The Fed and Stock Market: A Proxy and Instrumental Variable Identification[1]

Stefania D'Amico* and Mira Farka**[2]

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Abstract

Stock market fluctuations are likely to be an important determinant of monetary policy decisions because of their potential impact on macroeconomy. At the same time, innovations in fed fund rates affect stock prices as they change the expected future real interest rates. In this paper we apply a new identification procedure, based on proxy and IV variables, to estimate the contemporaneous relations between stock market and monetary policy without imposing any exclusion restrictions on the parameters of interest. Our empirical results indicate: first, that monetary policy responds in a positive fashion to contemporaneous changes in the stock market, but this relationship is not significant; second, that stock returns respond negatively to a positive monetary policy shock and that this response is significant at 1% level. This estimation analysis, while indicating that stock market participants react strongly and significantly to monetary policy innovations, seems to confirm the fact that in the past the Fed has not directly targeted asset prices in the conduct of monetary policy.

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[2]*Columbia University, email: sd445@columbia.edu; www.columbia.edu/~sd445.

**Columbia University, email: ef158@columbia.edu; www.columbia.edu/~ef158.

1 Introduction

The past decade has recorded some interesting and seemingly contradictory economic phenomena for the US economy. First, an observed increase in financial wealth particularly in the form of equity holdings; second, a lower and steadily declining rate of inflation, and third, large increases and rapid movements in financial asset prices. By the end of year 2000, the total financial wealth of US households amounted to 36 trillion dollars, with one third of this financial wealth being held in form of equity holdings. During this period inflation remained low, with the consumer price index rising at an average annual rate of 2.2 percent as asset prices continued their remarkable increase to an all time high. For example, during 1995-1998 period, Standard and Poors 500 composite index recorded an extraordinary gain of 76%[1]. Fueled by this rise in stock market, the median amount of publicly traded stocks held by households grew 82.3% in this period, rising from $9,000 in 1995 to $17,500 in 1998.

These developments in financial markets have led many economists and policymakers to focus their attention in asset prices and their impact in the macroeconomy. There are several channels through which stock market performance influences macroeconomic activity. First, changes in asset prices affect the financial wealth of households thereby influencing consumption expenditures. Second, changes in asset prices affect the ability of enterprises to raise funds for their investment project by changing both the ability of firms to issue new stock and by altering the value of firms' collateral. Third, asset prices -determined by risk adjusted expected returns- may contain useful information about current and future economic conditions[2]. Moreover, the rapid and positive gains of asset prices in recent years have heightened concerns about "irrational exuberance" on the part of the investors, thus redirecting attention towards the appropriate monetary policy actions in presence of a potential asset bubble[3].

[1] This data is taken from the 1998 Survey of Consumer Finances, produced by the Federal Reserve Board.

[2] To this end, asset prices may play a valuable indicator role in inflation and output forecasts (see for example Alchian and Klein (1973), Goodhart (1999), Filardo (2000)).

[3] Central Bank should intervene to deflate an asset bubble provied it can properly identify and puncture the bubble. Although the latter recommendation is hard to implement in practice (it suggests that monetary authority has superior information relative to other market participants in being able to identify and deflate the bubble in a timely and well measured fashion), it nevertheless provides additional incentives for central banks to pay

Because of their potential impact in the macroeconomy, stock market fluctuations are likely to be an important determinant of monetary policy decisions. On the other hand, innovations in fed fund rates affect stock prices as they change the expected future real interest rates and alter the leverage position of firms. This simultaneous response leads to the endogeneity problem between fed fund rates and stock returns. In a structural VAR context, the simultaneous determination of policy rates and stock prices requires identifying assumptions that do not allow for contemporaneous reactions between these variables. At best, exclusion restrictions allow identification of one of them[4]. *In this paper we apply a new identification procedure that attempts to overcome these shortcomings allowing the estimation of contemporaneous relations between stock market and monetary policy*[5]. Closely related to the independent work by Faust et al. (2002a, 2002b), our identification method departs from existing literature of exclusion restrictions and traditional instrumental variables[6].

Our methodology uses proxy and instrumental variables in achieving identification. Following the influential work of Kuttner (2001) we use changes in federal fund futures prices rate on the days of FOMC meetings as a measure of monetary policy surprises. Since the Fed funds futures prices are a natural market based proxy of expectations on future monetary policy, any change in the price of the contract on the day of FOMC meetings should capture unexpected monetary policy actions. On the other hand, we use changes in S&P500 futures prices on the days of monetary policy announcements to gauge the response of stock market to monetary policy shocks. In particular, to provide a precise empirical examination of this response we use a new dataset consisting of eight years of real-time S&P500 future price quotations.

The simultaneous use of changes in prices of fed funds futures and of S&P500 futures on the days of policy announcement, allows us to locate a point in the impulse response function of stock returns to a policy shock. The point on the impulse response function identifies the additional relation between the contemporaneous parameters of the model needed to complete identification.

Since the existence of futures contract in S&P500 is crucial in identifying

close attention to asset price movements.

[4]See for example: Farka (2001), Gotto and Valkanov (2001)

[5]Rigobon and Sack (2001), in the same context, solve this endogeneity problem through changes in variance of structural shocks.

[6]See Bernanke and Gertler (2000).

the response of stock market to a monetary policy shock, the problem of identification would remain unsolved in the absence of such contracts. To allow for a more general use of our identification procedure we extend our technique to address those cases where futures contracts are inexistent or thinly traded. The method develops an instrument for the stock return variable in the policy reaction function where the "instrument" is "purified" from its correlation with the structural shock. We regress stock returns on monetary policy shocks[7] and use the residuals from this regression as instrument variable for stock returns in the policy reaction function. By construction, residuals from this regression would be uncorrelated with monetary policy shocks since we have partialled out the effect of these disturbances on stock returns and eliminated the endogeneity between asset prices and monetary policy actions.

The empirical result presented in this paper should be regarded as a first tentative in estimating the contemporaneous relationships between stock market and monetary policy under more general conditions and without imposing any exclusion restrictions on the parameters of interest. Our empirical results indicate that monetary policy responds in a positive fashion to contemporaneous changes in the stock market, but this relationship is not significant. These findings suggest that positive innovations in stock market elicit tighter monetary policy realized through increases in interest rates. At the same time, we find that stock returns respond negatively to a positive monetary policy shock and that this response is significant at 1% level.

