**Monetary Policy Shocks and Their Effects on Business Borrowings, Aggregate Output, and Prices**

by

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Abstract

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Developed from previous financial acceleration research, this thesis employs two VAR (vector-auto regression) systems to measure monetary policy shocks and their effects. The first uses the conventional Cholesky method and the second uses the methods developed by Bernanke and Blinder (1992) and Bernanke and Mihov (1998). I use the federal funds rate and as the two monetary policy instruments in the VAR systems.

With the Cholesky method, net financial borrowings rise (fall) for about one year after contractionary (easy) monetary policy shocks. This is consistent with what has been found by Christiano, Eichenbaum, and Evans (1996). The responses of corporate sector appear to explain the entire business sector, with no significant results found from the impulse responses of the other two sectors (noncorporate and farm). With the BM model, easing policy shocks lead to an initial fluctuation within the first half of year and the prolonged decrease in borrowings after half of year. The responses of borrowings in the BM model demonstrate different amplitudes and patterns from the Cholesky method following the policy shocks, this is from the structural shocks are defined differently in these two VARs. However, the decreases (rise) in borrowings after the easy (tight) monetary shocks are the same. In both systems, there is a significant expansion of real GDP following monetary easing. The price puzzle, that price levels are positively related to monetary tightening, does not appear in the plots of impulse response functions with the Cholesky method but they appear in some versions of the BM model.

(JEL classification: E52, G30)

Key Words: Monetary Transmission Mechanism, Financial Acceleration, VAR Model, Flow of Funds, Federal Funds Rate, Nonborrowed Reserves, Price Puzzle.

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## DEDICATION

To my parents, Qiubao Yuan and Zhongli Yao.

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**Chapter1.**

**Introduction**

In the last several decades, a considerable literature has grown where the outcomes of monetary and other shocks are traced by means of VAR techniques. When examining the responses of real variables to the exogenous shocks to monetary policy, two different VAR systems are employed in this paper. The objective is to provide some empirical evidence to evaluate monetary policy impacts on the major macroeconomic variables and especially on the aggregate U.S. business sector by using data from the flow of funds accounts (FFA).

The previous theoretical framework in this field gives two complementary perspectives (Gertler and Gilchrist 1993a, Walsh 2010 page 477- 510): the money and credit view, and the financial accelerator. The Money view connects the nominal stock of money and the aggregate price level to the performance of the general economy, as suggested by the traditional Keynesian liquidity-preference theory. However, with the development of financial markets borrowers do not only depend on cash at hand. Borrowers can use their non-money assets as collateral to ask for loans or to issue bonds. The more general "credit view" is therefore getting more attention in the literature on transmission of monetary policy actions to the real economy, what can be explained by the chain effect that the monetary policy regulates bank credits and the credit's impact on lending to bank customers.

The credit view stresses the distinct role played by the borrower's financial assets and liabilities (on the balance sheet) in helping them to get credits or loans. Different kinds of assets and liabilities cause different sizes of the wedge in borrowing costs, and even the ability in getting the borrowings.  It raises questions like how and to what extent credit constraints affect the loan-dependent borrowers with different financial characteristics or balance sheets. A more direct question is: Do credit constraints in bank reserves actually decrease loans (Romer and Romer 1989)? If yes, whose loans are decreased by such constrains? These questions bring us a series of studies in the field of credit rationing, which is defined by Jaffee and Russell (1976) as the situation where supply of loans is less than borrower's demand. When analyzing the allocation of scarce credits, the models in this field call for distinguishing the costs and properties of internal or external funds, borrowers with different creditworthiness (Stiglitz and Weiss 1981), small and large borrowers with different default possibilities (Jaffee and Stiglitz 1990).

Imperfections in the credit markets account for the diversification of credit channels (Mishkin 2007, chapter 8). Asymmetric information makes efficient distribution of credits hard to attain at zero expense. These include: adverse selection (Jaffee Russell 1976), moral hazard (Stiglitz and Weiss 1981), monitoring costs (Williamson 1986, 1987 a, 1986b, 2006) and agency costs (Bernanke and Gertler 1989, Gertler 1988, Bernanke, Gertler and Gilchrist (BGG) 1996). Take agency cost as an example. Here, external funds become more expensive than internal funds due to additional costs like project auditing, which should not exist if information is perfect. Consequently, the firm's balance sheet affects the financing cost because the more external funds to use the more the agency costs. Here with symmetric information the assumption of the Modigliani-Miller capital structure irrelevance theorem no longer applies, and the allocation of credit depends on financial features of the borrowers.[1]

The financial accelerator (BGG 1996, 1999) view starts from the credit view but goes further and uses broader credit information to reveal financial propagation mechanism underlying the transmission. Cash flow and net worth, besides the non-money assets stressed in the credit view, become important as the indicators of the borrower's creditworthiness, ability of finance, interest in future investment. One example of this propagation mechanism is summarized by Walsh (2010 page 507): "the firm is forced to rely more on higher-cost external funds just at the time the decline in internal finance drives up the relative cost of external funds. Contractionary monetary policy that produces an economic slowdown reduces firm cash flow and profits. If this policy increases the external finance premium, there will be further contractionary effects on spending." The tight monetary policy not only deteriorates the general economy, it causes a second round negative impact on the borrowings and investment behavior as a result of changing in credit worthiness of borrowers.

[1] It is worth mentioning that the credit view is not restricted to the bank lending channel, a significant part but not the only part of the broad credit channel given the no-close-substitute role played by bank loans (Bernanke and Gertler 1989, Fuerst 1994a, 1994b, Gertler and Gilchrist 1993b). The view was first tested by King (1986), who found that banking loans are not as useful as monetary aggregates in predicting future output. Bank lending research has been continued by Ramey (1993) and Kashyap (1993), and more recently by Meh (2010), who analyzes shocks from the banks' capital with the combination of DSGE (dynamic stochastic general equilibrium) and business cycle models.

Since the literature of financial accelerator emphasizes the second round effect, much of the discussion focuses on the comparisons of the performance of borrowers with different credit-worthiness, especially during recession and periods of contractionary monetary. The less-creditworthy borrowers are the most adversely affected groups during an economic slump, and the impacts of monetary policy on these groups are magnified most. In a recession environment, deteriorating internal funds and worsening balance sheet make firms turn to the external financing at higher cost, which leads them to scale back investment. Later on, with shrinking economic activity the values of balance sheet accounts or net worth indicators will fall and start the vicious cycle again.

The financial accelerator view dates back to Irving Fisher (1911, 1933), who first discussed how a deteriorated collateral assets can increase external borrowing cost. Later studies by Gertler and Gilchrist (1993b, 1994) and BGG (1999) show that small firms are more negatively impacted by general economic downturn and therefore more sensitive to business cyclical fluctuations. The comparison between small and large firms shows the difference between internal and external funds and gives a clearer view of the monetary transmission functions.  There are many transmission mechanisms proposed, such like the original BGG (1996) financial frictions, its revised version (Christiano, Motto and Rostagno 2003, 2008), and expanded monetary sector (Chari Christiano Eichenbaum 1995), which include M1, M3, bank reserves and currency in the discussion. Many of the shocks underlying the transmission are classified by Christiano, Motto and Rostagno

(2010) as seven broad categories: goods technology, markups, financial factors, demand, money demand and banking, monetary policy, monetary policy objective.

