The Fed's Policy Reaction Function and U.S. Stock Returns

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Abstract

This paper examines the dynamic linkages between monetary policy and the stock market during the monetary regimes of Volcker, Greenspan, Bernanke, and Yellen. The empirical findings from the benchmark model indicate that there have been distinct reactions of stock returns to fed funds rate shocks during each different monetary regime. These reactions appear more turbulent and persistent during the Bernanke and Yellen regimes than during the previous Chairs' terms. Thus, it can be concluded that monetary policy has had real and significant (short-run) effects on the stock market under all four monetary regimes examined. When augmenting the Fed's reaction function with variables such as stock returns, yield spreads, unemployment, and financial uncertainty, it is revealed that the Fed might have actually considered each of these magnitudes separately in its deliberations to conduct monetary policy. Finally, stock returns are found to react differently over different phases of the business cycle, with their reactions also found to be dissimilar during each expansion and contraction.

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I. INTRODUCTION

The dynamic interactions between monetary policy and the stock market are well known. However, the actual impact of monetary policy shocks to stock returns remains mixed. For example, while some authors (e.g., Cecchetti et *al*., 2003 and Becher et *al*., 2008) cite evidence that central bankers can indeed contribute to economic stability and growth by targeting asset prices (such as stock prices), others (e.g., Bernanke and Gertler, 2001) find little evidence that concentrating on asset prices the Fed could do much to improve economic activity. There is also mixed evidence that stock market behavior influences monetary policy decisions. For example, early research by Rogalski and Vinso (1977) and Vickers (2000) suggests that while monetary policy should not be guided by movements in the stock market, the Fed should not ignore it due to the (forward-looking) market's influence on economic activity. By contrast, later research by Gilchrist and Leahy (2002) argues against including asset prices in monetary policy rules because they may be destabilizing. Thus, the above evidence implies that there is no single, consistent and

unifying framework that describes the nature of the interaction(s) between monetary policy and the stock market (see also Laopodis, 2013).

Evidence is also mixed when it comes to the asymmetry of effects of monetary policy on the stock market. Kashyap et *al.* (2000) present general evidence of asymmetric effects of monetary policies over the business cycle. Bernanke and Gertler (1989) and Azariadis and Smith (1998) also note that monetary policies were more effective during bear markets than during bull markets. However, the extent and nature of the impact of monetary policies on different bull and bear markets is scant and thus more research is clearly warranted.

The relationship between monetary policy and the stock market has been investigated within two main Fed's reaction function settings, namely a modified Taylor-rule (Taylor, 1993) approach (see McCulley and Toloui, 2008, and Cúrdia and Woodford, 2010) and/or a general macroeconomic or structural framework (see Christiano et *al*., 1999). In this paper, we use the second approach --because it lends itself easily to be investigated via a vector autoregression (VAR) framework-- and employ the federal funds rate as the main policy instrument in setting monetary policy.

Specifically, the following three questions will be addressed. First, how has monetary policy responded to movements in the stock market during the previous four monetary policy regimes of Volcker in the 1980s, Greenspan until the mid-2000s, Bernanke until 2013 and, presently, Yellen? The differences in each Chair's view about the proper conduct of monetary policy are clear. Greenspan, for example, in one of his testimonies before Congress in 1996, had suggested using asset prices (being claims on future goods and services) in the Federal Open Market Committee's (FOMC) deliberations. He had especially highlighted the impact of rising asset prices (such as equities) on consumer wealth and aggregate spending. By contrast, Bernanke

had argued against explicitly targeting asset prices when conducting monetary policy (Bernanke and Gertler, 2000, 2001).

The current Chair of the Fed, Janet Yellen, advocates that asset purchases work to support economic growth by boosting stock prices and house values, maintaining that the resulting improvement in household wealth supports greater consumption spending (Yellen, 2013). Her recent comment (Yellen, 2016) that the Fed might be able to help the U.S. economy in a future downturn by expanding its toolkit to include buying stocks and corporate bonds, in the event that the Fed's current toolkit were to reach the limits in terms of purchasing safe assets like longer-term government bonds, is indicative of her support of intervening directly in assets where the prices have a more direct link to spending decisions.

Further academic research (Patelis, 1997, and Thorbecke, 1997) has shown that shifts in monetary policy help explain U.S. stocks. Moreover, Orphanides (2002) notes that the monetary policy rules of the 1970s (aimed at achieving full-employment) were sharply reversed in the 1980s and 1990s. In order to further investigate this controversy we explicitly augment the Fed's policy reaction function with stock prices (returns) and trace the function's impact on the stock market.

Second, has the Fed looked at other (than inflation and output) market indicators for guidance in conducting monetary policy and, if so, to what extent have these indicators played a significant role, if at all? For example, the Fed sharply reduced its (operating target for the) federal funds rate in late 2007 in complete absence of evidence of decline in real output or inflation (in fact, inflation was increasing). Therefore, one might surmise that the Fed was closely watching other economic and/or financial indicators (including asset prices) which showed deterioration in the financial sector. The obvious question is whether Fed's attention to such indicators would make monetary policy more effective. To explore this possibility, we include several economic and financial variables in the Fed's reaction function, such as various credit spreads, the rate of

unemployment, and measures of financial market uncertainty (in addition to stock prices, as mentioned above) to determine their significance in influencing future monetary policy (via changes in the fed funds rate).

The third and final question we address in this paper refers to the asymmetric effects of monetary policy on equity returns during bull and bear markets. Research on the effects of monetary policy on bull and bear markets has been rather limited. An early study by Cover (1992) examines the asymmetric effects of money supply changes (but not the federal funds rate) on stock returns. Lobo (2002) finds asymmetric reactions of stock returns to surprise announcements of the federal funds rate target. In general, when there are informational disadvantages among market participants, firms and other investors behave as if they are financially constrained (see Kiyotaki and Moore, 1997). Such behavior may become more pronounced during bear markets, due to deterioration in the firms' balance sheets, implying that monetary policy may have a greater impact during such markets. A related and new question is whether monetary policies had asymmetric effects on stock prices during *different* bull markets, for example, during the boom years of the mid-1980s and the long boom of the mid-1990s, and *different* bear markets, such as those of the early 1980s and early and late 2000s. We examine this question using an algorithm for identifying bull and bear markets.

In all above cases, the identification of the monetary policy shocks is derived from an extension of the macroeconomic framework put forth by Christiano et *el*. (1999), according to which the Fed's information set is composed of certain macroeconomic variables. This framework would constitute the Fed's benchmark federal funds reaction function, which will subsequently be augmented with the above-mentioned economic and financial variables to see if there has been a different impact of monetary policy on the stock market. The analysis will take place from

January 1979 to July 2016 to capture the last four Fed chairpersons' views on monetary policy and the asymmetric impact of monetary policy during up and down markets.

This study is important for several reasons. First, it is useful to determine if the real economy, proxied by industrial production growth or the unemployment rate, constitutes important inputs in the Fed's policy deliberations. If so, then market agents should be expected to adjust their behavior following news about the real economy. Second, if the information provided by the financial sector of the economy, from changes in credit spreads or financial uncertainty, for example, is relevant to the Fed then periods of financial uncertainty should be accompanied by a looser monetary policy stance which, in turn, would positively affect stock prices. Finally, can we conclude that monetary policies change during different bull and bear markets or when financial markets are unstable? If so, it would be interesting to find out which magnitudes (financial and economic indicators) the Fed paid attention to each time, the extent to which these magnitudes enter the Fed's interest-rate setting process and the speed with which policy is subsequently implemented. These questions have significant implications for all market agents, retail and institutional alike.

The rest of the paper is organized as follows. Section II deals with model construction, data sources and identification of the four monetary regimes. Section III presents and discusses the main empirical results, both with the estimation of the benchmark and the augmented Fed reaction functions. Section IV starts with a discussion of the returns – monetary policy interactions during selected economic expansions and contractions, selected bull and bear stock markets, and ends with some robustness tests. Finally, section V concludes the study.

II. METHODOLOGY AND DATA

II.1. Model construction

We follow the approach in Christiano et *al.* (1999) in constructing the benchmark model and use the federal funds rate as the main monetary policy instrument. This choice among other policy instruments is clear since the funds rate is now the accepted measure of monetary policy (Bernanke and Blinder, 1992). Then comes the identification of the monetary policy shock through the derivation and estimation of the Fed's reaction function. The idea in this step is to make this shock orthogonal (exogenous) to the Fed's information set that is, to abide by the so-called recursiveness assumption. The Fed's initial (benchmark) information set is composed of the following five variables: industrial production, the producer price index, the consumer price index, the federal funds rate and total bank reserves, all expressed in first-difference form to induce stationarity. All these variables have been standard in the literature and, therefore, are being used as established (see Christiano et *al.*, 1999).