The rest of the paper is organized as follows: Section II provides a brief description of recent attempts in the literature in identifying the simultaneous determination of interest rates and stock returns in a structural VAR model. This section also offers a brief overview of recent work in identifying policy shocks through federal funds futures contracts. Section III develops the identification method via changes in fed funds futures and futures contract on stock indices. This section also discusses a generalized version of the identification procedure through construction of instrumental variables. Section IV discusses and lends support to our identification assumptions. Section V presents a detailed explanations about the data and the variables included in the model. Section VI provides empirical results and analysis. Concluding remarks and implications for our empirical findings are discussed

[7] Similar to the first method, we measure structural monetary policy shocks by fed fund future price changes.

in Section VII.

2 Overview of Recent Literature

The purpose of this section is to review two important and growing strands of the literature that are closely related to our own work. The first overview focuses on recent attempts in the discipline to identify monetary policy reaction functions in a VAR setting augmented with financial variables. The second overview concentrates on recent work in measuring monetary shocks through changes in futures of federal funds rate. Since our identification method depends crucially on price changes of fed funds futures as proper measure of monetary policy shocks and on price changes in SP500 futures as reactions of stock prices to monetary policy, a brief review of the growing work in the area is needed to fully explain our starting assumptions.

2.1 Identifying Monetary Policy Reaction to Stock Returns

Earlier attempts in the literature focusing on the impact of monetary policy on financial markets have used exclusion restrictions to identify their structural models (see for example Goto and Valkanov (2000) and Farka (2001)).To complete identification, these papers assume a contemporaneous recursive relationship between the variables in order to isolate monetary policy shocks. While these assumptions may hold true when analyzing responses of macroeconomic variables to monetary policy shocks (a large body of empirical work indicates that monetary policy affects macroeconomic variables with lags), it may be the case that such exclusion restrictions may not be appropriate when analyzing the endogenous response of financial markets to monetary policy shocks at the same time that policy may be reacting to stock market.

Bernanke and Gertler (2000) estimate a forward looking policy rule augmented with contemporaneous changes in stock prices. The forward looking nature of the model requires the replacement of expectational variables with realized values of those variables, using as instruments macroeconomic variables known at time t-1 or earlier. To circumvent the endogeneity problem that arises from simultaneous responses between stock market and monetary policy, the paper instruments for contemporaneous changes in stock market index with lagged values of stock prices. Under the assumption of rational expectations, monetary policy shocks will not be correlated with lagged values of stock prices. Nevertheless, as Rigobon and Sack (2001) point out in the context of US economy "it is hard to conceive of any instrument [for stock prices)[8]] that would affect the stock market without affecting the path of interest rates". Empirical results reported by Bernanke and Gertler demonstrate that the response of monetary policy to stock market is insignificant and negative (the reported parameter on stock prices has thus the "wrong" sign) indicating that the Fed has not actively sought to stabilize or react to stock prices.

In a related work, Rigobon and Sack (2001) develop a new identification method in a structural VAR allowing for simultaneous responses of monetary policy to stock market. Their analysis attempts to measure the reaction of monetary policy to an exogenous movement in stock prices controlling for the influence of macroeconomic shocks. With this specification, any estimated response of policy to stock returns must be over and above the predictive power of the stock market in the macroeconomy. In a VAR setting, the simultaneous determination of interest rates and stock prices poses a great challenge in identifying monetary policy response to stock market. Since exclusion restrictions require that either monetary policy does not respond contemporaneously to stock prices or that stock market is not affected within the same time period from monetary policy shocks, departing from them necessitates a novel identification technique.

The identification method employed by Rigobon and Sack uses the heteroskedasticity found in interest rates and stock market returns to identify the reaction of monetary policy to the stock market. The paper identifies the slope of monetary policy reaction function through regime shifts of the variance-covariance matrix of the shocks. Identification assumptions require that monetary policy shocks are homoskedastic across regimes, while allowing for heteroskedasticity of stock market shocks. Regime changes in the variance-covariance matrix provide the additional equations needed to identify the estimated response of monetary policy to stock market. Their results show that monetary policy responds positively (though the estimated parameter is small in magnitude) and significantly to stock returns.

Despite the significant contribution of this paper to the literature, some caveats are in order. As the authors point out, even though regime shifts

[8]To this end, our IV method concentrates in constructing rather than finding an instrument.

in variance-covariance matrix are central for the identification method, the choice of these regimes are somewhat arbitrary. Furthermore, the identification depends crucially on the assumptions that monetary policy shocks are homoskedastic across different variance regimes (in absence of this assumption the system remains unidentified). In our view, such assumption is especially restrictive given the richness of monetary policy setting and its evolvement through time.

In order to capture more accurately the dynamic interaction between interest rates and stock returns, the authors augment their VAR with unobserved heteroskedastic shocks that allow for contemporaneous correlation between monetary policy and stock market shocks. The generalized specification with unobserved shocks, while important in measuring the policy reaction, may contribute to the size of the estimated parameter of central bank response to stock market. For some parameter values, we find that the this coefficient is a positive function of the variance of unobserved shocks, biasing upwards the response of monetary policy to stock market.

In a related independent work, Faust et al (2002a) achieve identification by expoliting additional informations from the federal funds rate futures market. The method measures the impulse response of the federal funds rate to the policy shock using federal funds future data and identifies structural VAR model by imposing that the impulse response of the funds rate to the policy shock in the VAR matches the one measured from futures data. In a successive work (Faust et. al (2002)), the authors apply this method to identify contemporaneous relations between interest rates, monetary policy rates and exchange rates. Identification is again achieved by requiring that the impulse responses of the exchange rate and interest rates in a standard open-economy VAR match the responses estimated from the high frequency financial market data.

In what follows we propose a new method to identify monetary policy reaction to stock market that is closely related to the work by Faust et al.(2002a, 2002b). In contrast to their paper and similarly to Rigobon and Sack(2001), our method is destined to address the endogeneity issue between stock market and policy variables. To this end, we depart from existing literature of exclusion restrictions and allow for contemporaneous response of monetary policy to asset prices. Since our identification method depends on measures of policy shocks through changes in futures of fed funds rate, below we provide a brief review of the literature pioneering this measure.

2.2 Changes in Futures of Federal Funds Rate as a measure of monetary policy surprises

Kuttner (2001) initiated the use of changes in futures of federal funds on the days of FOMC meetings as a proxy for monetary policy shocks. The federal funds rate futures contract is based on a monthly average of the relevant month's effective funds rate. Since federal funds futures embody market expectations on Fed policy actions for that month, any change in the settlement price of the spot-month future contract on the days of FOMC announcement constitutes a surprise in monetary policy actions as perceived by market participants.

