following regression model; $R_t = (\alpha_1 + \beta_1 \Delta i_t^u)(1 - D_t) + (\alpha_2 + \beta_2 \Delta i_t^u)(D_t) + \varepsilon_t$, where R_t is the return of stock futures, Δi_t^u is the un-expected change in the Federal Funds Rate and D_t is one of two dummy variables. The first dummy variable (named Positive) that takes a value of 1 for all unexpected rate changes that are *non-negative* (no change and positive rate changes) and takes a value of 0 for all unexpected rate changes that are *negative* (negative rate changes). The second dummy variable (named Reversal) takes a value of 1 for all rate changes that are in an opposite direction of the preceding rate changes and a 0 otherwise. Panel A, Panel B and Panel C represent the estimates obtained using daily data, intra- day data and "out of event window" data, respectively The intra-day event window is from 10 minutes before to 20 minutes after the announcement. The columns named "All Announcements", "Excluding Outliers" and "Scheduled Announcements Only", respectively represents, the full-sample, the full-sample excluding outliers, the full-sample excluding unscheduled announcements. The full-sample starts the 4th of February 1994 and ends the 31st of January 2007 it contains 108 FOMC meetings, including, respectively, 4 outliers and 4 unscheduled meetings. The sub-columns named "normal" and "crisis" present the estimates for respectively, the normal time period and the period during the 2007-2008 financial crisis. The regressions are estimated using OLS in combination with the so-called Huber-White sandwich estimators (White (1980), Huber (1973)). Standard errors are shown in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively. Furthermore, all estimates are rounded to two decimals.

VI. Conclusion

This paper investigates the relationship between monetary policy and the stock market. It confirms previous findings that the stock market only reacts to unexpected changes in monetary policy. The paper contributes to the literature by focusing on the asymmetric effects of conventional monetary policy on stock market returns. More specifically, the paper investigates whether or not monetary policy is more, or less, effect during different stages of the business cycle. The results suggest that monetary policy is equally effective during recessionary (economic busts) and expansionary (economic booms) periods. In other words, the findings indicate that the effect of monetary policy is not state dependent. Moreover, the paper also investigates whether or not the direction of monetary policy indicates its effectiveness. The results suggest that expansionary monetary policy (monetary loosening) and contractionary monetary policy (monetary tightening) are equally effective. However, the paper finds that when the direction of monetary policy is reversed, monetary policy has a stronger effect on stock market returns. This finding is in line with previous papers like Bernanke and Kuttner (2005). Thus, the paper finds that the effect of monetary policy does depend on whether or not the policy change is a reversal in the direction of monetary policy.

A highlight of my study is that the analysis is simultaneously conducted for respectively daily and intra-day. This paper shows that the use of daily data results in problematic OLS biases. More specifically, these biases are severely problematic for assessing whether or not there are state dependency asymmetries and/or directional asymmetries, when daily data is used. For example, this paper finds evidence in support of state dependency asymmetries at daily data frequency but this evidence evaporates at intra-day data frequency. Nevertheless, these biases do not seem to driving the finding that monetary policy is more effective when the policy change is a reversal in the direction of monetary policy. A recommendation for future research is explicitly comparing the effect of contractionary monetary policy during a boom to expansionary monetary policy during a recession. As this paper, along with the majority of the literature, does not account for the fact that most expansionary monetary policy changes are conducted during a recession. Thus an insightful comparison would be to compare contractionary monetary policy during economic busts to expansionary monetary policy during economic booms.

VII. Acknowledgements

I would like to thank my parents in Suriname for their support, professor Kan Ji from the Erasmus University in Rotterdam for her insightful comments, the associate professor Alexander Kurov and doctoral student Chen Gu of West Virginia University for providing part of the data. None of these aforementioned persons can be held accountable for the views expressed in this paper, nor any of the potential errors and omissions.

VIII. References

Andersen, T. G., Bollerslev, T., Diebold, F. X., & Vega, C. (2007). Real-time price discovery in stock, bond and foreign exchange markets. *Journal of International Economics, 77,* 251-277.

Andrews, D. W. (1993). Tests for parameter instability and structural change with unknown change point. *Econometrica*, *62*(6), 821-856.

Bai, J., & Perron, P. (1998). Estimating and testing linear models with multiple structural changes. *Econometrica, 66*(1), 47-78.

Bashista, A., & Kurov, A. (2008). Macroeconomic cycles and the stock market's reaction to monetary policy. *Journal of Banking and Finance,* 2606-2616.

Basistha, A., & Kurov, A. (2008). Macroeconomic cycles and the stock market's reaction to monetary policy. *Journal of Banking and Finance, 32*, 2606-2616.