More concretely, let i_t be the monetary policy instrument (the federal funds rate here) being a linear function, ξ, of the information set, Ω_t, which includes the variables listed above, available to the monetary authority as follows:

$$i_t = \xi(\Omega_t) + \theta(\varepsilon_{i,t}) \qquad (1)$$

where θ is a positive number, and $\theta(\varepsilon_{i,t})$ is a serially uncorrelated monetary policy shock that is orthogonal to the elements of Ω_t and has a unitary variance. In order to justify interpreting $\varepsilon_{s,t}$ as an exogenous policy shock, equation (1) must be viewed as the monetary authority's rule for setting i_t. Moreover, the orthogonality conditions on $\varepsilon_{s,t}$ correspond to the assumption that policy shocks at time t do not affect the elements of Ω_t. Therefore, conditional on this specification (or the Fed's feedback rule) we can measure the dynamic response of a variable to a monetary policy

shock by the coefficients in the regression of the variable on current and lagged values of the fitted values in equation (1). This procedure can be charted into an asymptotically-equivalent VAR from which the impact of monetary policy shocks on stock returns is obtained.

Specifically, the reduced-form, 5-variable VAR can be conveniently expressed (using matrix notation) as follows:

$$\boldsymbol{A(L)\, Z_t = \varepsilon_t} \tag{2a}$$

$$\boldsymbol{A(L) = \Sigma^{\infty}_{j=0}\, A_j\, L^j} \tag{2b}$$

$$\boldsymbol{\varepsilon_t = H\, \upsilon_t} \tag{2c}$$

where Z_t contains the five variables identified above, $A(L)$ is the matrix lag operator, $A_0 = I$, ε_t is a vector of residuals (innovations) with covariance matrix Ω, which can be expressed as a linear combination of orthogonal structural disturbances, υ_t.

To identify H, assume that the υ_t's are normalized (with unit variance) so that $HH' = \Omega$. The interest here is on the monetary policy shock only and thus, following the standard VAR literature on recursive ordering, it is placed last among the other variable shocks (emanating from the other four variables) in the H matrix. Finally, to ensure (under the standard Cholesky decomposition or ordering) that the variables are not allowed to simultaneously respond to the monetary policy variable, but the variables are allowed to simultaneously react to the policy variable, we impose a restriction on the H matrix that the policy shock can have no long-run interactions on the fed funds rate (for more details, see Christiano et *al.*, 1999).

II.2. Data sources and variable construction

Monthly data on the five macroeconomic variables (industrial production, the producer price index, the consumer price index, the federal funds rate, and the total bank reserves) are collected from the Federal Reserve's *FRED* databases for the period of January 1979 to June 2016.

The industrial production growth rate, the inflation rate (measured by the consumer price index for all urban consumers, all items), the rate of change in commodity prices (or the monthly spot market commodity price index), and the change in total reserves (the Board of Governors total reserves adjusted for changes in reserve requirements) are all seasonally adjusted. The federal funds rate is the effective funds rate as averages of daily rates. The risk-free interest rate in this study is the 3-month Treasury bill. Finally, the S&P500 index (and its variants such as with and without dividends) is obtained from the Center for Research in Security Prices (*CRSP*) database for the same period.

The following variables are constructed from the original ones above. The continuously-compounded, nominal stock returns (*nsr*), the real stock returns (*rsr*), obtained by subtracting the rate of inflation from the nominal returns, the stock returns with dividends, the excess stock returns, obtained by subtracting the 3-month Treasury bill from the nominal returns, and the credit spreads, obtained by taking the difference between AAA or BAA corporate bonds and treasury bonds, as well as among the BAA-rate and AAA-rate corporate bonds. All original and constructed variables are stationary and so no unit root issues are present.

II.3. Monetary policy regimes

The four monetary regimes coincide with the terms of the four Fed chairmen, Paul Volcker (August 1979 to August 1987), Alan Greenspan (August 1987 to December 2005), Ben Bernanke (January 2006 to December 2013) and Janet Yellen (January 2014 to date). Volcker, a monetarist advocate, shifted the Fed's policy tools (fed funds rate, money supply and borrowed and non-borrowed reserves) several times. This 'monetarist experiment' only lasted for three years (1979-1982), as the fed funds rate became highly volatile, plunged the economy into recession and, ultimately, forced Volcker to begin paying more attention to the funds rate to bring inflation

down. All told, retargeting the fed funds rate in effect implied the Fed's return to the pro-cyclical monetary policy.

Greenspan continued the interest-rate targeting rule to counter inflation and unemployment. Greenspan's idea of monetary policy was to carefully balance its use to offset adverse shocks to the economy with vigilance, such that monetary policy is not too expansionary. Bernanke's monetary policy philosophy follows that of Greenspan's, focusing on inflation targeting and permitting the Fed to concentrate on combating unemployment. The latter objective was not emphasized much by Volcker. Bernanke continued Greenspan's widely accommodative monetary policy and greatly expanded it to combat the financial crisis of 2008 to the end of his reign in 2013.

Yellen vowed to start paying a closer attention to the labor market and inflation, compared with her predecessor. During most of her tenure to date, she has kept interest rates low and only raised them in December 2015. Despite low rates and additional quantitative easing policies, economic growth remained sluggish. Thus, in August 2016, Yellen explicitly argued for raising the 2% inflation target and expanding the types of asset purchases, as just cutting interest rates may not be adequate in combatting recession.

III. MAIN EMPIRICAL RESULTS

This section contains selected empirical findings, from both the benchmark and augmented federal funds reaction functions, and discusses them at length. The optimal lag length for the variables comprising the Fed's information set, and used to derive the policy rule, was six months. For the sake of space preservation, we only report selected results, which include variance decompositions and impulse response graphs for both nominal and real stock returns.

III.1. Benchmark Federal Funds Rate Reaction Function Results

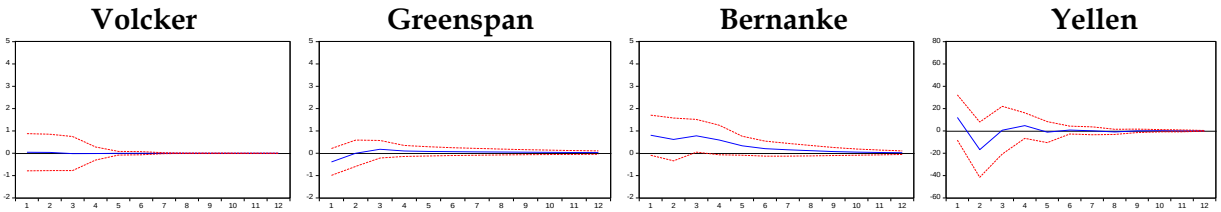
Table 1 contains the variance decomposition (*vd*) results from the benchmark federal funds reaction function (*brf*). The benchmark reaction function is the one identified in subsection 1.1. Several observations can be made from the first panel of the table. First, nominal stock returns (*NSR*) appear to explain an average of 5% of *brf* in the 1980s, nothing until the mid-2000s and a mere 1% in the 2000s. By contrast, *brf* is seen to explain a negligible portion of the error forecast variance of *nsr* in the first regime. That portion becomes a bit larger thereafter (an average of 3% in the Greenspan and Bernanke regimes), but greatly rises (to almost 9%) during the Yellen period. Second, *brf* seems to exhibit remarkable persistence to own innovations during the second and fourth monetary regimes, but less so in the first and third regimes (94% and 92% respectively). By contrast, the returns show a very high degree of persistence in the Volcker era (more than 99%) but a bit lower in the other two eras.

The second panel of the table indicates the real returns (*rsr*) fed funds rate reaction function *vd* results. In general, we note some differences in the results for the four monetary regimes as far as the explanatory power of *rsr* on *brf* is concerned, which appears to increase over time reaching up to 10% in the Yellen regime. However, *brf*'s explanatory portion amounts to a marginal 1% of *rsr*'s forecast variance in the first three regimes, but almost 10% in the Yellen regime.

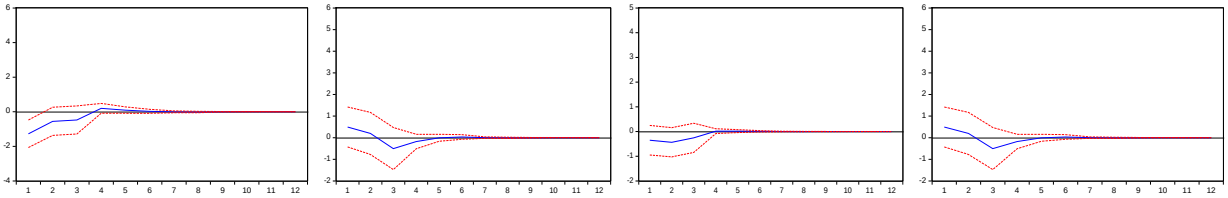
To obtain more insights about the dynamic linkages between the two series and to facilitate the comparison among the four monetary regimes, Figure 1 illustrates in four panels the dynamics, both unanticipated and unanticipated, between the fed fund rate's reaction function and nominal stock returns. The graphs in Panel A of Figure 1 show the impulse responses of nominal returns (*nsr*) to anticipated and unanticipated funds rate shocks for up to twelve months.