As pointed out in Kuttner (2001), building the monetary policy shock through changes in futures prices can be complicated by at least two factors. One is that the Fed funds' future contract is based on an average of the fed funds rate rather than the rate on any specific day. The second complication arises from the fact that the futures contract is based on the effective fed funds rate rather than the target rate. Both of these caveats are addressed in Kuttner (2001) where 1) the contract on the average funds rate is unwound through the use of appropriate weights depending on the day of the month in which FOMC meeting takes place, and 2) the difference between target rate and effective rate on monthly averages is usually very small - within few basis points.

The advantage of using futures data to measure policy shocks rests with the ability to circumvent model selection and generated regressor problems (Kuttner 2001). At the same time, changes in spot-moth fed funds futures deliver an almost pure market-based measure of the policy surprise. On the downside, the novelty of fed funds futures market limits any analysis using future contract to the post 1989 period (future contracts on fed funds rate were introduced in January 1989).

In this context, fed funds futures are used as proxies for market expectations about Fed policy actions. This is true only if the expectations hypothesis holds and funds rate forecasts based on futures price are efficient. Kuttner and Krueger (1996), find conclusive evidence that funds rate forecast errors are not significantly correlated with other variables or any information available to market participants at the time when the contract is priced. In a related work, Faust et al. (2002) further corroborate these results.

Recent papers in the discipline have adopted similar measures for exogenous monetary policy shocks through the use of futures data. Faust et. al.

(2002), use changes in current month fed funds futures contracts to gauge monetary policy shocks and achieve identification in a structural VAR model by matching the impulse response of the funds rate to a policy shock in a VAR to the response measured with futures market data. To avoid sample limitations, Piazzezi and Cochrane (2002), employ changes in 1 month Eurodollar rate in a time frame from just before to just after an FOMC meeting as a measure for exogenous policy shocks.

3 Identification through Proxy and IV variables

The above discussion indicates that, in a structural VAR context, attempts to separate responses of monetary policy to stock market from endogenous reaction of stock market to federal funds rate have contended with renewed challenges regarding identification method. In this section, we propose a new way of dealing with this problem that uses proxy and instrumental variables to identify the system. In what follows we draw extensively from the growing literature in the area and our identification assumptions rely on previous works related to our own.

3.1 Identification through proxy variables

Suppose the economy is described by a structural form equation:

$$A(L)y_t = \varepsilon_t \tag{1}$$

where A(L) is a matrix polynomial in lag operator L, y_t is (n x 1) vector of macroeconomic variables, and ε_t is a n x 1) vector of structural errors such that Var$(\varepsilon_t) = D$. D is a diagonal matrix assuming that ε_t are mutually orthogonal. The structural shocks are the primitive exogenous disturbances in the economy. In what follows, we restrict our attention in the dynamic structural equations for the stock market and federal funds rate:

$$FFR_t = \beta SR_t + \theta(L)X_t + \varepsilon_t^{FFR} \tag{2}$$

$$SR_t = \alpha FFR_t + \delta(L)X_t + \varepsilon_t^{SR} \tag{3}$$

where X_t consist of lagged values of macrovariables, federal funds rate and stock returns. We can rewrite the system as follows:

$$\begin{pmatrix} 1 & -\beta \\ -\alpha & 1 \end{pmatrix} \begin{matrix} FFR_t \\ SR_t \end{matrix} = B(L)X_t + \begin{matrix} \varepsilon_t^{FFR} \\ \varepsilon_t^{SR} \end{matrix} \tag{4}$$

$$A_0 X_t = B(L)X_t + \varepsilon_t \tag{5}$$

where A_0 matrix is comprised of all contemporaneous parameters. The system can be estimated in its reduced form:

$$X_t = B(L)A_0^{-1}X_t + A_0^{-1}\varepsilon_t = G(L)X + u_t \tag{6}$$

where:

$$u_t = A_0^{-1}\varepsilon_t \quad G(L) = B(L)A_0^{-1} \text{ and } E(u_t u_t') = \Sigma = (A_0^{-1})D(A_0^{-1})' \tag{7}$$

The $MA(\infty)$ representation of the model can be written as follows:

$$X_t = \sum_{i=0}^{\infty} \Psi_i u_{t-i} = \sum_{i=0}^{\infty} \Psi_i A_0^{-1} \varepsilon_{t-i} \tag{8}$$

s-periods ahead this representation becomes:

$$X_{t+s} = \sum_{i=0}^{\infty} \Psi_{i+s} A_0^{-1} \varepsilon_{t-i+s} \tag{9}$$

The expected value of X_t s periods from now conditional on information at time t, $E_t X_{t+s}$, (i.e. the impulse response of variables in the system to structural shocks) can be written as:

$$E_t X_{t+s} = \sum_{i=0}^{\infty} \Psi_{i+s} A_0^{-1} \varepsilon_{t-i} \tag{10}$$

where Ψ_s denotes the matrix of MA coefficients of the reduced form model.

Specifically, the expected value of stock market s periods from now due to a shock in monetary policy at time t, (i.e. the impulse response of stock market to a monetary policy shock) can be written:

$$E_t SR_{t+s} = \sum_{i=0}^{\infty} \alpha \psi_s \varepsilon_{t-i}^{FFR} \tag{11}$$

or alternatively:

$$\frac{\partial E_t SR_{t+s}}{\partial \varepsilon_t^{FFR}} = \alpha \psi_s \tag{12}$$

where α is the contemporaneous response of stock market to a policy shock and ψ_s is the appropriate element of Ψ_{i+s} matrix identifying the response of stock market to a reduced form policy shock s periods in the future.

Since all past shocks ($\varepsilon_{t-1}^{FFR}, \varepsilon_{t-2}^{FFR}, \varepsilon_{t-3}^{FFR}$...) are known at time t, the change in the expected value of SR_{t+s} is due only to monetary policy shock at time t. As such, we can eliminate all past lags and write:

$$\Delta_s E_t SR_{t+s} = \alpha \psi_s \varepsilon_t^{FFR} \tag{13}$$

The above equation captures the change in expectation in stock returns at time $t+s$ due to an exogenous monetary policy shock at time t. In other words, this equation identifies the impulse response of stock market at time horizon s to a monetary shock today (at time t).

Equation (13) can be estimated if we can find a proper measure for the following two unknowns: 1) a measure that captures changes in expectations in stock returns due to monetary policy shocks; 2) a measure that properly accounts for monetary policy shocks. We use changes in future prices of SP500 contracts in the days of FOMC meetings to measure the reaction of stock market to an exogenous monetary policy shock. Similar to the case of federal funds futures, SP500 future contracts at time t embed expectations of market participants about stock market performance at maturity $t+s$ based on all available information at time t. ($E_t SR_{t+s} = SP500_t^{fut}$). On the days of FOMC meetings, assuming no other major pertinent information is released, price changes in SP500 futures will capture the reaction of stock market participants to a monetary policy shock. Since future contracts are specified for a time horizon s, the change in its price on the day of the policy announcement delivers a measure of the stock market reaction at horizon $t+s$ to a monetary policy shock at time t (it is the stock market impulse response at time $t+s$ to a policy shock at time t).