This thesis concentrates on two exogenous shocks to policy instruments: the orthogonalized shocks to the federal funds rate and the orthogonalized shocks to the non-borrowed reserves. The main goal is to provide some additional empirical evidence on the monetary transmission mechanism in the business sector. There are many studies in this field showing, for example, that monetary policy shocks have significant impacts on the firm's future earnings and equity market performance (Ehrmann 2004), and on the firms' financial decisions, production scales and even stock market returns (Cooley 2006). This paper pays more attention than previous work to the firm's treatment of their financial liabilities and their assets.

The contribution of this paper is as follows: First, test the impact of monetary policy on the real GDP, GDP deflator, and price index, especially on the financial holdings of business sectors. Second, measure the responses of the firms' financial behavior to policy shocks using the flow amount instead of stock value. The flow of funds has the following features: a), its flow values provide a different view of business sentiment within specific asset/liability classes and sectors. b), its data come mainly from the banking system but not limited to the bank lending channel. Given the features of the flow value, I also examine the separated accounts of the business net borrowings, and describe the reasons for their different responses to policy shocks.  This is not the first time that flow value has been used when tracking the policy shocks in different models (Christiano, Eichenbaum and Evan (CEE) 1996, Fratzscher 2009).

The third contribution is in model specification. I employ the widely-used Cholesky method and also develop some more specified VAR models. The structure of the revised VAR model is presented by Bernanke and Mihov (1998) and is frequently illustrated in some time series or monetary policy textbooks (Favero 2001 page 188, Walsh 2010). The model here is revised to be consistent with recent changes in the reserve market. In the second Bernanke and Mihov's VAR (BM-VAR), there are three different models developed based on the nature of the monetary policy.

There are four major results on the performance of the net business borrowings in this paper: First with Cholesky method, following a contractionary (expansionary) monetary policy net business borrowings increase (decreases) for about a year. Second, consistently more apparent responses of the business borrowings can be found to the FFR shocks than to NBR shocks with the Cholesky method. The similar findings are presented by CEE (1996) and Den Hann et al (2007). Den Hann et al find there is a rise of commercial and industrial loans (through bank lending channel) following contractionary monetary policy with federal funds rate used as the policy indicator. CEE uses a similar VAR but only with the Cholesky identification method. I use both Cholesky and Bernanke and Mihov's method. With the BM methods, (the exogenous policy shocks are re-defined and different from those specified by Cholesky methods), net business borrowings fluctuate in the first half of year and then demonstrate a prolonged decrease following expansionary policy.

The third result is with the business net borrowings being set to business liability minus assets, I find no evidence that the responses are driven by either the financial assets or liabilities. The fourth result is a stronger response of corporate sector to the monetary policy shocks and no significant responses are founded in the impulse responses of the other two sectors (farm and noncorporate). This is similar to CEE's finding that stronger response of corporate business sector to policy shocks than the corresponding sector aggregate; weaker or no significant responses of the noncorporate sectors.

The results about the intercorrelation between monetary policy and the flow of funds are not the ones shown by the textbook IS-LM model, or by the existing credit transmission model and the business cycle model. The conventional Keynesian model predicts that when the fed fund rate increases, (which means the opportunity cost of the borrowing cost increases), borrowing amount is scaled back. As for the other models, which emphasizes either the transmission function conducted by bank credit or the information imperfection, predict the same fall of borrowings after the contractionary policy (Bernanke and Blinder 1988, 1992, Fisher 1999). However, the result here suggests another part of the transmission mechanism that previous system should have accounted for.

The remainder of the paper is organized as follows. Section 2 introduces the baseline VAR models with the rationale for the individual variables also explained. Based on the restriction in the VAR models, two identification methods are developed. The revision of the second BM model is also discussed. Section 3 presents the results for these two VARs, and explains the concern for the second VAR. Section 4 summarizes the results and provides some concluding remarks. The technical notes are attached in the appendix, which lists the sources for raw data, provides additional information on non-borrowed reserves, and explains model derivation and variable tests.

**Chapter2.**

**Methodology**

## 2.1. General Introduction of VARs

### 2.1.1. VAR Approach

There are two major approaches to the monetary transmission mechanism. The first is the Vector Auto-Regression method (henceforth abbreviated as VAR), and the second is the narrative approach. The narrative approach is proposed by David Romer & Christina Romer (1989), who follow the idea of Friedman and Schwartz (1971), and has been further extended by Boschen and Mills (1991, 1995). Romer's approach provides a zero-one dummy index based on the Federal Reserve's "Record of Policy Actions" and the minutes of the Federal Open Market Committee. However, this method simply considers the dates of contractionary policy shifts, but ignores the expansionary policy shifts. One of the biggest disadvantages is that the Romer's dates are strongly associated with oil price shocks (Hoover and Perez 1994).

Boschen and Mills rate the policy stances into five categories: "very tight", "tight", "neutral", "easy", and "very easy", and assign the integers from -2 to 2 to each category, based on the nature of the policy. When the policy targets reducing inflation, it is rated as "very tight" with the correspondingly assigned integer equal to -2. When it aims at reducing unemployment, it is considered as "very easy" with the integer equal to 2. Although compared with the Romer's approach, Boschen and Mills' method is more informative, it still inherits the fallacy of "post hoc ergo propter hoc" or the incorrect explanation of cause and effect relationship.

There are some advantages of the VAR models: First, the underlying interactions among variables can be quantitatively measured in greater details than the narrative methods. Second, it can be used to summarize the first and second moment properties of the data (expectation and variance). The Usage of VAR in the field of monetary policy started as a bi-variant system (Sims 1972, Christiano, Eichenbaum and Vigfusson 2003) and then tri-variant (Sims 1980a). Later on, it expands to be a larger and larger system (four variables by Boivin and Giannoni 2002, up to eight variables by CEE 1998, and even 24 innovations by Christiano, Motto and Rostagno 2010). However, we shall take efficiency into account when developing a system of large size.

Now we establish the core VAR equation in a reduced form as show in equation (1), where we use level data[2] and include seven variables in Z vectors. We assume there are no non-invertability/stationarity problems here.

$$Z_t = A_0 + A_1 Z_{t-1} + A_2 Z_{t-2} + \ldots + A_q Z_{t-q} + u_t \qquad (1)$$

A (L) is a K*K matrix, containing lag operators for the Z matrix. The Variance-Covariance (VCV) matrix of $u_t$ is V. Different assumptions on the error vector $u_t$ will provide different identification methods for the VAR.

The linear relationship between monetary policy and its shocks can be extracted from vector Z. Assume it is the Kth element of Z in the following form:

$$\mathrm{P_t} = f(\Omega_t) + \sigma v_{st} \qquad (2)$$

[2] Thought theoretically, we should be aware of the stationarity and the potential unit root problems of the variables in the VAR system. However, here following the suggestions by Sims (1980b) and Sims, Stock and Watson (1990), who recommend against differencing the variables even they have unit root, because the major function of VAR is to indicate the inter-correlation among variables, rather parameter estimation. Using difference will get rid of some significant information, which might bring co-movement among variables.

The second reason that the levels instead of differenced values is used because Eichenbaum and Singleton (1987) found that the explanatory power of money to the future output is significantly reduced if in log first difference form but not in log levels by running Granger Causality test.

The third reason that we can ignore whether the series is stationary and use the level data is that the results in monetary policy is usually presented by innovation accounting (Lutkepohl and Reimers 1992), specially the impulse response function.

$P_t$ is the policy instrument, $f(\ )$ is a linear function, $\Omega$ is the information set available to the monetary authority when they design $P_t$, $\sigma$ is the coefficient for structural innovation $v_{st}$, which is a serially uncorrelated exogenous policy shock (the features of $v_{st}$ is introduced more below). We also assume $v_{st}$ is orthogonal to the elements of the information set $\Omega$ and has variance unity.