Figure 1. Anticipated and Unanticipated Responses of the Fed's Benchmark Reaction Function (*BRF*) and Nominal Stock Returns to Shocks from each other in each Monetary Regime

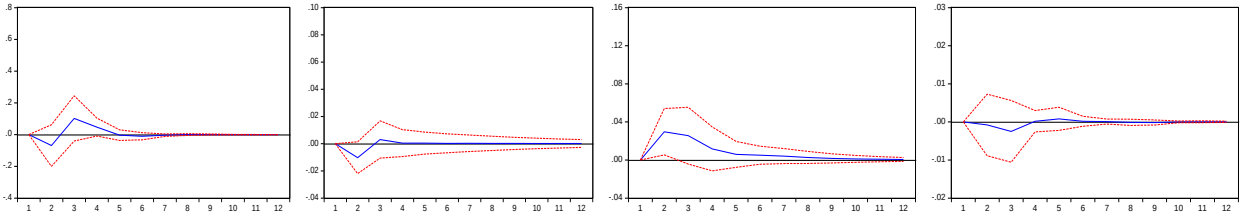
Panel A: NSR: Anticipated responses



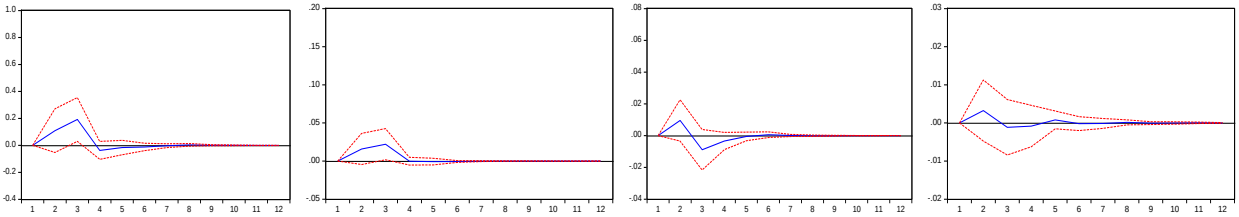
Panel B: NSR: Unanticipated responses



Panel C: BRF: Anticipated responses



Panel D: BRF: Unanticipated responses



The responses of *nsr* to expected fed funds shocks differ in each monetary regime. Specifically, they barely react in the Volcker and Greenspan regimes, but react positively in the Bernanke regime and sharply negatively in the Yellen regime. In the cases of the last two regimes, shocks appear to die out within ten to twelve months. Panel B contains the reactions of returns to unexpected shocks from the funds rate. Unanticipated responses are useful in determining the

role of market expectations regarding an impending monetary policy action. Unexpected shocks are defined as the differences between the actual fed funds rates and the expected rates from the Fed's benchmark reaction function for each monetary regime. From the graphs, we observe a negative initial reaction in the Volcker and Bernanke periods, but similar, alternating between negative and positive, reactions in the other two periods. Contrary to the anticipated shocks' duration, these seem to die out within 4 to 5 months.

Panels C and D show the responses of the fed funds rate to expected and unexpected stock returns shocks. The Fed's reaction function exhibits greater sensitivity to anticipated shocks during the Volcker and Bernanke regimes, but a mild one during the other two regimes. A more pronounced response is observed in the Bernanke regime relative to the Volcker regime. As far as the unanticipated fed fund's rate responses are concerned (see Panel D), we note a significant and positive one in the Volcker regime and a similar one but of much lesser intensity in the Greenspan regime. In the Bernanke and Yellen regimes we see similar, alternating between positive and negative, responses but those in the Yellen regime appear to be less intense compared to the Bernanke regime.

Taken overall, the responses of the stock returns to federal funds rate shocks imply that monetary policy switches have had real and significant quantitative (short-run) effects on the stock market. The different (and stronger) responses of returns to fed funds shocks during the Volcker and Greenspan periods attest to the FOMC's commitment to subdue inflation by conducting policies to offset it. Another observation is that the Bernanke regime seems to be similar compared to the Yellen one and this surfaces in the behavior of both returns and the fed funds rate. These findings are consistent with past evidence that shows significance of such effects, at least in the short run (e.g., Thorbecke, 1997, and Laopodis, 2009). Guo (2004) additionally found that stock

prices negatively and significantly responded to unexpected changes in the federal funds rate (target), but not to expected ones.

III.2. Augmented Federal Funds Rate Reaction Function Results

This subsection considers the linkages between stock returns and monetary policy when the Fed's benchmark funds rate reaction function (equation 1) is augmented with more variables such as stock returns, various credit spreads, the change in the unemployment rate and a proxy for financial market uncertainty. We begin with adding nominal stock returns in the funds rate reaction function.

III.2.1. Stock returns

Apart from the mixed evidence on the impact of monetary policy on stock returns mentioned in the Introduction, another argument for including stock returns in the Fed's reaction function is to depict whether the Fed uses them when it is at an informational disadvantage compared to the private sector. If stock prices, as leading indicators, convey useful information about the future state of the economy, then it is expected that they vary with the systematic part of monetary policy. But what about the question of central banks using asset prices as a separate objectives? Although Carlstrom and Fuerst (2001) suggest that credit market imperfections justify a separate response of monetary policy, Borio and Lowe (2002) argue that high asset price growth (with rapid credit expansion) serves as an indication for future financial instability, thus prompting an offsetting response from the central bank. Svensson (2009) notes that asset prices should influence policy only to the extent to which they affect (the forecasts of) policy variables such as inflation, but in no way do they constitute target variables (see also Clarida, 2012). Furthermore, while Gilchrist and Leahy (2002) argue against using asset prices for inclusion in monetary policy rules, Rigobon and Sack (2003) strongly argue in favor of using asset prices in

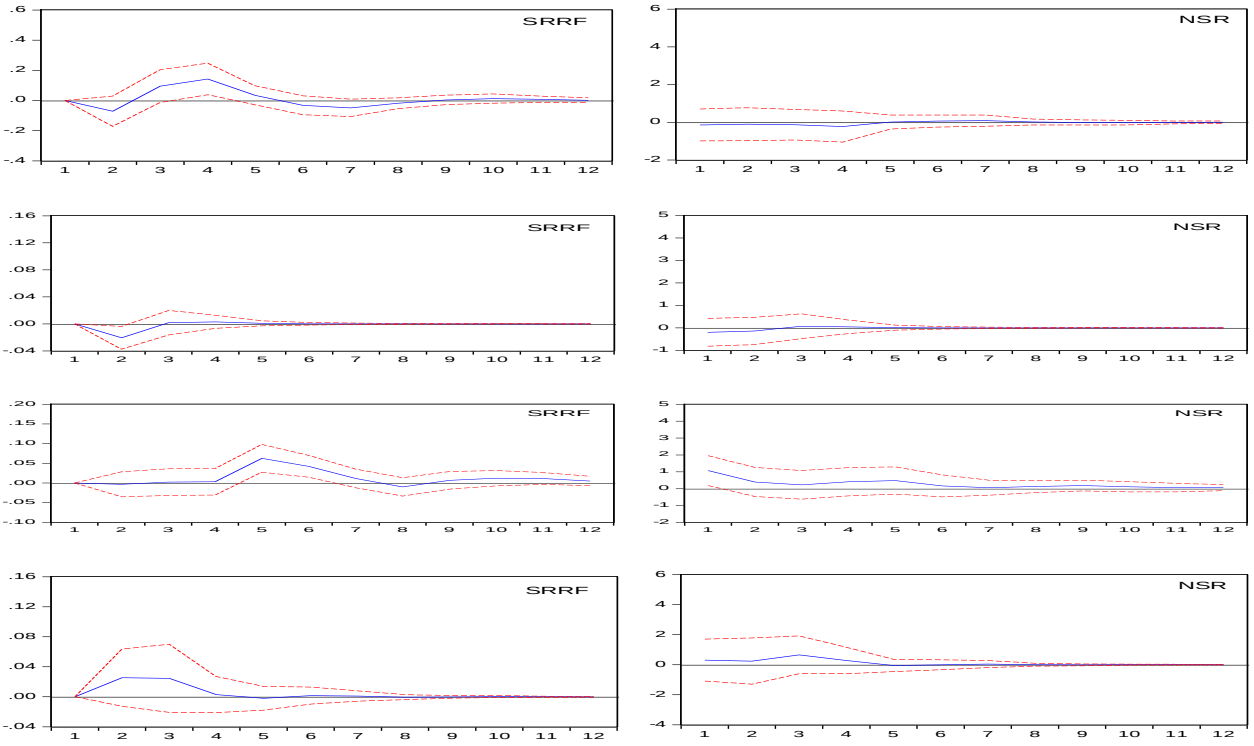
conducting monetary policy. In general, despite the lack of theoretical and empirical consensus on how useful asset price information is for monetary policymaking, one should not discard the possibility that stock prices are useful indicators to policymakers. Besides, it should be instructive to measure (gauge) the extent to which systematic monetary policy was affected by stock market developments.