Following recent work in the literature, we use changes in futures in federal funds rate on the days of FOMC meetings as measure of monetary policy surprises (see Kuttner (2001), Faust et al. (2002), Cochrane and Piazzesi (2002)). Since the Fed funds future prices are a natural market based proxy for expectations on future monetary policy, any change in the price of the contract on the day of FOMC meetings should capture unexpected monetary policy actions - in other words it is a pure measure of an exogenous monetary policy shock. As pointed out in Faust et al.(2002), there are reasons for which this assumption may not hold: 1) the FOMC could be reacting to macroeconomic data released on that same day and 2) the FOMC policy action itself may reveal information about macroeconomic data that is private information to the Fed. We address these issues in more detail in Section IV.

Based on above discussion, we can rewrite and estimate equation (13) as follows:

$$\Delta_s SP500_{t+s}^{fut} = c + \gamma_s \Delta FFR_t^{fut} + \epsilon_t \tag{14}$$

where

$$\gamma_s = \alpha \psi_s \tag{15}$$

Based on our model above, the reduced form variance-covariance matrix can be written as:

$$\sum = (\frac{1}{1-\alpha\beta})^2 \begin{pmatrix} \beta^2\sigma_{\varepsilon SR}^2 + \sigma_{\varepsilon FFR}^2 & \beta\sigma_{\varepsilon SR}^2 + \alpha\sigma_{\varepsilon FFR}^2 \\ \beta\sigma_{\varepsilon SR}^2 + \alpha\sigma_{\varepsilon FFR}^2 & \sigma_{\varepsilon SR}^2 + \alpha^2\sigma_{\varepsilon FFR}^2 \end{pmatrix} \tag{16}$$

The variance-covariance matrix of reduced form shocks provides three equations - while there are four parameters to identify $\alpha, \beta, \sigma_{\varepsilon SR}^2, \sigma_{\varepsilon FFR}^2$. With our method, the additional relationship (14) provides the fourth equation, completing identification of all unknowns and allowing for contemporaneous responses between monetary policy variable and stock market returns.

Our method hinges primarily on identifying good "proxy" variables in estimating equation (13). Changes of fed funds future price on the days of FOMC announcement are used as proxy for exogenous monetary policy shocks, while changes in future price of SP500 on policy announcement day, are used as proxy for stock market reaction to this policy shock. In both cases we rely on several important assumptions that rationalize the use of these proxy variables in our identification method. In what follows, we provide a detailed account of these assumptions and offer supporting evidence for their validity.

3.2 Extension of the Methodology: IV Procedure

As mentioned in the introduction, the above identification scheme depends critically on the existence of futures contract on financial instruments[9] for achieving identification. In cases when the market for futures contract is not properly developed or when it is altogether nonexistent, the identification method proposed above could not be applied. This would restrict the assessment of simultaneous responses between monetary policy and financial markets only to few financial assets.

To address this issue, we extend the above method to a more general setting adopting an instrumental variable approach. The quest for constructing instrumental variables to address the endogeneity problem has been extensively addressed in the literature (see for example Bernanke and Gertler (2000), Rigobon and Sack (2001)). For the majority of cases in these related works, stock market is allowed to instrument for itself through its own lagged values. As pointed out by Rigobon and Sack (2001), the search for an "instrument" in this context is a trying task since it is hard to conceive of any variable that would affect the stock market without affecting the path of interest rates.

While this argument remains undoubtedly true and no existing variable can independently determine stock returns without being affected from policy rate changes, below we attempt to instead construct (since it does not already exist) such an instrument. As in the previous section we focus our attention on the last two equations of our system which denote the policy reaction function and the stock return function:

$$FFR_t = \beta SR_t + \theta(L)X_t + \varepsilon_t^{ffr} \tag{17}$$

$$SR_t = \alpha FFR_t + \delta(L)X_t + \varepsilon_t^{sr} \tag{18}$$

A proper instrumental variable must address the endogeneity problem presented in the system above by eliminating the correlation between stock returns (SR_t) and monetary policy surprises (ε_t^{ffr}). Following our previous approach, we continue to measure monetary policy shocks by changes in fed funds futures prices on the days of monetary policy announcements. Based on this intuition, we construct our instrument by regressing stock returns on monetary policy surprises and use the residuals from this regression as

[9] Here we refer to futures contracts on bonds, single securities, and stock indices.

instrument for stock variable in the policy function. Specifically, we estimate the following regression on days of policy announcements:

$$SR_t = \gamma_o + \gamma_1 \Delta FFR^{fut} + e_t^{IV} \tag{19}$$

As constructed, residuals from this regression $\widehat{e^{IV}} = SR_t - \widehat{SR_t} = SR_t - (\widehat{\gamma_o} + \widehat{\gamma_1} \Delta FFR^{fut})$ are the share of SR_t which is uncorrelated with ε_t^{ffr}, because they contains all the information that is embodied in the stock market and is not explained by the monetary policy shock. These residuals are highly correlated with stock returns and by construction uncorrelated with monetary policy surprises, two desirable attributes for a good instrumental variable. This method, partialling out the effect ΔFFR^{fut} on SR_t, allow us to obtain an IV that "purges" the stock returns from ε_t^{ffr}, thereby eliminating the endogeneity problem.

It is important to note that equations (19) and (14) are essentially equivalent. In both cases, we regress changes in stock prices on monetary policy shocks. The only difference between the two rests with the fact that estimates of γ_s from equation (14) identify the response of stock market to a policy shock s periods in the future, while estimates of γ_1 captures the contemporaneous response. As can be seen, equation (19) requires the use of actual S&P500 index and not futures prices thereby allowing for a more general use of the procedure.