Asymptotically, we can expect equation (1) and (2) to be equal. The residual term $u_t$ of equation (1) is related to the structural innovations $v_t$ in equation (2) as the follows:

$$u_t = Cv_t \tag{3}$$

C is the K×K coefficient matrix for exogenous policy shocks.

**2.1.2. Variables**

Next, we introduce and explain the seven variables used in the VAR model. The first variable is the log of GDP (loggdp) and the second variable is the log of GDP deflator (logp). Both variables are conventionally put into a macroeconomics VAR model to represent the condition of real economy, because most macroeconomic phenomena are always described by the aggregate output and the price index (which are also used as the horizontal and vertical inputs of the classic AS&AD curve).

The third variable, the log of commodity price (logcomp), is included to deal with the price puzzle. The puzzle means the positive relation between FFR shocks and price level (inflation)[3], as opposed to what conventional macroeconomic theories projects. Sims (1992) conjectured the policy shocks could not accommodate all the information of future inflation. There exists a supply shock, which will temporally raise interest rate, decreasing output and increase prices. It was mistakenly treated as policy shocks, and causes the puzzle. Therefore, the VAR needs a variable to explain this supply shock. CEE (1996) argued to add commodity price into the model in order to explain future inflation and not related to supply shocks. Sims and Zha (1998) demonstrated that the price puzzle disappears after adding the commodity price in to the model.

Next, we introduced two variables of policy instruments: the federal funds rate (FFR), and nonborrowed reserves (NBR). The rationale to use FFR is addressed by the arguments of McCallum (1983), Bernanke and Blinder (1992) and Sims (1986, 1992). All of their analysis argues: when using VARs, "the monetary policy surprises may be more accurately represented by interest rate than money stock innovations, especially if the monetary authority uses an interest rate instrument." It is currently widely-used in the VAR monetary transmission analysis (Boivin 2002, Sims and Zha 2006). Even in the narrative approach, Boschen and Mills (1995) consider FFR as a good policy indicator.

[3] Balke and Emery (1994) run a regression for the subsequent inflation (measured by average of annualized GDP deflator of the subsequent 8 quarter) on FFR, the coefficient of FFR is as much as 0.75 (without trend in the regression), with adjusted R-square as 0.56, and the coefficient is 0.17 (with trend) with adjusted R-square as high as 0.92, during period from 1960 to 1979. However, after 1980 this correlation is no longer significant. And adding the commodity price still doesn't solve the "price puzzle" for the pre-80 periods, though it does work for their whole sample period (1960-1993).

FFR is the "interest rate at which depository institutions lend balances at the Federal Reserve to other depository institutions overnight."[4] The target rate of FFR is determined by the meeting of the Federal Open Market Committee (FOMC). The Federal Reserve uses open market operation to let the effective FFR follow the target FFR. The open market operation involves purchasing and selling government securities in the open market. When the Fed launches an expansionary policy by buying the securities and increasing the money supply, the FFR is supposed to go down, while an increase of FFR is considered as the result of contractionary monetary policy.

The application of nonborrowed reserves (NBR) is motivated by Christiano and Eichenbaum (1995). They argued that the innovations to NBR primarily reflect exogenous shocks to monetary policy, while innovations to broader monetary aggregates (ex. M1, M2) primarily reflect shocks to money demand. In detail, nonborrowed reserves is equal to total reserves (TR) minus borrowed reserves (BR), that is NBR = TR - BR. The BR is the money that a member bank of the Federal Reserve borrows from its Federal Reserve bank through the discount window, in order to maintain its required reserve ratio. The amount of demand for BR depends on the discount rate (as the opportunity cost of borrowing from the Fed) and the FFR (the cost of borrowings in the federal fund market).

[4] http://www.federalreserve.gov/monetarypolicy/openmarket.htm

NBR is controlled by the Fed also through open market operations. For example, when buying government securities, the Fed credits the reserves account of the seller's bank, which gets the credits with the increase of NBR. This action is considered as expansionary policy. Therefore, expansionary shocks are these involving positive shocks to NBR and negative shocks to FFR, vice versa, for contractionary shocks.

The sixth variable, total reserves (TR), is included and useful when the policy targets are specified for identifying the BM-VAR model. The function of the reserve market, the correlations of TR, BR, and NBR are discussed in more detail in the sector using Bernanke & Mihov's identification. Normally the above six variables are always used as macroeconomic variables in the current monetary transmission research.

The last variable is the net fund raised in business sectors, business net borrowings (BNET). This application is proposed by Christiano, Eichenbaum and Evans (1996). It is explained as one of the major variables from the national Flow of Funds Accounts (FFA). This variable is used as the proxy to analyze the activities of the business firms. Net means it equal to the flow value of the business liabilities minus the business acquisitions. Because it is one of the major focuses of this paper, the complete results and descriptions are provided in section 3.

### 2.1.3. Restrictions

We define vector Z in the Vector Auto regression (VAR) as follows:

$$Z \sim \left(\log gdp_t, \log p_t, \log comp_t, \log tr_t, \log nbr_t, ffr_t, bnet_t\right). \tag{4}$$

Equation (2), the reduced unrestricted form (or standard VARs), can be expanded in the following equation:

$$\begin{bmatrix} \log gdp_t \\ \log p_t \\ \log comp_t \\ \log tr_t \\ \log nbr_t \\ ffr_t \\ bnet_t \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \\ a_{30} \\ a_{40} \\ a_{50} \\ a_{60} \\ a_{70} \end{bmatrix} + \begin{bmatrix} a_{11}{}^i & a_{12}{}^i & \ldots & a_{17}{}^i \\ a_{21}{}^i & a_{22}{}^i & \ldots & a_{27}{}^i \\ . & . & . & . \\ a_{71}{}^i & a_{72}{}^i & \ldots & a_{77}{}^i \end{bmatrix} \begin{bmatrix} \log gdp_{t-1} \\ \log p_{t-1} \\ \log comp_{t-1} \\ \log tr_{t-1} \\ \log nbr_{t-1} \\ ffr_{t-1} \\ bnet_{t-1} \end{bmatrix} + \begin{bmatrix} a_{11}{}^i & a_{12}{}^i & \ldots & a_{17}{}^i \\ a_{21}{}^i & a_{22}{}^i & \ldots & a_{27}{}^i \\ . & . & . & . \\ a_{71}{}^i & a_{72}{}^i & \ldots & a_{77}{}^i \end{bmatrix} \begin{bmatrix} \log gdp_{t-2} \\ \log p_{t-2} \\ \log comp_{t-2} \\ \log tr_{t-2} \\ \log nbr_{t-2} \\ ffr_{t-2} \\ bnet_{t-2} \end{bmatrix} + \ldots + \begin{bmatrix} a_{11}{}^i & a_{12}{}^i & \ldots & a_{17}{}^i \\ a_{21}{}^i & a_{22}{}^i & \ldots & a_{27}{}^i \\ . & . & . & . \\ a_{71}{}^i & a_{72}{}^i & \ldots & a_{77}{}^i \end{bmatrix} \begin{bmatrix} \log gdp_{t-q} \\ \log p_{t-q} \\ \log comp_{t-q} \\ \log tr_{t-q} \\ \log nbr_{t-q} \\ ffr_{t-q} \\ bnet_{t-q} \end{bmatrix} + \begin{bmatrix} u_{gdp,t} \\ u_{p,t} \\ u_{comp,t} \\ u_{tr,t} \\ u_{nbr,t} \\ u_{ffr,t} \\ u_{bnet,t} \end{bmatrix} \tag{5}$$