Figure 2 displays the stock returns-augmented reaction function (*srrf*) and nominal returns (*nsr*) reaction functions to shocks from each other in the four monetary regimes examined. The responses of *srrf* appear somewhat turbulent in all but the Greenspan regime (and in comparison with those from the benchmark model, see Figure 1). Specifically, *srrf* seems to negatively react to stock market shocks with a 2-month delay in the Volcker and Greenspan regimes only. In the Bernanke regime, it is totally unresponsive until the fourth month when it sharply reacts in a positive manner. In the Yellen regime, it reacts mildly positively but by the fourth month it settles. The reaction function's responses are more notable in the Volcker regime. There is also a great degree of interest-rate persistence (inertia) in the system, especially during the Volcker and Bernanke regimes as *srrf* returns to its steady-state in almost a year. Woodford (2003) terms such interest-rate inertia as conduct of good monetary policy since the policymaker flattens the impact of policy on the private sector over a long period of time. Bjørnland and Leitemo (2009) also find such positive and persistent influence of stock prices on the federal funds rate, despite the fact that their approach is not directly comparable to the one here.

By contrast, the returns' responses to fed funds rate changes are seen to be non-responsive in the Volcker and Greenspan regimes (although they appear to be negatively affected), but react positively in the Bernanke and Yellen regimes, albeit in a more pronounced manner in the latter. Stability (steady-state) is achieved within six months in the Bernanke and Yellen regimes, but

takes about a year in the other two regimes. The negative result in *nsr* is consistent with the increase in the discount rate of expected dividends following the rise in the fed funds rate and

Figure 2 **Stock returns-augmented reaction function (*srrf*) and nominal returns (*nsr*) reactions to shocks from each other in the four monetary regimes**



with a short-run increase in the cost of borrowing which causes asset values (like future dividends) to decline. The interesting result is the positive reaction of the returns to a policy shock which can be, partly, explained by the gradual increase in the values of assets (stock prices and dividends) as the interest rate falls. Comparison with the anticipated returns' reactions from the benchmark model's impulse responses (Figure 1) shows higher volatility of returns (mainly in the Yellen regime), which may be interpreted as the Fed being able to calm financial markets by paying attention to stock prices and standing ready to intervene. Besides, one can argue that the Fed had indeed included share price information in its policy goals (this refers to the now famous notion of the 'Greenspan put' --lately the 'Yellen put'-- which basically implies that the Fed would not allow the stock market to fall below a certain level). A corroboration of this argument is the

evidence presented by Cecchetti et *al*. (2003) that the FOMC knew about the (upcoming) equity bubble but did nothing to prevent it.

III.2.2. Spreads

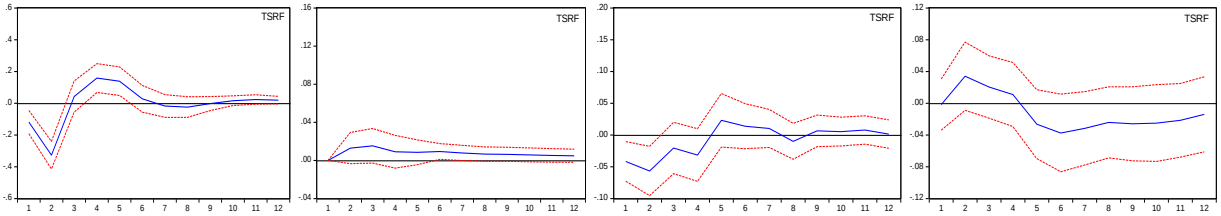
In this subsection, we examine the impact of various spreads on the Fed's reaction function. Credit spreads reflect the cost of borrowing and investing and play an important role in the economy and the stock market. Such spreads contain useful information about market expectations regarding inflation and real activity. The spike in credit spreads during the financial crisis of late 2007 rekindled the interest in their role and the obvious question is whether the Fed has considered such spreads (recently or in the past) in its response function. Recent evidence by Cúrdia and Woodford (2010) indicates that the Fed reacted to (short-term asset) spread changes (within a spread-augmented Taylor rule) but the (optimal size of the) reaction was not strong. In this subsection, we measure various spreads such as: a term spread, by taking the difference between the 10yr T-note and the 3m T-bill, and two credit spreads, the first one by the difference between BBB yields and the 10-yr T- note and the second one by the difference between BBB and AAA yields.

Figure 3 exhibits only the responses of the spreads-augmented reaction function of the Fed (*tsrf*) to shocks from the term and credit spreads in each regime. Panel A of the figure contains the reaction function's (*tsrf*) responses to term spread shocks, while Panel B portrays the function's reactions (*csrf*) to the first credit spread. Looking at the Volcker policy era response, we see that it is turbulent and alternating between positive and negative before decaying after almost nine months. A similar but less intense response is evident for the Bernanke policy era. The Fed's reaction function, by contrast, appears to respond in the opposite manner during the Yellen era taking well over a year to subside. Finally, the reaction function's response during the Greenspan era appears to behave welling and mild to term spread shocks. Looking at the second panel of

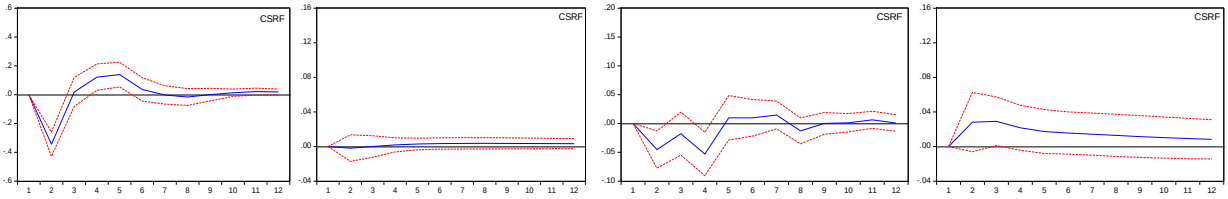
the figure, where the reactions of the Fed's reaction function (*csrf*) to credit spread shocks are plotted, we can essentially observe the same type of responses with the exception of those during

Figure 3 Responses of spreads-augmented Fed reaction function (TSRF) to spread shocks

Panel A: TERM SPREAD



Panel B: CREDIT SPREAD 1



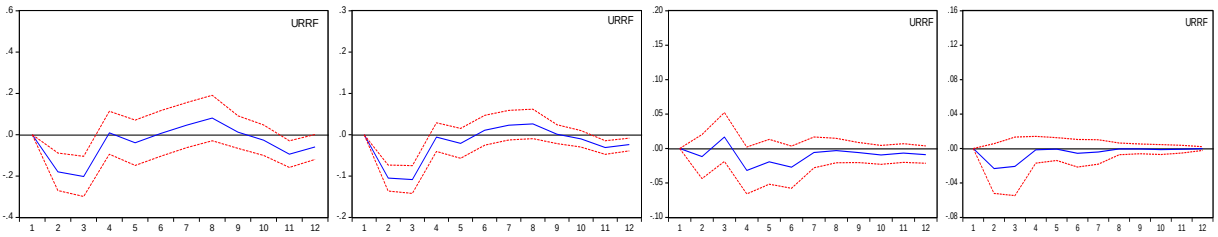
the Yellen regime. These surface as mostly positive, instead of alternating between positive and negative responses, and take, again, well over a year to die out.

In general, one could argue that such notable reactions of the Fed's policy rule to spreads may be due to increased monetary tightening (during the Volcker era) and to the market crash in the late 2000s (during the Bernanke and Yellen eras). By contrast, the impact was weak during the dot com crisis of early 2000s (during the Greenspan era). This makes sense because had the Fed reacted as strongly as before to spread increases, the fed funds rate would have been much higher than otherwise (and, in fact, it was at very low levels for a prolonged period). Thus, one can argue that the Fed might have (explicitly) paid attention to credit conditions in the market and addressed them aggressively in the past.

III.2.3. Unemployment rate

One of the Fed's mandates is to address unemployment issues and thus it is supposed to react to rising unemployment. Evidence suggests that the funds rate reacts negatively to positive changes in the unemployment rate (Bernanke and Blinder, 1992). Thus, high unemployment is followed by a stimulative monetary policy which decreases the funds rate and, in turn, increases stock prices (see also Rigobon and Sack, 2003). The impulse response analysis of the Fed's unemployment-augmented reaction function (*urrf*), shown in Figure 4, shows that monetary policy towards unemployment changes was similar but varied in intensity during each monetary regime. Specifically, the Fed appeared to aggressively react to changes in unemployment during the Volcker and Greenspan regimes but less so during the other two regimes. It seems that the Fed lowered the funds rate within a period of three to four months before it reversed it to a steady state, which took well over a year during the Volcker and Greenspan regimes. Again, comparison of these results with the ones obtained from the benchmark reaction function (available upon request) shows a much higher volatility in the unemployment-augmented reaction function in all four monetary regimes.

Figure 4 **Responses of unemployment-augmented Fed reaction function (URRF) to unemployment rate shocks**



These observations are borne out of the facts given that unemployment reached almost 11% during the Volcker regime and nearly so during the Bernanke regime (before it went down to 9%), while it only averaged 5% to 6% during the Greenspan regime and stood below 5% in mid-2016 during the Yellen regime. In addition, during the Greenspan regime information from the fed funds futures market (for example, during the 1990 to 1992 period) pointed to a lowering

of the funds futures rate when news of higher-than-expected unemployment broke. Finally, turbulent and similar reactions of *nsr* (red lines) are also evident during the first and third monetary regimes, which imply that the stock market was also affected by such strong Fed reactions to unemployment changes.