Berkman, N. G. (1978, May). One the significance of weekly changes in M1. *New England Economic Review*, 5-22.

Bernanke, B. S., & Gettler, M. (1999). *Monetary policy and asset price volatility.* Kansas: Federal Reserve Bank of Kansas City Economic Review 84.

Bernanke, B. S., & Kuttner, K. N. (2005, June). What explains the stock market's reaction to federal reserve policy? *The journal of Finance*, 1221-1257.

Bernanke, B., & Gertler, M. (1989, March). Agency costs, Net Worth, and Business Fluctuations. *The American Economic Review, 79*(1), 14-31.

Bredin, D., Hyde, S., Nitzsche, D., & O'reilly, G. (2007, February 8). UK Stock Returns and the Impact of Domestic Monetary Policy Shocks. *Journal of Business Finance & Accounting, 34*(5-6). doi:10.1111/j.1468-5957.2006.02001.x

Chen, S.-S. (2007). Does Monetary Policy Have Asymmetric Effects on Stock Returns. *Money, Credit and Banking*, 667-688.

Chulia, H., Martens, M., & Dijk, D. (2010). Asymmetric effects of federal funds target rate changes on S&P100 stock returns, volatilities and correlations. *Journal of Banking & Finance, 34*, 834-839.

Cook, R. D. (1977, February). Detection of Influential Observation in Linear. *Technometrics, 19*(1), 15-18. Retrieved from http://www.jstor.org/stable/1268249

Cooper, R. V. (1974). Efficient capital markets and the quantity theory of money. *Journal of Finance, 29*, 115-146.

Craine, R., & Martin, V. (2003, march). *Monetary Policy Shocks and Security Market Responses.* University of California at Berkeley.

Donald, M. P. (1993). Asymmetric effects of monetary policy: Agricultural and Business ... *Economic review, 78*(2), 21-33.

Florackis, C., Kontonikas, A., & Kostakis, A. (2014). Stock market liquidity and macro-liquidity shocks: Evidence from the 2007–2009 financial crisis. *Journal of International Money and, 44*, 97-117.

Florio, A. (2004). THE ASYMMETRIC EFFECTS OFMONETARY POLICY. *Journal of Economic Surveys, 18*(3).

Friedman, M. (1960). A program for monetary stability. (pp. 189-209). New York: Fordham University Press.

Friedman, M., & Schwartz, A. (1963). *A monetary history of the United States, 1867–1960.* Princeton University Press.

Furlanetto, F. (2004). *Does Monetary Policy React to Stock Prices? Some International Evidence.* University of Lausanne. Lausanne: University of Lausanne.

Gregoriou, A., Kontonikas, A., MacDonals, R., & Montagnoli, A. (2009). Monetary policy shocks and stock returns: Evidence from the British market. *Financial Markets and Portfolio Management, 23*, 401-410.

Gurkaynak, R. S., Sack, B. S., & Swanson, E. T. (2004). *The effect of monetary policy on asset prices an intra-day event study analysis.* Board of Governors of the Federal Reserve System.

Gürkaynak, R. S., Sack, B., & Swanson, E. (2005). Do actions speak louder than words? The response of asset prices to monetary policy actions and statements. *International Journal of Central Banking*, 55-93.

Huber, P. J. (1973). Robust regression: Asymptotics, conjectures and Monte Carlo. *Annals of Statistics*, 799-821.

Kakes, J. (1998, February). *Monetary transmission and business cycle asymmetry*. Working Paper, Groningen University.

Kontonikas, A., MacDonald, R., & Saggu, A. (2013). Stock market reaction to fed funds rate surprises: State dependence and the financial crisis. *Journal of Banking and Finance, 37*, 4025-4037.

Kurov, A., & Gu, C. (2016, March). Monetary Policy and Stock Prices: Does the "Fed Put" Work When It Is Most Needed? *Journal of Futures Markets*.

Kuttner, K. N. (2001). Monetary Policy surprises and interest rates: Evidence From the Federal Funds Futures Market. *Journal of Monetary economics, 47*, 523-544.

Kuttner, N. (2003). *Dating Changes in the Federal Funds Rate.* Oberlin college.

Leitem, K., & Bjornland, H. C. (2009, March). Identifying the interdependence between US monetary policy and the stock market. *Journal of Monetary Economics, 56*(2), 275-282.

Lim, S., Sum, V., & Khun, C. (2012). Interest Rate Sensitivity of Stock Returns: Effects across the Maturity Profile and Direction of Interest Rate Changes. *International Research Journal of Applied Finance, 3*(8), 1151-1162.