We can estimate the current value of the variables as long as we calibrate the coefficients of the VAR and knows the historical values. For example, we would estimate the first variable in the Z vector by using the formula blow:

$$\log gdp_t = $$
$$a_{10} + \sum_{i=1}^{q} \left( a_{11}{}^i * \log gdp_{t-i} + a_{12}{}^i * \log p_{t-i} + a_{13}{}^i * \log comp_{t-i} + a_{14}{}^i * \log tr_{t-i} + a_{15}{}^i * \log nbr_{t-i} + a_{16}{}^i * ffr_{t-i} + a_{17}{}^i * \log bnet_{t-i} \right) \tag{6}$$

The current GDP can be explained by the sum of all the previous performance, until the time period q. To see how the shocks work, we can check how equation (5) is transferred from the unobserved Structural VARs (SVARs) or the primitive VARs, which can be expressed as follows:

$$\begin{aligned}
\log gdp_t &= b_{10} - b_{12} * \log p_t - b_{13} * \log comp_t - b_{14} * \log tr_t - b_{15} * \log nbr_t - b_{16} * ffr_t - b_{17} * \log bnet_t + \sum (...) + v_{gdp,t} \\
\log p_t &= b_{20} - b_{21} \log gdp_t - b_{23} * \log comp_t - b_{24} * \log tr_t - b_{25} * \log nbr_t - b_{26} * ffr_t - b_{27} * \log bnet_t + \sum (...) + v_{p,t} \\
\log Comp_t &= b_{30} - b_{31} \log gdp_t - b_{32} * \log p_t - b_{34} * \log tr_t - b_{35} * \log nbr_t - b_{36} * ffr_t - b_{37} * \log bnet_t + \sum (...) + v_{comp,t} \\
\log tr_t &= b_{40} - b_{41} \log gdp_t - b_{42} * \log p_t - b_{43} * \log comp_t - b_{45} * \log nbr_t - b_{46} * ffr_t - b_{47} * \log bnet_t + \sum (...) + v_{tr,t} \\
\log nbr_t &= b_{50} - b_{51} \log gdp_t - b_{52} * \log p_t - b_{53} * \log comp_t - b_{54} * \log tr_t - b_{56} * ffr_t - b_{57} * \log bnet_t + \sum (...) + v_{nbr,t} \\
\log ffr_t &= b_{60} - b_{61} \log gdp_t - b_{62} * \log p_t - b_{63} * \log comp_t - b_{64} * \log tr_t - b_{65} * nbr_t - b_{67} * \log bnet_t + \sum (...) + v_{ffr,t} \\
\log bnet_t &= b_{70} - b_{71} \log gdp_t - b_{72} * \log p_t - b_{73} * \log comp_t - b_{74} * \log tr_t - b_{75} * \log nbr_t - b_{76} * ffr_t + \sum (...) + v_{bnet,t}
\end{aligned} \quad (7)$$

$\sum(\ )$ s contain the lagged variables and their coefficients. Comparing equation (5) with (7) we observe that both the current and lagged values appear on the right hand side of SVARs in (7), while all the current value depends on only the previous values in the standard or unrestricted VARs in (5). By rearranging the equation (7), and defining $B_0$ as a 7*7 coefficient matrix of the "current" values, we can put all the lagged variables to the right hand side and get the compact version of the SVARs:

$$B_0 Z_t = B_1 Z_{t-1} + B_2 Z_{t-2} + ... + B_q Z_{t-q} + v_t \quad (8)$$

However, only the $\mu_t$, the vector containing residuals in the reduced form VARs matrix, is observable. The VCV of the structural shocks $v_t$ is not observed and need to be recovered. By comparing the unrestricted VAR (1) and the structural VAR (8), we can easily obtain:

$$\mu_t = B^{-1} * v_t \text{, or } \mu_t = C * v_t \quad (9)$$

Here C is a K× K matrix defined in equation (3). The relation between the VCV of $\mu_t$ and the innovations is in the following equation[5]:

$$V = B^{-1} * \left(E v_t v_t'\right) * (B^{-1})' \qquad (10)$$

$$\underset{knowns}{\frac{n^2+n}{2}} \quad \underset{unknowns}{n} \quad \underset{unknowns}{n^2-n}$$

To recover the system to the SVARs, we need to identify the B matrix and the VCV matrix of the structural errors, or their combinations.

We can count the number of the knowns on the left hand side of equation (10) and the unknowns on the right hand side. Because the structure innovations, denoted by $v_t$ are assumed to be a series of uncorrelated i.i.d. (identical, independent, distributed) white-noise disturbances[6], the $\mu_t$ , as a linear combination of $v_t$ , therefore has zero means, constant variance, and the disturbance are individually independent. The VCV of $\mu_t$ , V,

[5] Most of monetary policy literatures assumes VCV of structural innovations $v_t$ is equal to one, instead of any other constant $(Ev \cdot v') = I$ and $V = B^{-1}(B^{-1})'$. It makes the number of the unknowns on the right hand side equal to (n*n). After imposing Cholesky restrictions on it, which is equal to making n*(n-1)/2 restrictions. (Without normalizing the diagonal of B matrix) we get the knowns and unknowns equalized on both sides of the equation. This paper assumes the other way: assuming the variances of structural innovations are not equal to one, instead they are constant numbers.

[6] A time series $y_t$ is a white noise process, if:
(1) E( $y_t$ ) = 0 for all t, (2) Var( $y_t$ ) = $\sigma^2$ for all t, and $\sigma^2 < \infty$ , (3) Cov( $y_t$ , $y_s$ ) = 0 if t $\neq$ s. A white noise process is a serially uncorrelated process with zero-mean, constant and finite variance. And an i.i.d. process is a white noise process but a white noise process is not necessarily to be an i.i.d. process.

is time invariant. Therefore, in the matrix V there are n(n+1)/2 parameters can be observed (the sum of the diagonal n numbers of variances and the off-diagonal n(n-1)/2 numbers of covariances).

On the right hand side of equation (10), the $\left(Ev_t v_t{'}\right)$ is assumed to have all the covariances as zero, only n(n+1)/2 numbers of the diagonal elements are need to be estimated. B contains $n^2$ unknowns. Even normalizing the diagonal elements of B (to make the numbers on the diagonal line as one ($b_{ii}=1$)), which is equivalent to imposing "n" restrictions, there are still ($n^2$-n) unknowns from the upper and lower off-diagonal part in the B matrix to be estimated. The total number of unknowns on the right hand side is $n^2$, (n from the VCV of structural innovations and n(n-1) from the B matrix). Therefore, we need at least n(n-1)/2 restrictions (that is $n^2$-n(n-1)/2) to exactly identify the system. In the following sections, we first introduce the model identified by the "Cholesky decomposition", and then use the Benanke & Mihov (1998)'s VAR with restrictions coming from previous research and assumptions.

**2.2. VARs with Cholesky Decomposition**

The first identification method is Cholesky decomposition. It is widely used in that the causality relationships among variables are reflected by the orderings of the vectors. When the policy shock is from nonborrowed reserves, the order of variables as follows: $Z=\left(\log gdp_t, \log p_t, \log comp_t, \log nbr_t, \log tr_t, ffr_t, bnet_t\right)$. When the shock is from the FFR, we use the order as follows: $Z=\left(\log gdp_t, \log p_t, \log comp_t, ffr_t, \log tr_t, \log nbr_t, bnet_t\right)$.