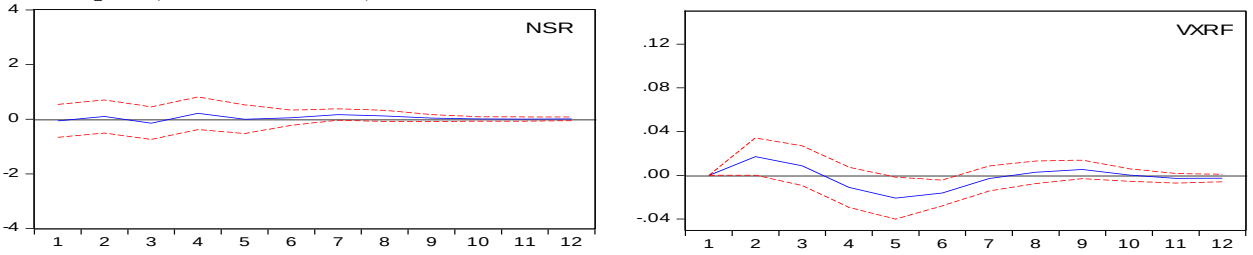
III.2.4. Financial uncertainty

It is hypothesized that as financial market uncertainty rises, employment and output may decrease thus motivating the Fed to respond by lowering the fed funds rate. It is also important to mention that market uncertainty can be generated from policy uncertainty, which emanates from the market's efforts to 'decipher' the Fed's FOMC reports. Thus, it is useful to augment the Fed's reaction function by some measure of financial market conditions to get a better idea of the Fed's interest-rate setting process. Very few studies (for instance, Whaley, 2000, and Bloom, 2009) have examined the relationship between financial market uncertainty and monetary policy stance or rule but did not arrive at a consensus on whether monetary policy should track some measure of financial uncertainty. One such measure is the volatility index (*vix*) which represents the option-implied volatility of the benchmark S&P500 index. The *vix* is known as the 'fear gauge' and reflects market participants' expectations of the stock market volatility over a 30-calendar day horizon. Other studies proposed augmenting the standard policy rule by including stock-market financial stability indicators (Akram et *al.*, 2007) and found that welfare gains are shock-dependent, or by taking bank capital adequacy requirements into account in the interest-rate rule (Cecchetti and Li, 2008), which should reduce the conflict between monetary policy and financial institution supervision.

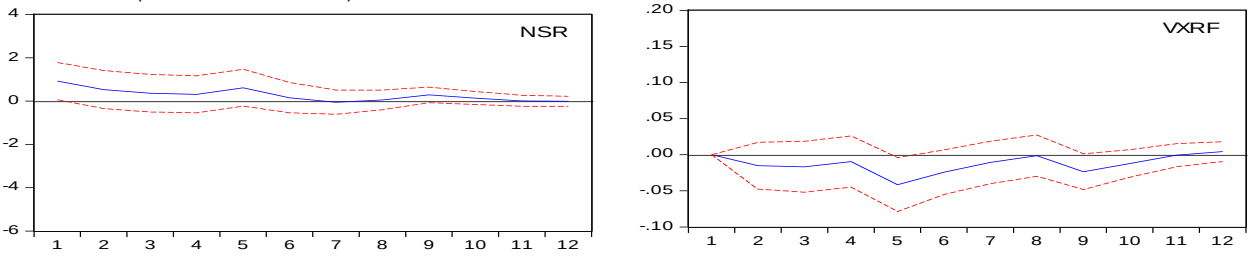
Figure 5 shows the reactions of stock returns (*nsr*) and fed funds vix-augmented reaction function (*vxrf*) to shocks from each other during the last three monetary regimes.[1] From these graphs it is observed that the stock market reacted more to policy moves during the Bernanke and Yellen regimes than during the Greenspan regime. We can interpret this finding by noting that when the economy (and the financial system) is stable, the Fed has no reason to consider

Figure 5. Responses of VIX-augmented reaction function (VXRF) and stock returns (NSR) to shocks from each other

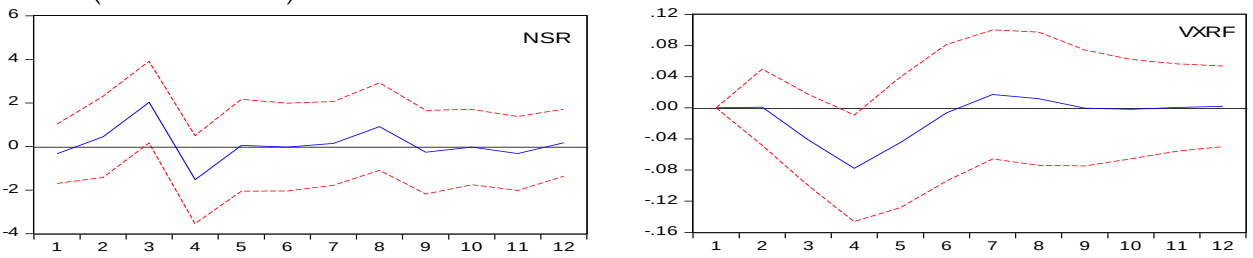
Greenspan (1990:1 – 2005:12)



Bernanke (2006:1 – 2013:12)



Yellen (2014:1 - 2016:6)



financial stability indicators in its interest-rate setting process; rather, it focuses on the usual fundamentals. The Greenspan period was mostly characterized by general financial stability (despite the stock market crash of the early 2000s) and that is why the stock market's response

[1] Note that the VIX series began in 1990 and thus did not exist during the Volcker years.

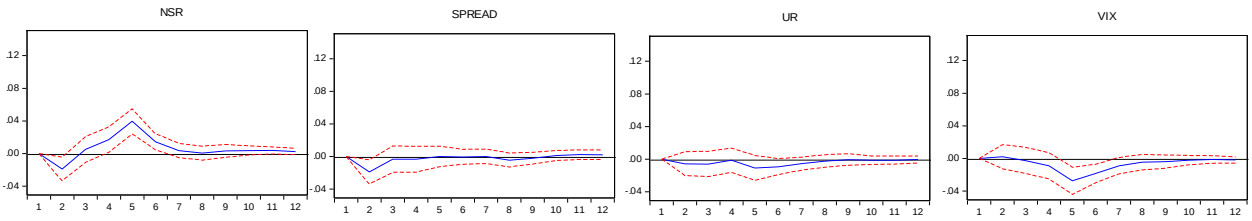
was mild. By contrast, the severe financial crisis of 2007-9, which took place during the Bernanke regime and during which the *vix* spiked, implied a direct and strong response by the Fed to the financial instability by sharply reducing and keeping interest rates near zero. Also, compared to the previous market contractions in the early 1990s and 2000s, the recent one has proven to be much more potent.

The responses of the Fed's reaction function were a bit different in each regime but mostly similar in the last two regimes. During the Greenspan regime, the reaction function appeared to be increasing and decreasing in response to financial uncertainty shocks before settling within a year. During the Bernanke and Yellen regimes, it seems that the Fed lowered the funds rate in response to such shocks and maintained them low for a long time (as seen in the Bernanke graph). Yellen's policy was to occasionally raise expectations of interest rate increases, as evidenced by alternating responses of the reaction function, but mostly maintained very low (or even negative) rates in the economy.

III.2.5 All variables

Finally, we examined all above-mentioned variables simultaneously with the Fed's benchmark reaction function to trace the impact of shocks from these variables on the reaction function. Due to the few remaining degrees of freedom after a 4-lag optimal VAR specification (no cointegration was detected) in each monetary regime when all variables are investigated simultaneously, we decided to use the entire sample period. Thus, the insights pertain to all four monetary regimes, in general. Figure 6 displays these responses.

Figure 6. Responses of the Fed's benchmark reaction function to shocks from all variables



Looking at the first graph, where nominal stock returns shocks take place, we note negative response, initially, of the Fed's policy reaction function followed by a strong positive response five months later, leading to a settling of the shock in less than a year, on average across all four regimes. A shock by a credit spread elicits a negative, yet weak, response by the Fed's reaction function lasting only less than four months. An unemployment rate shock causes the policy function to mildly and negatively respond across all monetary regimes. Finally, a financial uncertainty shock provokes a delayed response by the Fed (only after 3 or 4 months) in decreasing the fed funds rate. In sum, the Fed's policy function appears to have behaved as expected (that is, to decrease the fed funds rate) following adverse movements in credit spreads, unemployment outlook and financial status in the economy. The only difference in its response was in the stock market's behavior which appears to be counter-intuitive. In this case, the Fed's policy function's true response may be masked by the use of the entire period.

IV. FURTHER EVIDENCE ON POLICY - STOCK MARKET LINKAGE

In this section, we explore the impact of monetary policy, from the benchmark fed funds reaction function, on nominal and real stock returns during selected economic expansions and contractions and selected stock market advances (bull markets) and declines (bear markets). We end the section with some robustness tests.