Nakazono, Y., & Ikeda, S. (2016, July). Stock, Market Responses Under Quantative Easing; Stata Dependance And Transparency in Monetary Policy. *Pacific Economic Review*. doi:doi: 10.1111/1468-0106.12158

Rigobon, R., & Sack, B. (2001). *Measuring The Reaction Of Monetary Policy To The Stock Market.* Cambridge: National Bureau of Economic Research.

Rigobon, R., & Sack, B. (2002). *The impact of Monetary Policy on Asset Prices.* Board of Governors of the Federal Reserve System.

Rigobon, R., & Sack, B. (2004, November). The impact of Monetary Policy on Asset Prices. *Journal of Monetary Economics, 51*(8), 1553-1575.

Rogalski, R. J., & Vinso, J. D. (1977). Stock returns, money supply, and the direction of causality. *Journal of Finance, 32*, 1017-1030.

Sellin, P. (2001, September). Monetary Policy and the Stock Market: Theory And Empirical Evidence. *Journal of Economic Surveys, 15*(4), 491-541.

Thorbecke, W. (1997, June). On Stock Market returns and Monetary Policy. *The Journal of Finance, 52*(2), 635-654.

White, H. (1980). A heteroskedasticity-consistent covariance matrix estimator and a direct test for hetero skedasticity. *Econometrica, 48*, 817-838.

IX. Appendix

A1: Breakpoint test results

Bai-Perron tests

Break Test	F-statistic	Scaled F-statistic	Critical Value**
0 vs. 1 **	14.07608	28.15216	11.47
1 vs. 2 **	6.658689	13.31738	12.95
2 vs. 3	3.867817	7.735635	14.03

*,**,*** Significant at the respectively 1%, 5% and 10% level.
Test statistics employ White heteroskedasticity-consistent covariances assuming common data distribution
Sequential F-statistic determined breaks: 2

	Sequential	Repartition
1	1/31/2007	12/16/1997
2	12/16/1997	1/31/2007

Quandt-Andrews unknown breakpoint test

Statistic	Value	Prob.
Maximum LR F-statistic (1/31/2007)	17.52081	0.0000
Maximum Wald F-statistic (1/31/2007)	28.15216	0.0000
Exp LR F-statistic	6.935955	0.0000
Exp Wald F-statistic	11.64219	0.0001
Ave LR F-statistic	7.963854	0.0001
Ave Wald F-statistic	12.70870	0.0004

Quandt-Andrews unknown breakpoint test
Null Hypothesis: No breakpoints within 15% trimmed data.
Varying regressors: All equation variables
Number of breaks compared: 90

A2: List of observation (dates) identified as outliers

Intra day	daily
5/17/1994	2-4-1994
12/20/1994	10/15/1998
10/15/1998	1-3-2001
1-3-2001	4/18/2001
11-6-2002	1/22/2008
8/17/2007	3-11-2008
1/22/2008	3/18/2008
3-11-2008	10-8-2008
10/29/2008	12/16/2008

A.3 List of FOMC meetings in Sample

4-2-1994	5-2-1997	2-2-2000	10-12-2002	31-1-2006	16-9-2008
22-3-1994	25-3-1997	21-3-2000	29-1-2003	28-3-2006	8-10-2008
18-4-1994	20-5-1997	16-5-2000	18-3-2003	10-5-2006	29-10-2008
17-5-1994	2-7-1997	28-6-2000	6-5-2003	29-6-2006	16-12-2008
6-7-1994	19-8-1997	22-8-2000	25-6-2003	8-8-2006	
16-8-1994	30-9-1997	3-10-2000	12-8-2003	20-9-2006	
27-9-1994	12-11-1997	15-11-2000	16-9-2003	25-10-2006	
15-11-1994	16-12-1997	19-12-2000	28-10-2003	12-12-2006	
20-12-1994	4-2-1998	3-1-2001	9-12-2003	31-1-2007	
1-2-1995	31-3-1998	31-1-2001	28-1-2004	21-3-2007	
28-3-1995	19-5-1998	20-3-2001	16-3-2004	9-5-2007	
23-5-1995	1-7-1998	18-4-2001	4-5-2004	28-6-2007	
6-7-1995	18-8-1998	15-5-2001	30-6-2004	7-8-2007	
22-8-1995	29-9-1998	27-6-2001	10-8-2004	10-8-2007	
26-9-1995	15-10-1998	21-8-2001	21-9-2004	17-8-2007	
15-11-1995	17-11-1998	2-10-2001	10-11-2004	18-9-2007	
19-12-1995	22-12-1998	6-11-2001	14-12-2004	31-10-2007	
31-1-1996	3-2-1999	11-12-2001	2-2-2005	11-12-2007	
26-3-1996	30-3-1999	30-1-2002	22-3-2005	22-1-2008	
21-5-1996	18-5-1999	19-3-2002	3-5-2005	30-1-2008	
3-7-1996	30-6-1999	7-5-2002	30-6-2005	11-3-2008	
20-8-1996	24-8-1999	26-6-2002	9-8-2005	18-3-2008	
24-9-1996	5-10-1999	13-8-2002	20-9-2005	30-4-2008	
13-11-1996	16-11-1999	24-9-2002	1-11-2005	25-6-2008	
17-12-1996	21-12-1999	6-11-2002	13-12-2005	5-8-2008	