Basically the Cholesky method makes the B matrix to be either an upper or a lower triangular matrix, in which also means there are n*(n-1)/2 restrictions imposed. Following the decomposition and putting the 7 equations in the form of a matrix, we rewrite the left hand side of the equation (8) as follows (taking the NBR policy as an example):

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 & 0 & 0 \\ b_{51} & b_{52} & b_{53} & b_{54} & 1 & 0 & 0 \\ b_{61} & b_{62} & b_{63} & b_{64} & b_{65} & 1 & 0 \\ b_{71} & b_{72} & b_{73} & b_{74} & b_{75} & b_{76} & 1 \end{bmatrix} * \begin{bmatrix} \log gdp_t \\ \log p_t \\ \log comp_t \\ \log nbr_t \\ \log tr_t \\ ffr_t \\ bnet_t \end{bmatrix} = BZ \tag{11}$$

The relationship between the structural innovations $v_t$ and the disturbance $\mu_t$ in the unrestricted VARs is described in the matrix (12). Notice the inverse of the lower triangular matrix is again a lower triangular matrix, but the components are changed correspondingly.

$$\begin{bmatrix} u_{gdp} \\ u_p \\ u_{comp} \\ u_{nbr} \\ u_{tr} \\ u_{ffr} \\ u_{bnet} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ c_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ c_{31} & c_{32} & 1 & 0 & 0 & 0 & 0 \\ c_{41} & c_{42} & c_{43} & 1 & 0 & 0 & 0 \\ c_{51} & c_{52} & c_{53} & c_{54} & 1 & 0 & 0 \\ c_{61} & c_{62} & c_{63} & c_{64} & c_{65} & 1 & 0 \\ c_{71} & c_{72} & c_{73} & c_{74} & c_{75} & c_{76} & 1 \end{bmatrix} * \begin{bmatrix} v_{gdp} \\ v_p \\ v_{comp} \\ v_{nbr} \\ v_{tr} \\ v_{ffr} \\ v_{bnet} \end{bmatrix} \tag{12}$$

The low triangular coefficient matrix is the coefficient matrix for the innovation vector. Here in the Cholesky estimate, the specific ordering of the innovation vector will be very important. It reflects the assumption that the innovations of the variables listed anterior enter the residuals equations of the variables listed posterior, but not vice versa. For example, in equation (12), the first row of "C" matrix has only a "one" in the first position, therefore $\mu_{gdp} = v_{gdp}$. If we expand the second row of "C" matrix, we get $\mu_p = c_{21} v_{gdp} + v_p$. The innovations of the posterior variable (the variable listed in the second position is P) do not enter the equation of the $\mu_{gdp}$, but innovations of the anterior variable, $v_{gdp}$, enters equation of $\mu_p$. Since the innovation of GDP is listed in the first position of the innovation vector, it enters all the residual equations of the other variables. It makes sense, since all the other variables are causally affected by the general economy.

The basic assumption of this Cholesky decomposition means the policy shock (the variables listed in the fourth to seventh positions in the Z vector) has no contemporaneous effect on real output (the variables listed in the first to third positions in the Z vector). Monetary policy shocks do not affect the shocks of real variables like the GDP, GDP deflator and commodity prices, but the decision-maker of monetary policy might take into account the situation of current economy. These contemporaneous correlations among variables are assumed to reflect the underlying causalities. I place the variables of the business borrowings behind the policy instruments, assuming monetary policies will affect the borrowings contemporaneously, but the borrowings will not affect the current monetary policy.

The impulse response function (IRF) is often used in current macroeconomics research to visually show the effect of individual shocks to a specific variable. We use some algebra to derive the IRF from the VAR system: First, we convert the VAR to VMA (vector moving average), that is to reorganize equation (5) into the following equation:

$$\begin{bmatrix} \log gdp_t \\ \log p_t \\ \vdots \\ bnet_t \end{bmatrix} = \begin{bmatrix} \widehat{E}_{\log gdp} \\ \widehat{E}_{\log p} \\ \vdots \\ \widehat{E}_{bnet} \end{bmatrix} + \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ c_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ c_{31} & c_{32} & 1 & 0 & 0 & 0 & 0 \\ c_{41} & c_{42} & c_{43} & 1 & 0 & 0 & 0 \\ c_{51} & c_{52} & c_{53} & c_{54} & 1 & 0 & 0 \\ c_{61} & c_{62} & c_{63} & c_{64} & c_{65} & 1 & 0 \\ c_{71} & c_{72} & c_{73} & c_{74} & c_{75} & c_{76} & 1 \end{bmatrix} \sum_{i=0}^{\infty} \begin{bmatrix} a_{11}{}^{i} & a_{12}{}^{i} & \dots & a_{17}{}^{i} \\ a_{21}{}^{i} & a_{22}{}^{i} & \dots & a_{27}{}^{i} \\ . & . & . & . \\ a_{71}{}^{i} & a_{72}{}^{i} & \dots & a_{77}{}^{i} \end{bmatrix} \begin{bmatrix} u_{gdp,t} \\ u_{p,t} \\ u_{comp,t} \\ u_{nbr,t} \\ u_{tr,t} \\ u_{ffr,t} \\ u_{bnet,t} \end{bmatrix} \quad (13)$$

$\widehat{E}$ represents the expected value of each variable. Second, the MVA can be expressed as a regression with its expectation value plus the product of the cumulated coefficient times the structural innovations:

$$\begin{bmatrix} \log gdp_t \\ \log p_t \\ \vdots \\ bnet_t \end{bmatrix} = \begin{bmatrix} \widehat{E}_{\log gdp} \\ \widehat{E}_{\log p} \\ \vdots \\ \widehat{E}_{bnet} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} \phi_{11}{}^{i} & \phi_{12}{}^{i} & \dots & \phi_{17}{}^{i} \\ \phi_{21}{}^{i} & \phi_{22}{}^{i} & \dots & \phi_{27}{}^{i} \\ . & . & . & . \\ \phi_{71}{}^{i} & \phi_{72}{}^{i} & \dots & \phi_{77}{}^{i} \end{bmatrix} \begin{bmatrix} u_{gdp,t} \\ u_{p,t} \\ \vdots \\ u_{bnet,t} \end{bmatrix} \quad (14)$$

The cumulated $\phi_{kk}{}^{i}$ coefficient for the corresponding innovation describes the impact of such innovation on the variable. For example, the cumulated sum of the impact of FFR shocks on the GPD sequence is $\sum_{i=0}^{\infty}\phi_{1k}{}^{i}$. The set of coefficients $\phi_{kk}{}^{i}$ are the impulse response functions for each variable.

### 2.3. VARs of Bernanke & Mihov's Identification and Revision

The second identification method for the VAR model uses Bernanke & Mihov (1998)'s argument. There are 3 different targeted monetary policies of consideration: the FFR (federal fund rate), NBR (nonborrowed reserves), and NBR/TR (nonborrowed reserves and total reserves) model[7]. All the three models are based on different identification restrictions, whose assumptions come from two models (from equation (15) to (20)). The first assumption is to explain the relationship between the policy variables and the variables of the real economy. It re-organizes the 7 variables in equation (5) as two different categories: the policy and non-policy variables, in equation (15) and (16) as suggested by Bernanke and Blinder (1992):

$$Y_t = \sum_{i=0}^{k} B_i Y_{t-i} + \sum_{i=1}^{k} C_i P_{t-i} + A^y v^y{}_t \tag{15}$$

$$P_t = \sum_{i=0}^{k} D_i Y_{t-i} + \sum_{i=0}^{k} G_i P_{t-i} + A^p v^p{}_t \tag{16}$$

[7] CEE (1998, page 116) shows some critiques of the BM model. The main objection is that the BM's theoretical way of defining certain policies may not accurately reflect what have been done by the monetary policies.