IV.1 Impact of monetary policy during economic expansions and contractions

In general, during economic contractions firms experience a worsening in liquidity and may become financially strapped. An accommodative monetary policy, attacking the economic

contraction, reduces the cost of financing, boosts liquidity, and raises the firms' investment demand. By contrast, a contractionary monetary policy may lower stock returns and actually trigger an economic contraction, thus accentuating the decline in stock returns. Therefore, such policy actions are likely to have a greater impact on the real economy during economic contractions than during economic expansions.

To identify economic expansions and contractions, as proxies for stock market bull and bear regimes, we will use the National Bureau of Economic Research (NBER) classification of U.S. business cycles. Table 2 records the NBER's business cycle reference dates for peaks, troughs, contractions and expansions, as well as their duration (in months) between 1980 and 2009. In what follows, we examine two expansions (1991-2000 and 2002–2007) and two contractions (1980–1982 and 2008–2009) with both nominal and real stock returns.

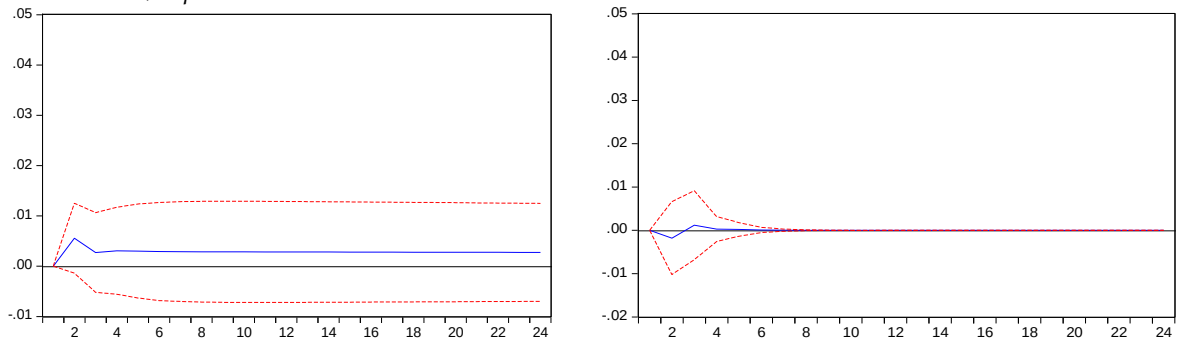
Figure 7 shows the reactions of nominal and real returns for the two expansions (Panels A and B) and the two contractions (Panels C and D) to fed funds reaction function shocks (derived from the benchmark fed funds reaction function, *ffrrf*). The reaction of *nsr* (see first graph in Panel A) during the first expansion (April 1991 to February 2001) surfaces as positive yet weak and somewhat persistent, whereas that of the second expansion (December 2001 to December 2007) is seen as negligible (see second graph in Panel A). *Rsr*'s reaction, by contrast, in the first expansion emerges mostly positive, turbulent and persistent, while that of the second expansion emerges as weak and negative. Full absorption of the shock takes place within two years, in the case of *rsr* during the second expansion.

The benign reaction of the stock market following several policy changes during the 1990s can be explained as follows. First, the economy was emerging from a recession in the early 1990s and thus small interest rate decreases were necessary and favorably contributed to market advances. Second, beginning in the mid1990s, rapid advances in the stock market were not

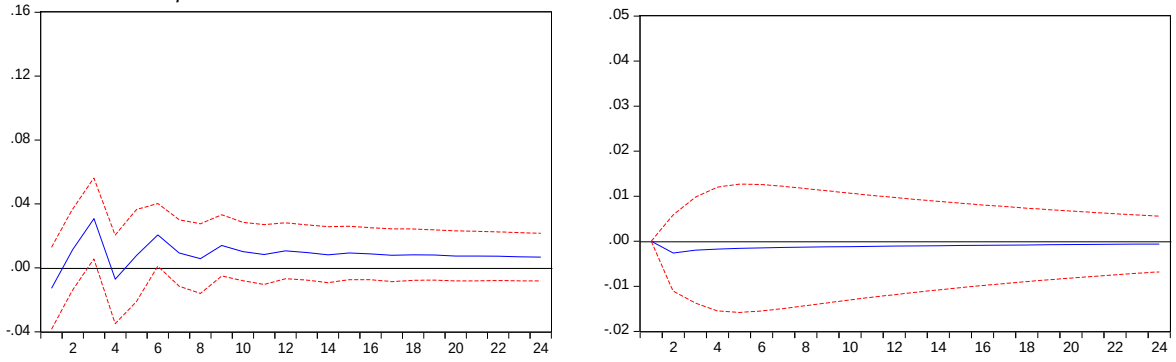
hindered by the frequent (and sharp, at times) rate increases. The stock market was at a boom with near zero inflation and very low unemployment. Thus, despite several contractionary monetary policy moves, the market appeared to move largely independently. Finally, economic shocks were sparse and this added to the 'exuberant' behavior of the stock market. Similarly, during the second expansion, the stock market was barely affected (in fact, it kept expanding by about 3% throughout the period from mid-2002 to mid-2007) following several early fed funds rate decreases and then frequent rate increases that drove rates to almost 5.25%).

Figure 7. Responses of nominal (NSR) and real stock returns (RSR) during selected expansions and contractions*

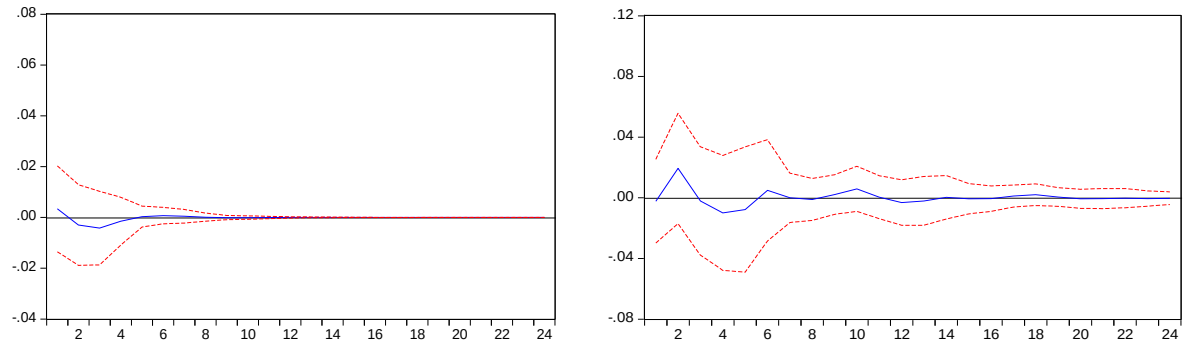
Panel A: NSR, *expansions*: 1991:04 – 2001:02 *and* 2001:12 – 2007:12



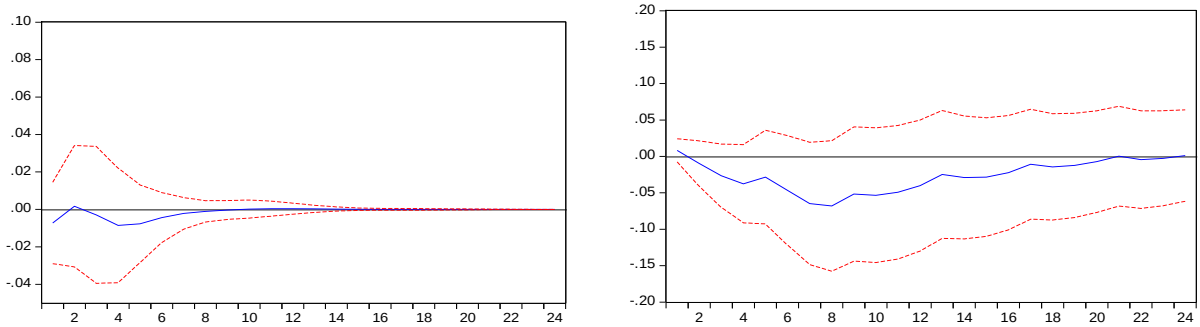
Panel B: RSR, *expansions*: 1991:4 – 2001:02 *and* 2001:12 – 2007:12



Panel C: NSR, *contractions*: 1980:01 – 1982:11 *and* 2008:01 – 2009:06



Panel D: RSR, *contractions*: 1980:01 – 1982:11 *and* 2008:01 – 2009:06



* Dotted lines are error bands

As expected, *nsr*'s reactions during contractions surface as more turbulent, although much more so during the second contraction (see 2nd graph in Panel C) than during the early 1980s contraction (1st graph in Panel C). However, the nature and size of monetary shocks were fairly small or less volatile during the second contraction episode compared to that in the early 1990s. This suggests that monetary policy became more effective in stabilizing the general stock market (via the policy's effect on the economic activity) since the 2000s (see Boivin and Giannoni, 2006). The equity market actually realized positive gains (6%, on average) during the first recession and rebounded rather quickly from the recent recession, advancing by almost 7% within one year from its lowest point (February 2009). *Rsr*'s negative responses are seen, again, as more pronounced in the second contraction (see 2nd graph in Panel D) relative to the first one taking almost two years to fully absorb the shock.