B: Formulation of the bias

As suggested in the literature review there are mainly two endogeneity issues plaguing this strain of literature. First, there could be a reverse causal relationship running from stock market returns to monetary policy. For example, it is plausible that the Fed changes its monetary policy stance because of developments in the stock markets. The reason being that these developments contain information about the state of the economy. Second, there could be a spurious relationship between monetary policy and the stock market return. More specifically, there could be an omitted variable bias in the OLS estimates because of a third variable is influencing both monetary policy decisions and stock market returns. For example, the new reports indicate that there is lower/higher than expected consumer demand then the stock market would internalize this news and the Fed would presumably cut/raise rates to stimulate the economy. This last endogeneity concern is biggest for the data pre-1994 because during this time the Fed did react rather fast to the release of worse than expected employment growth. For the data post-1994 this endogeneity problem is less of an issue because after the 4th of February 1994 the Fed set predetermined FOMC announcements.

I now outline these problems more formally. Let us assume that relationship between monetary policy and stock market returns is as follows;

$$\Delta i_t = \beta r_t + \gamma z_t + \varepsilon_t, \qquad (5)$$

$$R_t = \alpha \Delta i_t + z_t + \eta_t, \qquad (6)$$

where Δi_t is the change in federal funds rate, R_t is the stock return and z_t represents a set of macroeconomic shocks which can impact both stock returns and the federal funds rate, ε_t and η_t represent the error term which are presume to be independent and identically distributed with mean zero, and sub-script denotes the time period. Equation (1) specifies the reaction of federal funds rate to stock market returns and macro-economic shocks like labor market forecasts. Equation (2) specifies the response of the stock market returns to changes in the federal discount rate and macro-economic shocks.

From equations (5) and (6) it follows that the OLS bias is given by;

$$E\bar{\alpha} - \alpha = (1 - \alpha\beta)\frac{\beta\sigma_\eta + (\beta+\gamma)\sigma_z}{\sigma_\varepsilon + \beta^2\sigma_\eta + (\beta+\gamma)^2\sigma_z}, \qquad (7)$$

There is a reverse causality bias if β$\not\Leftrightarrow$0 and σ_η>0 and there is a omitted variable bias if γ$\not\Leftrightarrow$0 and σ_z>0. With respect to the reverse causality bias, the smaller the variance of the stock returns shocks (σ_η) relative to the variance of monetary policy shocks, the more the bias in the OLS estimates approaches zero. Similarly, with respect to the omitted variable bias, the smaller the variance of the macro-economic shocks (σ_z) relative to the variance of monetary policy shocks, the more the bias in the OLS estimates approaches zero. As stated earlier, Rigobon and Snack (2004) have found this bias to be relatively small. Yet, equation (3) implies that if, ceteris paribus, there is an increase in either the variance of stock return shocks (σ_η), the variance of macro-economic shocks (σ_z) and/or the response of the federal funds rate to stock returns (β) then the bias will become larger. During periods of financial crisis there will, probably, be increases in these 3 aforementioned parameters, resulting in a higher bias. According to Kurov and Gu (2016) this increase of bias is likely to be the reason why event studies that use daily data find evidence that suggest that there is a structural break in the relationship between monetary policy and stock prices.

It is difficult to objectively determine at what point a recession becomes a crisis. Regarding a lot of aspects, a crisis can be viewed as an extreme case of a recession. Thus, similar dynamics could result in roughly the same endogeneity bias during recession, albeit to lesser extent. For example, the results with respect to state dependency asymmetries can also be driven reverse causality biases being stronger during recessions compared to expansions. More specifically, it could be that the Fed's policy rate is more sensitive to the stock market during recession then during expansions. The reason could be that during recession there is more pressure on the central bank to cut rates then there is pressure to raise rates during expansions. More specifically, the sensitivity of the monetary policy (β from appendix B) to stock market returns could be higher during recession compared to expansions.