Here, Y is a vector of macroeconomics variables. According to the previously introduced Z vector, they are: GDP, GDP deflator, commodity price and BNET. P in the equations represents policy indicators: TR, NBR, and FFR. We assume the errors of $v^y$ representing the real variables shocks, and the errors of $v^p$ representing policy shocks, are mutually uncorrelated, and their corresponding coefficient matrix are $A^y$ and $A^p$. It worth mentioning that in the first equation, the sum of the coefficients for P vector is $\sum_{i=1}^{k} C_i$, which starts from period 1 not 0, and is different from the coefficients for Y, which is $\sum_{i=0}^{k} B_i$. This is consistent with the assumption made above in the Cholesky order, which means the policy vector has no contemporaneous effect on the real variables and it only enters its own equation. On the other hand, the real variables enter the equation of the policy vectors, as shown in the second equation.

After regrouping the variables, we further assume that the policy residual $u_t{}^p$ is orthogonal to the non-policy ones, therefore policy disturbances only contain the errors of policy information. Combined with the equation (11), we can obtain

$$u_t{}^p = \left(I - G_0\right)^{-1} A^p v_t{}^p. \tag{17}$$

The second assumption is to recover the unobserved $v_t{}^p$ from the observed $u_t{}^p$. It uses the established equations from (18) to (21) for the monetary policy and reserves market:

$$u_{tr} = -\alpha u_{ffr} + v^d \tag{18}$$

$$u_{br} = \beta\left(u_{ffr} - u_{disc}\right) + v^b \tag{19}$$

$$u_{nbr} = \phi^d v^d + \phi^b v^b + v^s \quad . \tag{20}$$

Equation (18) comes from equation (21), which describes the demand side of reserve market. It means the demand of total reserves depends on the funds rate $i^f$ (the cost to

$$TR^d = -\alpha i^f + v^d \tag{21}$$

The borrow reserves from private banks) and the demand disturbance $v^d$. Equation (19) describes the decision of either to borrow from private banks at FFR or from the Federal Reserve paying at discount rate. The difference between the higher FFR and lower discount rate (DR), (only before 2002[8]), will bring some potential arbitrage opportunities and increase the incentive to borrow from the Federal Reserve. But there's a tradeoff with such borrowing. Banks who now borrowed from the Fed will have less opportunity to borrow again in the future, because borrowing reserves at the lower discount rate is a "privilege" not a right, and not encouraged by the Fed. So the more concrete version of how the banks make decision on borrowing reserves is:

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[8] The website of FRED from St. Louis Fed and NY Fed shows the rate change:
http://research.stlouisfed.org/fred2/data/DISCOUNT.txt
http://www.newyorkfed.org/markets/statistics/dlyrates/fedrate.html#top

$BR_t = b_1\left(i_t^f - i_t^d\right) - b_2 E_t\left(i_{t+1}^f - i_{t+1}^d\right) + v_t^b$. The simplified version is to use another b to contain information of the expected future tradeoffs in the E ( ). Then we can get $BR_t = b\left(i_t^f - i_t^d\right) + v_t^b$. If we put the equation in the innovation form and we can get (19), where b varies across different operating procedures. The innovation of discount rate $i_t^d$, denoted as $u_{disc}$, is always assumed to be zero[9].

Equation (20) is to reflect the Fed's behavior in controlling nonborrowed reserves, assuming the Fed can respond contemporaneously to all the disturbances. The values of $\phi^d$ and $\phi^b$, which are the coefficients for the non-policy factors, mean different operating procedures. The graphic description for the equations from (18) to (20) is in Figure 1 (Walsh 2010, page 540). Equation (18) reflects the downward sloping demand curve for total reserves, and equation (19) describes the upward sloping supply curve of total reserves. The vertical part of the supply curve under the discount rate is draw under the assumption that when the FFR is below the discount rate banks borrow reserves from the Fed. The steepness of the slope reflects reluctance to borrow; otherwise the supply curve will become horizontal.

[9] The innovation of discount rate is set as zero by BM (1998) for two reasons: First, all the previous research ignores the discount rate since it is an "infrequently changed administrative rate". Second, it is already contained in the innovation function of borrowings.

If we rearrange all the equations (see Appendix 2.1 for derivation), we can demonstrate the relationship between the monetary policy shocks $v^s$ and the residuals of the unrestricted VARs in the following equation:

$$v^s = -\left(\phi^d + \phi^b\right)u_{tr} + \left(1 + \phi^b\right)u_{nbr} - \left(\alpha\phi^d - \beta\phi^b\right)u_{ffr} . \qquad (22)$$

As previously calculated, the total number of restrictions we need is n (n-1)/2. Assume real innovations, $v_t^{\,y}$ s, are not included in the policy innovations $v_t^{\,p}$ s. There are 7 unknowns (three structural shocks and 4 coefficients $\alpha, \beta, \phi^d, \phi^b$ ) to be calculated and 6 known covariances already in the VCV matrix of $u_t$ s.

Based on equation (22), three models demonstrating a certain policy preference can be developed. First, in the FFR model, Bernanke-Blinder (1992) assumed that the Fed targets the federal funds rate, and offsets shocks to the demand for total reserves and borrowed reserves. Then it imposes $\phi^d = 1, \phi^b = -1$ as the restrictions in the VAR. The corresponding policy innovation is

$$v^s = -\left(\alpha + \beta\right)u_{ffr} . \qquad (23)$$

According to equation (23), the underlying policy targeting to offset the increase of FFR shocks is supposed to be an expansionary policy. Second, the NBR model by Christiano and Eichenbaum (1992) proposed that only let policy shocks reflect NBR shocks, which means imposing $\phi^d = \phi^b = 0$, and the policy shock is:

$$v^s = u_{nbr} . \tag{24}$$

Therefore, the increased value of the shocks means expansionary policy. Third, in the NBR/TR model, Strongin (1995) argued that demand shocks are the only shocks to total reserves, therefore there is no effect of $u_{ffr}$ in equation (18) and no effect of $v^b$ in (20), and $\alpha = 0, \phi^b = 0$ should be imposed. The policy targeting innovation is:

$$v^s = -\phi^d u_{tr} + u_{nbr} . \tag{25}$$

As in the previous two models, the increase of the policy shocks of NBR/TR model is also expansionary policy. Here all the three models are all over-identified, because they all impose a pair of two restrictions but what we need is only one.

We can take a close look of all the three innovations $v^s, v^d, v^b$, and see their policy meanings. The positive policy shock $v^s$ increases nonborrowed reserves and decreases the funds rate (refer to the third column in matrix A4 in Appendix 2.1). In Figure 1, this shock makes the NBR curve shifts horizontally. The shocks to reserve demand $v^d$ and supply $v^b$ have different impacts in different operating procedures. In the FFR model, by setting $\phi^d = 1$, the Fed fully accommodates the positive shock to the reserve demand by increasing nonborrowed reserves. As a result, the increment of $v^d$ shifts both the demand and supply curves of the reserves to the right and keeps the funds rate unchanged. Under a NBR procedure, with $\phi^d = 0$, a positive shock to the reserve demand increases the funds rate, total reserves and nonborrowed reserves. But with this model, the amount of the increased total reserves, due to $v^d$, is less than that under FFR procedure ($\beta / (\alpha + \beta) * v^d < v^d$ , see equation A8 and A9 in the Appendix 2.1). Under the NBR/TR model, the Fed only accommodates $v^d$ and ignores the other shocks. The increase of $v^d$ makes total reserves increase by the same amount as of the innovation (A10).