IV.2 Impact of monetary policy during bull and bear stock markets

At the outset, it is important to define 'bull' and 'bear' markets. In general, there are no widely accepted definitions of asset booms and busts, despite the attempts of many studies to identify turning points for bull and bear stock markets using statistical (probability) filters. Specifically, existing models of identification of bull and bear markets rely on an ex post evaluation (examination) of the peaks and troughs of a stock market index. Popular models include two-state (Chen, 2007) and three-state Markov (regime) switching models (Lunde and Timmerman, 2005), and other dating algorithms to identify turning points of business cycles (Bry and Boshan, 1971, Hamilton and Lin, 1995, and Pagan and Sossounov, 2003).

In this paper, we adopt a modified version of the Lunde and Timmermann (2004) algorithm, whereby we calculate the cumulative return of the nominal stock returns to identify the peaks and troughs of the stock market index moving forward. The threshold we use is a 20% return, at or beyond which the stock market is classified as a bull market.[2] Following the above procedure (algorithm), the following bull and bear markets (for this part of the analysis) were identified: a bull stock market, starting in September 2002 until September 2007, and a bear stock market, beginning in October 2007 and ending in March 2009 (see Figure 8).[3] Although this analysis implies immediate (ex-post) action by the Fed when the market hit its lowest point, it is important to bear in mind that the monetary policy rule (that is, the benchmark federal funds reaction function) was derived with six lags of each variable (which made up the Fed's information set).

Figure 8. Logarithm of S&P500 index, 1978:1 – 2016:6

[2] We define a dummy variable which takes the value of 1, if the market is identified as bull state at time *t* by the procedure, and 0, if the market is in a bear state.

[3] The results from the other expansion and contraction for both nominal and real returns are available upon request.

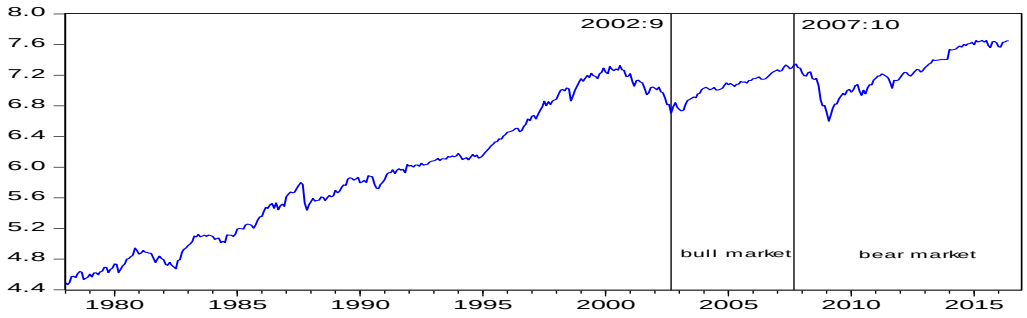
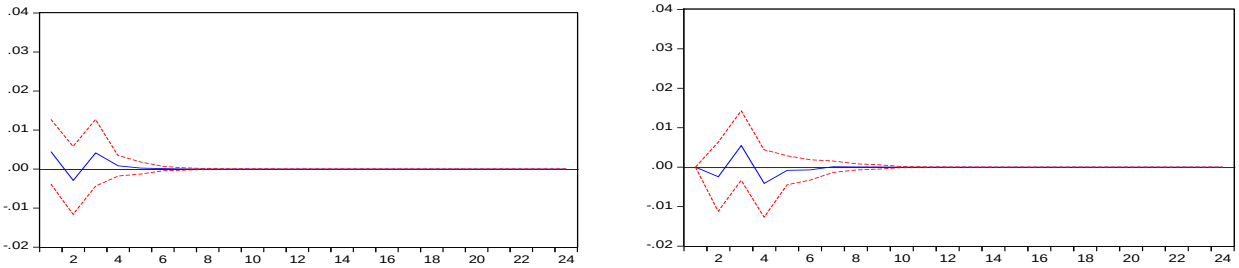


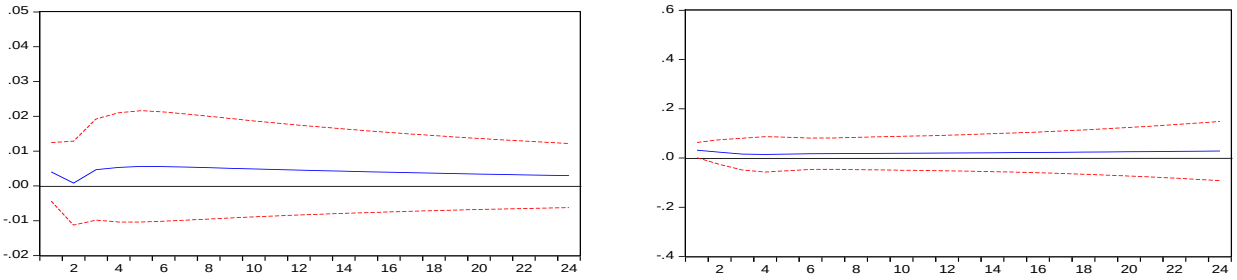
Figure 9 displays the responses of nominal returns (in Panel A) and real returns (in Panel B) to the benchmark fed funds reaction function for the two bull and two bear markets. Inspecting the first graph of Panel A, one can see that the nominal returns' reaction to shocks from the monetary authority surfaces a bit stronger but also short-lived (as the shock is fully absorbed within four months). The returns' response during the bear market (see 2nd graph in Panel A) emerged as behaving well, meaning that the stock market's reaction to the monetary shock was a bit turbulent but short-lived. Once again, this attests to the market's resilience to quickly rebound following economic downturns as well as policy shocks, as concluded earlier (see Figure 2). Finally, the real returns' reactions are seen mostly positive, persistent but not turbulent to policy shocks, contrary to the nominal returns' reactions. One interpretation may be that the stock market welcomed the Fed's fast and unprecedented intervention to stabilize the equity market and thus prevent it from recording further losses.

Figure 9. Responses of stock returns during bull and bear markets

Panel A: *nominal returns,* 2002:09-2007:09 bull market *and* 2007:10-2009:03 bear market



Panel B: *real returns,* 2002:09-2007:09 bull market *and* 2007:10-2009:03 bear market

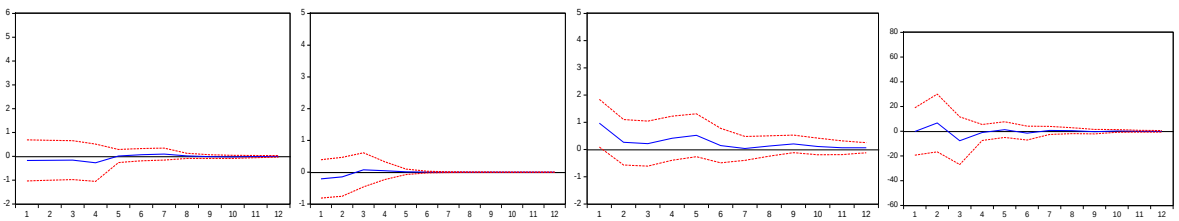


IV.3. Robustness Tests

To ensure that the main results on the behavior of stock returns following policy shocks were not driven by the way stock returns was measured or the Fed's reaction function constructed, we conduct several robustness tests with alternative measures of stock returns, different variables in extending the Fed's reaction function (for example, by alternatively measuring credit spreads), and with recalibrations of the market downturns and upturns. For the sake of space preservation, we will discuss and present graphs for selected results only (the remaining results are available upon request).

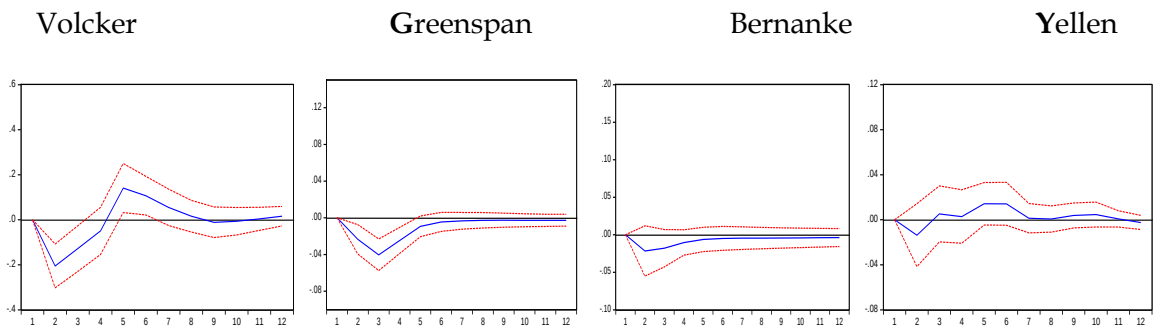
The original measure of stock returns contained only capital gains ignoring dividends. In this analysis, we consider the full stock returns (which include dividend yields) in the benchmark model. Clearly, the results from the full returns were qualitatively similar to the ones obtained in **Table 1 and Panel A of Figure 1** for each monetary regime. Figure 10 shows the reactions of the full stock returns for each monetary regime, which are very similar to those obtained for the nominal stock returns (see Figure 1).