Abstaining from the use of futures contracts is one of the advantages associated with this method. There is a second advantage to implementing the IV procedure: used in conjunction with the original method, it provides additional relations among variables in the system that could be exploited in order to relax other restrictions in the structural VAR. More specifically, rewriting equation (15):

$$\alpha = \frac{\gamma_s}{\psi_s}$$

As indicated by above relation, using the first method to identify α entails estimation of $\widehat{\gamma_s}$ from equation (14) and $\widehat{\psi_s}$ from a reduced form VAR. Various specifications of VARs would produce a different value of $\widehat{\psi_s}$ rendering the latter model-specific. However, a joint implementation of two methods would allow an independent identification of ψ_s, providing an additional relationship between variables in the system. The combined use of both methods adds the following relations:

$$\gamma_1 = \alpha$$

$$\gamma_s = \alpha\psi_s$$

Both equations could be used to relax further identifying assumptions in the VAR. In addition to estimating the contemporaneous response between stock market and policy variables, we could, for example, estimate the contemporaneous response of industrial production or inflation, or any other macroeconomic variable to a monetary policy shock.

4 Identifying assumptions.

Our approach to identification relies on the following three assumptions.

1) Changes in price of spot-month federal funds futures contract on FOMC announcement days deliver a proper measure of the exogenous monetary policy shock.

2) Changes in prices of S&P500 futures contract on the days of monetary policy announcement appropriately identify the response of stock market to a monetary policy shock.

3) VAR is an adequate representation of the economy. This means that the information that the market participants use to form expectations about monetary policy actions and stock market performance is coincident with the information set included in the VAR.

Due to its generality and common usage, we start with the last assumption which can be written as follows:

$$E_t(FFR_{t+1}) = FutFFR_t = \beta E_t(SR_{t+1}) + \theta(L)X_{t+1} \tag{20}$$

$$E_t(SR_{t+1}) = FutSR_t = \alpha E_t(FFR_{t+1}) + \delta(L)X_{t+1} \tag{21}$$

This assumption is implicitly made in the vast majority of related empirical works, where it is normally assumed that the central bank, the econometrician and the market participants have the same information set. Our results rely on this assumption the same way as earlier work does. In the identification context of our paper, however, this assumption assumes more relevancy since it implies that forecasts obtained by the futures market should be similar to the forecasts generated from VAR. Rudebush (1998) pointed it out that the two forecasts in effect have little correlation. In contrast, Kuttner and Evans (1998) argue that sampling uncertainty associated with VAR coefficients increases the variance of VAR forecasts thereby reducing the correlation between futures market and VAR forecasts[10]. Also, quantitatively small deviations from perfect futures market efficiency further contributes to the perceived reduction of this correlation. In their work, the authors point out that the "informational advantage" of the VAR forecasts, VAR's too generous parametrization and parameter stability can additionally lead to the low correlation between monetary policy shocks measured from VAR models and shocks identified from futures market.

In a related work, Robertson and Tallman (2001) argue that the correlation between two sets of forecasts can be greatly improved if the VAR is estimated with Bayesian shrinkage methods that are commonly used to improve the forecasting performance of a highly parametrized VAR. Following this argument, Faust et al. (2002), reestimate their structural VAR system with Bayesian estimates and report that their substantive results remain largely unchanged by this modification.

Further attempts to reduce the information gap between market participants and econometrician are reported in Brunner (2001), where a VAR augmented with market participants' expectations of economic variables is used to mitigate this problem. The author concludes that the innovations, monetary policy shocks and the impulse response functions derived using this alternative approach were fairly similar to the standard VAR.

For our first identifying assumption we refer to the work by Kuttner and Krueger (1996) and Faust et al. (2002). Kuttner and Krueger demonstrate that funds rate forecasts based on the futures' prices are "efficient" in that the forecast errors obtained are not significantly correlated with any variables known at the time when the contract is priced. Faust et al. (2002) test the efficiency of the federal funds rate futures markets by regressing the effective federal funds rate for month t on the federal funds futures price in months $t-1, t-2, t-3, t-4, t-5$. Results indicate that the expectations hypothesis holds and that the fed funds futures markets provides efficient forecasts of the fed funds rate. If the price of fed funds futures are efficient

[10]This can be easly seen through the following formula $Cov(\widehat{FFR}_{var}, \widehat{FFR}_{fut}) = Var(\widehat{FFR}_{var} + \widehat{FFR}_{fut}) - Var(\widehat{FFR}_{var}) - Var(\widehat{FFR}_{fut})$

forecasts of the federal funds rate, then they embody all the relevant present and future information available to market participants about policy actions. Therefore, a change in the price of fed funds futures on the days of monetary policy announcement delivers a nearly pure measure of policy shock since it represents a sudden change in the market participants' expectations due to the arrival of new information.

Another reason that may contribute to the potential failure of the first assumption is the possibility that other important information could be released in the market in the same day with monetary policy announcement.. If this is the case, market participants may react to this new information and changes in prices of futures contracts fail to deliver a pure measure of the policy shock. In addition, this assumption may also fail if the policy announcement reveals to the market participants information about the macroeconomy that is private to the Fed, in which case movements in prices on futures contracts may be due to the reaction of market participants to this new piece of information. In addressing both of these difficulties we rely, once again, on the work by Faust et al. (2002), where detailed explanations and tests are provided in support of the assumption. Specifically, the authors check for other major macroeconomic releases in the days of policy announcements and conclude that during the entire sample (which coincides with ours), there are few macroeconomic releases on the days of FOMC meetings. We perform the same test checking for common macroeconomic releases on the days of monetary policy announcements and find that for all the variables included in the VAR, industrial production and NAPM coincide with FOMC meeting and inter-meeting days only four times, PPI and CPI 5 times and 7 times respectively and nonfarm payroll ten times. On three occasions, more than one variable were released on the same day with policy announcement slightly reducing the number of problematic days.

To address the problem that policy announcements may reveal information on macro variables, Faust et al. (2002) perform a test regressing market participants' surprise about macroeconomic announcements on the target rate surprise. The intuition behind this test, as explained in their paper, is that if the fed funds surprise effectively releases any information about macroeconomic data private to the Fed, then the target surprise should be correlated with macroeconomic surprises. Their test results indicate that the estimated coefficient on the target surprise is not significantly different from zero for any macroeconomic indicator, further lending support to the assumption that on days of policy announcements changes in fed funds futures capture policy shocks.

The above assumption can be further improved with the use of intraday data on fed funds futures contract on the days of policy announcements. This exercise ensures a more exact measure of market participants' expectations right before and right after an FOMC meeting. A change in these expectations captured by a change in price on fed fund futures on a smaller time-window around policy announcement (i.e. futures price changes 5 minutes before and 5 minutes after the meeting) would be able to deliver an even purer measure of policy shock. This is true, since there will be a smaller likelihood for other information to confound our results.

The second assumption is the most problematic one and requires more attention. Our test for macroeconomic releases on days of FOMC announcements is also useful in the context of this assumption, since it increases the probability that changes in expectations of stock market participants are due only to policy shocks. Additionally, performing a test to compare release days on dividend news, earnings and profit announcements with policy announcement days, would further strengthen the reliability of this assumption.