Equations from (18) to (20) describe the relationships of all the major variables in the reserve market. It reflects a more dynamic policy change if we take the arbitrage spread between discount rate and federal funds rate into consideration. Before 2002, the discount rate is below the FFR traditionally. For those banks who can borrow from the Fed can take advantage of the spread between these two rates. The arbitrage opportunity from the spread of the rates is offset by the non-price "credit rationing" of the banks. After the 9th of January 2003, the discount rate was set above FFR, which automatically eliminated the arbitrage incentive. The spread $\left(i_t^f - i_t^d\right)$ should been fixed and changes sign. In principle, if we describe the amount of the borrowed reserves as the linear regression function (19), the slope of the demand for borrowed reserves (BR) with respect to funds rate should be different. After 2003, the BR equation should reflect such a shift. A change in slope can be estimated with a time-dummy, D, added into the equation. We demonstrate this level shift of BR equation in (26), as opposite to the original equation (19):

$$u_{br} = \beta_1 u_{ffr} + \beta_2 * D * u_{ffr} + v^b \quad . \tag{26}$$

According to the other two equations (18) and (20), we can get the revised policy shocks as follows (derived in Appendix 2.2):

$$v^s = -\left(\phi^d + \phi^b\right)u_{tr} + \left(1 + \phi^b\right)u_{nbr} - \left(\alpha\phi^d - \beta_1\phi^b - \beta_2 D\phi^b\right)u_{ffr} \quad . \tag{27}$$

The innovation function of the policy shocks in the second NBR and third NBR/TR model stay the same, though the intermediate steps are more complicated and revised. The innovation equation of the first model FFR becomes:

$$v^s = -\left(\alpha + \beta_1 + \beta_2 D\right)u_{ffr} \, . \tag{28}$$

Although it seems the dummy is simple and can be easily plugged into the equation, the derivation is necessary when there is higher frequency of policy changes and more sub-periods correspondingly. In the next section, both identification methods are estimated.

## Chapter 3.

## Data, Estimation and Results

We have the data for 49 years, from 1959Q1 to 2009Q4. NBR however demonstrates a huge negative number in 2008 (as much as $-430.790 billion in the third quarter) and then an abnormally huge positive number in 2009 ($1540.672 billion in the third quarter). As explained in Appendix 3, the meaning of NBR appears to be changed after 2008. Accordingly, the data later than 2007 Q4 were dropped. All the variables, except those from the flow of funds accounts, are plotted in Figure 2 Panel A. The data sources are described in Appendix 1.

All the major variables of business sectors from the Flow of Funds Accounts (FFA) are plotted in Figure 2 Panel B. The definition and calculation follow the data manual "Guide to Flow of Funds Accounts (March 2010)". The FFA is one of the two categories of the 1993 System of National Accounts (SNA) used to measure national economic activities. The advantages of using FFA include: (1) the flow values offer a different view of the economic movements, while most of the other macroeconomic research uses stock values. (2) The accounts cover different sectors and transactions. Though our focus is on business sectors, the entire FFA account includes thirty sectors, even households and non-profit organizations. The database allows us to combine the flows in different ways. For example, the calculation of business assets below combines the flows from nine categories. (3) As suggested by the IMF: "Flow of funds accounts that combine the capital account with the financial account provide an integrated presentation of nonfinancial and financial accumulation. This combined account allows analysis of the links between saving, capital formation, and financial flows for the whole economy and for each institutional sector." [10]

BNET refers to the net financial borrowings of business sectors. The non-financial business sector, as defined in the Board of Governors of the Federal Reserve System, includes three sectors: nonfarm nonfinancial corporate business, nonfarm noncorporate business, and farm business. The calculation of the business net borrowings is set to be the amount of funds raised by issuing financial liabilities (BLIAB), net of funds spent on acquiring financial assets (BASSET):

$$BNET = BLIAB - BASSET \tag{29}$$

The annul flow of nominal BNET from 2005 to 2009 is ($ billions) -44.8, -201.5, -272.1, -230.2, 201.5 respectively. In terms of 2005 dollars, the real quarterly average of BNET is ($ billions) 108.5, with a maximum of 410.2 and minimum of -377.0 in the whole sample. In our model estimation, we use real values (2005 dollars). It is important to be aware that there is a big statistical discrepancy in the Flow of Funds Accounts. Most of the individual accounts are collected from all the 3 business sectors and seasonally adjusted unless there is no corresponding account in the sector.

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[10] (IMF Statistics manual Ch8 item 441)
http://www.imf.org/external/pubs/ft/mfs/manual/pdf/mmfsch8.pdf

The account of business liabilities issued to raise funds is the sum over five categories.[11] The annual flow value of nominal BLIAB from 2005 to 2009 is ($ billions) 1425.7, 1420.3, 1822.4, 715.2, -3.6, respectively. In terms of 2005 dollars, the real quarterly average of BLIAB is ($ billions) 515.4, with a maximum of 1964.5 and minimum of -65.0.

The account of financial assets acquired is more complicated. It measures the flow changes in nine accounts.[12] The annual flow value for nominal BASSET from 2005 to 2009 is ($ billions) 1380.8, 1218.8, 1550.3, 485.0, 198.0, respectively. In terms of 2005 dollars, the real quarterly average of BASSET is ($ billions) 406.9, with a maximum of 1848.6 and minimum of -78.1.

### 3.1. VARs with Cholesky Decomposition

[11] The five categories are: 1 Credit market instruments, which includes commercial paper, municipal securities corporate bonds, bank loans other loans and advances, mortgages, and corporate equities for corporate business. 2 Trade payables, means change in trade payables owed to lenders other than the federal government. 3 Taxes payable, sum of income taxes accrued prior and current years, net of payments. 4 Miscellaneous liabilities, includes the foreign direct investment, contribution payable to private pension funds and other unidentified items. 5 Proprietors' net investment, but it is not considered as one of the major category because this account is calculated mainly as a residual in noncorporate and farm businesses.

[12] The nine categories are:1 Credit market instruments, includes commercial paper, U.S government securities , municipal securities, mortgages, consumer credit, 2 Foreign deposits, 3 checkable deposits and currency , 4 Time and savings deposit, 5 money market funds, 6 outstanding loans under repurchase agreement ,7 Mutual fund shares (only for corporate business), 8 Trade payable, 9 Miscellaneous assets.

In the model estimation, the quarterly data is used for Cholesky method, and both monthly and quarterly data are applied in the Bernanke & Mihov VAR.  Based on the lag length test (Appendix 4), the VAR with monthly data uses four lags, whereas two lags are used for the VAR with quarterly data. The result for the VARs identified by Cholesky decomposition is explained in this section. The numerical results of IRF are in Table 1. The impulse responses to NBR shocks are plotted in Figure 3 and those to FFR shocks are plotted in Figure 4. Two dashed lines show the results of two standard errors away from the center.

The results from Figure 3 and 4 are consistent with each other and also with what the previous theories have projected. Both figures show that the expansionary (contractionary) policy brings up (down) GDP, and reserves. TR strongly responds to the shocks to NBR and relatively mildly to the FFR shocks. The negative response of FFR to the NBR shocks and the negative response of NBR to the FFR shocks show the negatively related reserve volume and FFR. It is consistent with the theory of liquidity effect: when the Fed is adopting expansionary monetary policy, increasing money supply will cause a decrease in nominal interest rate.