Figure 10. Responses of total, nominal stock returns for each monetary regime



To further validate the impact of credit spreads on the nominal returns, we use two alternative proxies for spreads namely, the difference between the 10-year Treasury note and the 3-month Treasury bill (the long-term spread) and the difference between the BBB and the AAA corporate bond yields (the corporate spread). These proxies showed strong similarities in explaining the behavior of the Fed's reaction function as well as stock returns to shocks from each other. For example, Figure 11 shows the responses of the long-term spread-augmented reaction function to shocks from the nominal returns for the four regimes. The function's reactions mostly resemble those obtained with the credit spread (see 2nd panel in Figure 3) especially in the Volcker and Yellen regimes. In the Volcker years, the Fed's reaction function is fluctuating quite sharply before fading out after nine months, while in Yellen's regime it largely lies in positive territory and takes about a year to fade out.

FIGURE 11. Responses of long-term spread-augmented reaction function to stock returns shocks

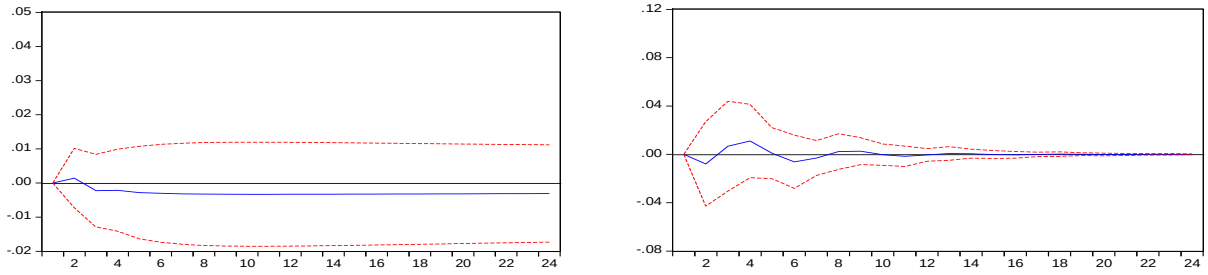


Finally, in an attempt to see if the two above ways of detecting market booms and busts have any significant differences, we will use Bordo et *al*. (2007) estimate for the long stock market boom, which started in April 1994 and ended in August 2000 (to contrast with NBER's dates, presented in Table 2) and recent market bust extended by one or two months (to contrast with the derived S&P500 turning points, shown in Figure 8, which ended in March 2009) to trace the market's reactions to monetary shocks. Figure 12 displays the responses of nominal stock returns

to monetary shocks during the alternatively dated market boom (1st graph) and bust (2nd graph). As evidenced from the graphs, although the stock returns' reaction is seen as mostly negative, it is still persistent throughout the twenty-four month forecast horizon (contrast this graph to the 1st graph in Panel A, Figure 9). In interpreting the above evidence, however, it is important to keep in mind that the two expansion dates differ by 3 years in length at the beginning and five months are the end. By contrast, the returns' response to the alternatively-dated (i.e., extended by two months, to end May 2009) market bust surfaces very similar to the ones obtained in Figure 9 (2nd graph in Panel C) and Figure 7 (2nd graph in Panel A).

In sum, the above analysis indicates that our benchmark and extended findings remain robust to changes in the way stock returns are measured and in the manner in which expansions or market booms and contractions or market busts are defined.

Figure 12. Responses of stock returns to monetary shocks during alternative dates for a market boom (1994:03 – 2000:08) and bust (2007:11 – 2009:05)



V. CONCLUDING REMARKS

This paper investigated the influence of the Federal Reserve's reaction function on U.S. stock market returns as a proxy for the dynamic interaction between monetary policy and stock returns during four monetary regimes, namely Volcker's (1979-1987), Greenspan's (1987-2005), Bernanke's (2006–2013) and Yellen's (2014–2016:6). The federal funds rate was used to derive monetary shocks based on the Fed's information set, the latter comprising several standard

macroeconomic variables and defining the Fed's benchmark fed funds reaction function. The reaction function was subsequently augmented with other variables to examine the extent to which the Fed paid attention to them in its effort to affect the stock market in each monetary regime. Finally, the analysis was performed during several expansions/bull markets and contractions/bear markets to depict the differential impact, if any, of traditional monetary policy on the stock market.

The findings revealed distinct reactions of stock returns to funds rate shocks during each monetary regime. These reactions were more turbulent and persistent during the Bernanke and Yellen regimes than in the two previous ones. Thus, it can be concluded that monetary policy has had real, short-run effects on the stock market in all four monetary regimes. When augmenting the Fed's reaction function with stock returns, credit spreads, the unemployment rate and a measure of financial uncertainty, we observe that the Fed might have actually considered each of these magnitudes separately in its deliberations to conduct monetary policy. For example, we find that stock returns' responses to the spreads-augmented reaction function were far less turbulent during the Greenspan and Bernanke regimes than during those of Volcker and Yellen. In addition, the Fed's reaction to changes in unemployment appeared to be more aggressive during the Volcker and Greenspan regimes compared to the more recent Bernanke and Yellen regimes. Finally, stock returns seem–to react differently during and across expansions/bull markets versus contractions/bear markets, with nominal returns' response to monetary policy shocks being stronger during the (2007-2009) contraction than during that of the 1980s.

These findings have important implications for investment professionals and policy makers alike. For example, market agents can have a better understanding of the Fed's interest-rate setting process, especially during financial turmoil, since it can be argued that monetary authorities broaden their information set beyond traditionally looking at inflation and output

before deciding on interest rate changes and do indeed consider conditions in the financial sector. Finally, it is important to point out that the above variables may not always play a role in the Fed's reaction function during normal market conditions and thus investment professionals should be taking that into account when revisiting their portfolios.

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Table 1. Benchmark Variance Decompositions for Nominal Stock Returns (NSR), Real Returns (RSR) and Fed Funds Rate's Benchmark Reaction Function (BRF), 1979:08 – 2016:6

Panel A: Nominal Stock Returns, NSR

Variable	BRF		NSR	
Periods	BRF	NSR	BRF	NSR
1979:08-1987:08				
2	99.48161	0.518387	0.016620	99.98238
6	94.37415	5.625849	0.395975	99.60402
12	94.36412	5.635854	0.396575	99.60322
18	94.36915	5.633821	0.396585	99.60342
24	94.36940	5.630602	0.396590	99.60432
1987:08-2005:12				
2	99.67691	0.323435	1.501897	98.49810
6	99.70208	0.297916	2.352934	97.64987
12	99.70255	0.297544	2.369718	97.63008
18	99.70255	0.297448	3.369811	97.63018
24	99.70255	0.297448	3.369811	97.63018
2006:01 – 2013:12				
2	96.55161	3.448387	3.100660	96.89928
6	92.65415	7.345849	3.485975	96.51402
12	92.69412	7.304854	3.496575	96.50322
18	92.69085	7.303911	3.495385	96.50462
24	92.69082	7.309179	3.495385	96.50462
2014:01 – 2016:6				
2	99.89161	1.103387	9.710660	90.28928
6	98.85415	1.140049	9.865975	90.13402
12	98.85312	1.141654	9.861575	90.13222
18	98.85011	1.141911	9.868385	90.13162
24	98.85882	1.141179	9.868385	90.13160

Panel B: Real stock Returns, RSR

Variable	BRF		RSR	
Periods	BRF	RSR	BRF	RSR
1979:08-1987:08				
2	98.81618	1.183871	0.016620	99.98238
6	98.37415	1.625849	1.995975	98.00402
12	97.36412	2.635854	2.576575	97.42322
18	96.36915	3.633821	2.786585	97.21342
24	95.36940	4.630602	2.896590	97.14432
1987:08-2005:12				
2	98.07691	1.923435	0.501897	99.49810
6	97.70208	2.297916	0.352934	99.64987
12	97.70255	2.297544	1.369718	98.63008

18	97.70255	2.297448	1.369811	98.63018
24	97.69255	2.307448	1.369811	98.63018
2006:01 – 2013:12				
2	95.96161	4.032387	1.510660	98.48998
6	91.65415	9.345849	1.585975	98.42432
12	91.69412	9.304854	1.587575	98.41252
18	90.59085	9.403911	1.595385	98.40462
24	90.59082	7.409179	1.596085	98.40962
2014:01 – 2016:6				
2	99.90161	0.092387	9.740660	90.25398
6	98.89415	1.105849	9.885975	90.10432
12	98.89412	1.104854	9.887575	90.10252
18	98.89085	1.103911	9.885385	90.10242
24	98.89082	1.103179	9.884085	90.10232

Table 2. **U.S. Business Cycle Reference Dates and Duration, 1980 – to date**

Reference dates		Duration (in months)			
Peak	**Trough**	**Contraction** Peak to Trough	**Expansion** Previous Trough to this Peak	**Cycle** Trough from Trough	Peak from Peak
Jan. 1980	July 1980	6	58	64	74
July 1981	Nov. 1982	16	12	28	18
July 1990	Mar. 1991	8	92	100	108
Mar. 2001	Nov. 2001	8	120	128	128
Dec. 2007	May 2009	18	73	91	81

Source: NBER.
Note: contractions start at the peak of the business cycle and end at the trough.