The ideal way of supporting the notion that changes in S&P500 futures prices on days of monetary policy announcements deliver a measure of stock market reaction to policy shock would be through the analysis of intraday data on stock futures prices. Similar to the above case, futures price changes right before and right after the meeting would better capture the response of stock market to a policy shock. In that case, the computations are based on a narrower time-window allowing for a small possibility that stock market is reacting contemporaneously to any other piece of information. In this paper we employ a new dataset consisting of intraday S&P500 future price data in order to narrow the time frame around a policy announcement as accurately as possible. Specific details about new dataset, its use and applications are described in Section 6.

Despite the use of a smaller window of estimation and similar to the first assumption, the response of stock market to monetary policy shock (measured by changes in S&P500 futures prices on the days of FOMC announcements) could be muddled by the reaction of market participants to any additional information about the state of the economy that policy shocks may reveal. To address this issue, we again invoke the results reported by Faust et al. (2002). which demonstrate that correlations between macro announcement surprises and target rate surprises are not significantly different from zero. Their test is based on forming a measure of the surprise component on macroeconomic announcement based on survey measures of expectations on market participants. Since their survey data is market-based, it reflects expectations from a broad range of market participants, including those that trade in the futures market. Based on their findings, we believe that changes in S&P500 futures prices on days of FOMC announcement trace the response of stock market to a policy shock rather than its reaction to releases of macro data.

5 Data and Variable Description

5.1 Description of the S&P500 future data

In order to achieve identification, we employ a new dataset consisting of intraday, real-time future price quotations spanning the period from January 1994 - December 2001. We restrict our attention to this period, since prior to 1994 there was no exact time for policy releases: the announcements were irregular on the FOMC meeting days. From 1994 however, the Fed changed its announcement practices and decided to release changes regarding monetary policy at a precise time: 2:15 PM Eastern time on the announcement day[11]. The raw data were obtained from Chicago Mercantile Exchange and it consists of continuously-recorded S&P500 future price tick-data with the following information: a ticker symbol, the delivery date followed by a contract month code, the time of the transaction, the price, an ask/bid indicator, and the trade date. For one tick observation to be recorded, it is necessary for at least one transaction of one contract to establish a new tick with a different value from the existing one.

The contract months are as follows: March, June, September and December and they trade for one year in such a manner that at any point in time there are four contracts available for purchase. The final price settlement day is the third Friday of the specified contract month. As expected, the shortest two maturity contracts are the most heavily traded and as such, the most liquid. They register tick data (or price quotations) with an average

[11] Exceptions to this new practice were as follows: 11:05 am Eastern time on 02/04/94, 2:20 pm on 03/22/94 and 07/06/94, 2:30 pm on 11/15/94, 2:26 pm on 05/17/94, 2:23 pm on 12/20/94, 1:17 pm on 08/16/94, 2;22 pm on 09/27/94, 2:24 pm on 02/01/95 and 3:15 pm on 10/15/98 after the futures market in Chicago had closed so we had to consider the opening price on the 16th.

frequency of one trade every 30 seconds[12]. This richness in observations allows us to narrow the time-frame around monetary policy announcement in a very precise fashion.

The time window is constructed by computing percent changes in average price data 5 minutes before and 5 minutes after the monetary policy announcement time (usually 2:15 Eastern time - exceptions to this rule as explained in footnote 7 are duly noted). Since the time frame before and after policy release is small, it is reasonable to assume that any price change occurring within this window results primarily from changes in market expectations due to monetary policy announcement. The decision to use a five minute window is quite arbitrary; it's sole purpose was to narrow the time frame around announcement moment as accurately as possible. To ensure that our results are not affected by this arbitrary choice of time-window, we redefine and document results for the other time-frames. We compute windows of: 1 minute, 2 minute, 3 minute, 4 minute, and 10 minute. Table 1 summarizes some of the properties of each constructed window.

Summary Statistics for the window data

Variable	mean	std. deviation	min	max
1minute window	.10542	2.742	-7.377	11.611
2minute winow	.5061	3.926	-6.689	17.99
3minute window	.594	5.063	-7.687	27.81
4minute window	.593	6.229	-9.11	37.73
5 minute window	.7043	8.221	-12.29	55.23
10 minute window	.3164	9.495	-18.46	59.118

Table1

It is important to note that future price changes due to monetary policy announcements reflect reaction of stock market participants to a monetary policy shock not for the current period, but for the day when the contract matures. Since policy announcement days are spaced irregularly during the year, each price change observation derived from same maturity contracts captures the response of stock market to a policy shock at different points in time. The exact horizon is determined by the distance in days between policy announcement and the day of maturity of the futures contract. Specified as

[12] The shortest maturity contract trades very heavily with an observation registered on average every 8 seconds. The next contract, while still liquid, registers a trade on average every 50 seconds. The frequency of trades declines with the maturity of the contract.

such, a simple regression of the window data on the monetary policy shock as represented by equation (14) would have little meaning. If each price change observation ($\Delta SP500_t^{fut}$ in equation 14) registers the reaction of the stock market to a policy shock at a different time horizon, then the estimates we obtain from (14) would not have a precise temporal connotation.

We address this complication by attempting to construct a window consisting of price changes that reflect same-time horizon expectations. Since a variety of contracts with different maturity date are available at any point in time, this can be done by selecting those contracts that deliver approximately same period expectations. For example: if the FOMC meeting is in March, using the June contract we would be able to capture the reaction of stock market to monetary policy 3 months ahead. Similarly, if the meeting occurs in June, price changes of the September contract register reaction of stock market to a policy shock 3 months in the future. Through this selective process, we can construct a time window consisting of expectational changes that correspond to a specific horizon: three months in the future. We generate the window data by using, depending on the day of FOMC announcement, either the shortest maturity contract or the next one after that, since only these two contracts deliver expectational changes for three month ahead horizons. Clearly, we could likewise employ longer maturity contracts to construct reactions of stock market to a policy shock for longer horizons. While this is still possible, we employ the shortest two maturity contracts since they are considerably more liquid relative to the other contracts. This improves our analysis in two levels: 1) the time-window is better defined around the time of FOMC announcement due to the high number of observations (trades) occurring each minute; 2) small number of trades in the long maturity contracts may introduce noise in our analysis by providing little information about the reaction of stock market to policy actions.

With the new window data constructed as explained, the estimates of equation (14) have a precise meaning: they identify the reaction of stock market to a monetary policy shock three months in the future. Rewriting our model:

$$\Delta SP500_{t+s}^{fut} = c + \gamma_s \Delta FFR_t^{fut} + \epsilon_t$$

$$\Delta SP500_{t+s}^{fut} = c + \alpha\psi_s \Delta FFRfut_t + \epsilon_t$$

where the index s underlines the dependence of the dependent variable and of the coefficient ψ on the time horizon. As explained in section 3.1 ψ

is the appropriate element in the matrix of MA coefficients (Ψ) that comes from the reduced form model, representing the response of stock market to a reduced form monetary policy shock. In the present case $s = 3$, since by construction $\widehat{\gamma}$ delivers the response of stock market to a policy shock three months from now. The contemporaneous response of stock market to a policy disturbance is given by:

$$\widehat{\alpha} = \frac{\widehat{\gamma}}{\psi_3}$$

5.2 Fed Funds Futures and Macro Data

In the spirit of traditional empirical literature on monetary policy, we estimate a seven variable VAR for the United States augmented with stock returns. Our specification includes several benchmark variables: industrial production (IP), consumer price index (CPI), the smoothed change in an index of sensitive commodity prices (PCOM), a survey index based on the National Association of Purchasing Managers (NAPM), a measure of monetary aggregate (M2), the federal funds rate (FFR) and S&P500 stock return (SR). Datastream and Bloomberg are the underlying source for all data series.

Industrial production, and inflation rate are common variables in monetary business cycle work. Because traditional monetary policy literature assumes that central banks' reaction function systematically responds to output and inflation variables and their indicators, inclusion of these variables in the system allows for a more accurate identification of central banks' policy reactions. We use industrial production instead of the traditional GDP data since the latter series is available quarterly whereas industrial production is reported monthly. The inclusion of NAPM is used to gauge market-based valuation about the performance of the economy.

All variables with the exception of interest rates and stock market are expressed in logarithmic form. In our specification we include contemporaneous and seven non-consecutive lags of each variable, and an FFR shock corresponds to a measure of monetary policy shock. We use a bloc-recursive identification methodology for macroeconomic variables and follow the proposed technique presented in this paper to complete identification in the FFR and SR equations.

We use daily changes (close-to-close) in spot-month federal funds futures prices to measure of a monetary policy shock, on the days of policy announcements (including FOMC meetings and intermeeting days). Our sample includes a total of 69 monetary policy announcements, 5 of which are intermeeting rate changes and 64 are FOMC meeting releases. Similar to Faust et al. (2002) and in contrast to Kuttner (2001), our sample includes those days for which the policy announcement decides to leave the federal funds rate unchanged.

The federal funds futures contracts' settlement price is based on the **average** of the relevant month's effective overnight Fed funds rate. As mentioned above, we apply the procedure proposed by Kuttner to undo this average and measure the policy shock as follows:

$$\Delta FFR_t = \frac{m}{m-t}(FFR_t^{fut} - FFR_{t-1}^{fut}) \tag{22}$$

where m is the number of days in the month, t is the day of the monetary policy announcement and FFR_t^{fut} (FFR_{t-1}^{fut}) is the future rate of the day t ($t-1$) in the contract based on the current month's funds rate. Weighting the daily change in futures prices by this method, corrects the problem by unwinding the average rate and delivering a purer measure of surprise. This adjustment factor is quite large if a policy announcement takes place towards the end of the month, in which case, similar to Kuttner (2001), we use differences in one-month futures rates instead of the spot-month contracts. We employ a similar adjustment in cases when policy announcements occur in the first day of the month since expectations about policy actions would have been reflected in the previous month's one-month futures contracts.[13]

Our identification methodology requires the use of price changes in S&P500 futures on days of FOMC announcement to measure the reaction of stock returns to a policy shock. As mentioned in the above section, this response is computed as percent changes in S&P500 futures prices resulting from the 5 minute window around the time of the policy announcement.

The VAR estimates are carried out in monthly frequency. To confirm the robustness of our results, we reestimate our model over several time periods: January 1959-December 2001, January 1979-2001, January 1982-December

[13]This method is same as Kuttner (2001) who suggested that in cases when policy announcement occur in the first day of the month, the differences between spot-month rate and the 1-month futures rate from last day of the previous month are a more appropriate measure of the shock.

2001 and January 1994-December 2001.We reestimate the model from 1982 in the spirit of identifying important changes in monetary policy (the post-1979 era known as the Volcker-Greenspan period) and assessing the importance of these changes in the reaction of monetary policy to stock market. The definition of the third subsample (January 1994-December 2001), is due to the restricted dataset on intraday S&P500 futures. The window data (as described in the above section) can be constructed only for the last subsample since only from 1994 we can identify a precise moment for monetary policy announcements. Under stability conditions, we can use the same data window to identify the reaction of stock market to a monetary policy shock for the other longer samples.

6 Estimation Results

We begin by estimating the reduced form of a monthly seven variables, seven lags VAR to obtain the appropriate moving average coefficients (Ψ_3) in order to identify the contemporaneous response of stock market to a policy shock: $\widehat{\alpha} = \frac{\widehat{\gamma}}{\psi_3}$. We then report the response of stock market to a monetary policy shock as indicated by equation (14), estimated on the days of policy announcements from January 1994-Dec 2001. A contractionary monetary policy (represented by positive policy shocks and as such increases in fed funds rate), should have a contemporaneous negative impact in stock prices. Table 2 summarizes our estimates of α (response of stock market to a policy disturbance) for the 1994-2001 sample. As a robustness check, we report estimated coefficients for all the windows constructed (1 minute, 2 minute, 3 minute, 4 minute,5 minute and 10 minute windows).

Response of Stock Market to a Monetary Policy Shock

dependent variable	Constant (t-stat)	Estimated Response to Shock (α) (t-stat)	R^2 adj
1minute window	-.046 (-0.024)	-.042 (-2.59)	0.0779
2minute window	.107 (0.44)	-.066 (-2.84)	0.0943
3minute window	.075 (0.246)	-.099 (-3.35)	0.1313
4minute window	.010 (0.028)	-.126 (-3.493)	0.1414
5minute window	-.011 (-0.024)	-.16 (-3.330)	0.1292
10minute window	-.25 (-0.438)	-.176 (-3.15)	0.1162

Table 2

As expected, *for all event windows the contemporaneous response of stock market to a policy shock is negative and significant.* This result is very important: it implies that identification schemes which assume no contemporaneous reaction of stock market to a policy shock are inappropriate. A contractionary monetary policy has a consistent negative contemporaneous effect in the stock market. As Table 2 indicates, the estimated response coefficient increases with the size of the window: the largest response is recorded for the 10 minute window and the smallest one for the 1 minute window. For further analysis, we focus our attention on coefficients estimated over a five minute window, since this time-frame is wide enough to allow for adjustment in responses of stock market to a policy disturbance, and narrow enough to center attention around policy announcement time.

For the 1994-2001 sample, the response of stock market to policy shock on a monthly basis is -0.16, significant at 1% level. Under stability assumption, we report estimates of α for the longer samples: 1959-2001, 1979-2001, 1982-2001. Table 3 summarizes these results. The estimates for all samples are negative and significant. The magnitude of the response decreases in the most recent samples, indicating that stock market participants, being better informed about policy actions in the later years, register less surprise with respect a policy change than before.

Response of Stock Market to a Monetary Policy Shock

Sample	Constant(t-stat)	Estimated Response to Shock $(\alpha)(t-stat)$
Jan.1959-Dec.2001	-0.071 (-0.024)	-0.969 (-3.330)
Apr.1979-Dec.2001	-0.189 (-0.024)	-2.57 (-3.330)
Jan. 1982-Dec.2001	-0.017 (-0.024)	-0.235 (-3.330)

Table 3

Once estimates of $\widehat{\alpha}$ are obtained, the identification of policy response (β) to a stock market shock follows from the VAR estimation. Estimates of VAR for β indicate that, over most subsamples, the response of monetary authority to a stock market disturbance is positive and small, and in all cases except one statistically not significant.

As mentioned in the literature review there is much recent debate in the discipline concerning the sign and the magnitude of the monetary policy response to a positive financial market innovation. Assuming that increases in stock prices indicate expansionary business cycle periods with increases in inflationary expectations, monetary policy should respond by increasing interest rates thus dampening inflationary pressures. However, if positive innovations in financial markets are due to improvements in market fundamentals (technology shocks, supply shocks), monetary authority should not respond to these innovations, since they do not signal inflationary or growth stability concerns. To the extend that monetary authority can sift between different types of financial shocks they should respond to stock market disturbances when appropriate: responding to shocks that reflect increases in inflation and ignoring those shocks that underlie market fundamentals. Since the ability of Fed to determine types of disturbances affecting financial markets is limited at best, most advocates in the literature a passive monetary policy with respect to financial market innovations.

Our empirical findings, summarized in table 4, reflect the "non-responsiveness" of the Fed to these financial shocks.

Response of FFR to a Stock Market shock

Sample	Estimated Response to Shock $(\beta)(t-stat)$
Jan.1959-Dec.2001	0.0019 (0.3318)
Apr.1979-Dec.2001	0.0315 (4.016)
Jan. 1982-Dec.2001	0.003 (0.6304)

Table 4

For the 1994-2001 sample, our estimates of β are negative and insignificant ($\widehat{\beta} = -0.0038$ and $t - stat = -0.6066$). This is the only case that the estimated response of monetary policy to a stock market shock is of the "wrong" sign. Puzzling as this may be, this findings while in contrast with Rigobon and Sack (2001) are similar to those reported by Bernanke and Gertler (2000), obtained by estimating forward looking Taylor rules. For the 1959-2001 and 1982-2001 sample, our estimates of β are positive and insignificant with magnitudes of $\widehat{\beta} = 0.0019$ for the 1959-2001 period and $\widehat{\beta} = 0.003$ for the 1982-2001 period. These results seem to lend support to the idea that in reality monetary authority has not targeted financial market directly; the estimates of β are very small and in the above samples not significant. Only the estimated response for the 1979-2001 sample is significantly positive with a magnitude of $\beta = 0.031$. However, since 1979-2001 and 1982-2001 are overlapping for most of the sample, the differing results between these two periods could be due to the conduct of policy between 1979-1982 (in this period the Fed targeted non-borrowed reserves as a policy instrument).

7 Conclusion

This paper attempts to address the endogeneity issue arising in a structural VAR model between monetary policy and stock market variables. In order to assess contemporaneous relations between fed funds rate and an aggregate stock market index, we employ a new identification scheme that allows estimation of simultaneous reactions among these variables, therefore eliminating exclusion restrictions commonly employed in the literature. We use changes in fed funds future data on the days of FOMC announcements to measure exogenous structural policy shocks, and changes in future prices of

S&P500 defined over a small window around announcement time to measure reaction of stock market participants to a policy innovation. The additional relationship, resulting from the use of future data to estimate stock market reaction to a policy disturbance, completes identification and allows for contemporaneous responses between monetary policy variable and stock market return.

Our results indicate that stock market participants react strongly and significantly to monetary policy innovations. A contractionary monetary policy depresses asset prices for the current period. These results are robust accross various sample specifications, with the most recent sample (1994-2001) registering the smallest magnitude of response. We believe that diminishing reactions over time are due to the higher degree of transparency and an improved communication between the Fed and market participants during recent years. At the same time, increased efforts from the part of private sector in predicting and monitoring actions of the central bank, have contributed towards the creation of a better informed public. If central bank's actions are correctly anticipated in advance, a diminished response from the part of stock participants to a policy disturbance should be expected.

Our identification method enables us to assess the other side of the issue: reaction of federal funds rate to a financial market shock. Although much of the recent debate in the literature attempts to address the question whether central banks should systematically respond to asset prices, this paper focuses in estimating this response. Our empirical results indicate that over most samples the response of monetary authority to a stock market shock is small and insignificant. In the 1994-2001 subsample the response is small, negative and insignificant. Over all other subsamples, the response is positive and insignificant, with the exception of 1979-2001 period, where the response coefficient is larger than all other samples and statistically significant. This estimation analysis seems to confirm the fact that in the past the Fed has in effect acted as it has professed so far: it has not directly targeted asset prices in the conduct of monetary policy.

The empirical results presented in this paper should be regarded as a first tentative in estimating the contemporaneous relationships between stock market and monetary policy under more general conditions and without imposing any exclusion restrictions on the parameters of interest. One important limitation of the proposed method rests with the restricted availability of futures data both for federal funds rate and S&P 500. Fed funds futures contracts were introduced in January 1989. The S&P 500 futures data were introduced in January 1982, however, the irregular announcements of monetary policy prior to 1994 diminishes the practical use of this data in the present context. As such, analysis for earlier samples can be carried out only under stability assumption. Despite these caveats, we believe that new identification methods should be employed to sidestep exclusion restrictions and address the endogeneity problem between variables with simultaneous reaction. Although identification issues in cases of endogenous responses continue to remain a complex task, we believe that further research in the area will enrich our understanding and offer a better characterization of the interaction between monetary policy and financial markets.

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