The impulse responses of real GDP to policy shocks are described in the first chart on the first row of Figure 3 and 4, and numerically listed in the second column of Table 1[13].

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[13] When we use input GDP in the VAR, we use log values. Therefore, the numerical results of the IRF of GDP are not as important as that for FFR and BNET. But we can still see the magnitude of the impulse responses in the table, to compare the magnitude of the responses in different time period.

The results are consistent with the previous research. There is a decline of the real GDP in response to the contractionary shocks (positive shocks to FFR), and an increase to the expansionary shocks (positive shocks to NBR). The variance decompositions of GDP with respect to different policy shocks are described in the eighth column of Table 2. Up to 31.12% of the 12-quarter-ahead forecast error of GDP is affected by the FFR shocks, and only 7.35% explained by the NBR shocks.

The IRFs of price level to both shocks to the policy instruments are illustrated in the second chart on the first row of Figure 3 and Figure 4, and numerically listed in the third column of Table 1. The impulse responses of the GDP deflator can be ignored due to the small and insignificant movement around the zero line. Including commodity price in the VAR, there is no “price puzzle” here.

The most important results concern the IRFs of the business net borrowings (BNET) to the policy shocks. BNET’s responses are illustrated in the first chart on the second row of Figure 3 and Figure 4. Easing policy (positive shocks to NBR) makes the BNET decrease (Figure 3) and the monetary tightening (the positive shocks to FFR) makes it increase (Figure 4), and these responses die out after seven quarters. The numerical results of the IRFs of BNET with respect to the policy shocks are listed in the fifth column of Table 1. The decrease of BNET reaches -16.03 billion in the fourth quarter in response to the positive NBR shocks (Panel A), and reaches 21.36 billion in the third quarter in response to the positive FFR shocks (Panel B).

The 12-quarter-ahead forecast errors of BNET are listed in Table 3. Only 6.58% of the forecast error of the net borrowings is affected by the NBR shocks (Panel A, column eight), and up to 13.88% of the forecast error of the BNET is affected by the FFR shocks [14] (Panel B, column eight). According to both the impulse responses and the decomposition of forecast errors, both GDP and BNET demonstrate more significant response to the FFR shock than to the NBR shock.

Besides the innovations of policies and BNET itself, the forecast error of BNET is also affected by the GDP shocks (third column of Table 3), which describes the general economic environment. Up to 17.43% of the forecast error of the net borrowings is affected by the shock to GDP. Another way to understand the BNET account is that it is also defined, in the flow of funds account, as the negative financial investment flow (FIF). Then the results here will be consistent with the mainstream thought, when the opportunity cost of holding funds is going up, the flow of financial investment immediately goes down.

To see the reaction of the components of the BNET, we can decompose it in several ways. First, we can measure the impacts of the policy shocks on the two major components of BNET, the business liabilities (BLIAB) and the assets (BASSET). Panel A of Figure 5 shows the impulse responses of BLIAB, and Panel B shows the responses of BASSET. Neither gives any significant responses to the policy shocks. The second

[14] CEE (1996) also finds it accounts for 10-13% of the 24-quarter-ahead variance in the net funds

major decomposition is to reclassify the aggregate BNET on the basis of the three business sectors, and generate three BNETs for each sector. According to the definition, the non-financial corporate sector takes the biggest share among all the three sectors. The impulse responses of BNET of the corporate sector are very similar to those of the entire business sector, as what we see in Panel A of Figure 6. BNET of noncorporate and farm sector do not significantly respond to the shocks to NBR or FFR, as we can see in the Panel B and C of Figure 6.

It is worth mentioning that CEE (1996) also break down BNET according to the time of holding the underlying accounts. For example, BLIAB can be decomposed to long-term and short term liabilities. Long-term liabilities (BLONG) consist of the funds raised by issuing equity (BEQUITY) and funds raised by issuing long-term debt (BDEBT). Short-term debt (BSHORT) composes funds raised by issuing commercial paper, bank and other loans. I find no significant result for these accounts in the VARs.

### 3.2. VARs of Bernanke & Mihov's Identification

As with Bernanke and Mihov's research (1998), both monthly and quarterly data are used in this section. The VARs with quarterly data still use two lags, while the VARs with monthly data use four lags. Compared with the Cholesky VAR, the VAR model here is designed to reflect more specific policy targets. Two questions are answered in this section: (1) whether the slope in the equation (26) of borrowed reserves has any difference before and after 2003, when the Federal Reserve set the discount rate above the FFR? (2) How is the performance of the BM-VAR with monthly and quarterly data, compared with the Cholesky VAR?

The data from 2003 to 2007 is too short to have an independent VAR. Therefore, to answer the first question, I will estimate two coefficients of the slope in the following way. The coefficient with a whole sample period (from Jan 1959 to Dec 2007) will be compared with the coefficient of the sub-sample (from Jan 1959 to Dec 2002), and the difference of the estimated coefficients will be tested to see whether it is statistically significant. I ignore the first eight days of 2003 (though the actual date to change the discount rate to FFR plus a penalty rate is January 9th of 2003).

### 3.2.1. Slope of Borrowed Reserves

The parameter estimation[15] of the models with monthly data is reported in Panel A of Table 4, and quarterly results are in Panel B. Two tests are applied in model estimation: the t-test for individual coefficient and the joint over-identification tests. All the P-values of the t-test for the coefficients are 0, which means the possibility of committing type I

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[15] There are some differences of my results with B&M's, the possible reasons are: (1) they use different time periods (from Jan. 1965 to Dec. 1996) and different lags (13 months for monthly data) in VAR models with higher frequency (bi-weekly and monthly). I use 12 month lags, to be consistent with my quarterly test introduced before, with monthly and quarterly data set. (2) They revised their data and used an unusual standardized moving average methods for some of the variants (GDP and GDP deflator), but I use the raw one. Since they smooth the data, my estimated coefficients are generally greater than theirs. (3) I used a more general commodity price while they used Dow-Jones index of spot commodity prices. (4) Since they used the data with a higher-frequency, they interpolated the missing variables by state space methods and assuming the interpolation error follows AR (1) process.

error is statistically not significant (Type I error: mistakenly reject the null hypothesis when it is correct, with the null hypothesis is to set the true beta as zero). Or we can say the estimated coefficients in all the three models can not to be rejected, and they are significantly different from zero. As introduced in the methodology section, $\phi^d$ and $\phi^b$ reflect operating procedures, $\alpha$ and $\beta$ vary with different operations (Goodfriend 1983).

Over-identification (OID) tests show that none of P-values of the OID test in the three models is greater than 0.05, which means the restrictions are unfortunately not significant statistically. (In BM's paper, the authors used different variables and separate the dataset into five different subsamples based on the monetary policy regime. In their monthly result, the NBR models are never statistically significant, and the FFR and TR/NBR models are significant for the three out of five subsamples).

To see whether the slope of the borrowed reserves is changed, we can recall equation (26) $u_{br} = \beta_1 u_{ffr} + \beta_2 * D * u_{ffr} + v^b$. We can see the level effect of the Fed's policy change by comparing the slope coefficient of the shocks to FFR for pre-2003 period and the value of the whole sample period. The dummy, D, is set to zero for the pre-2003 period, and set to one for the sample period from 2003 to 2007. In another word, we take $\beta_1$ as the slope coefficient for the period from 1959 to 2002, and ($\beta_1 + \beta_2$) for period from 1959 to 2007. Recall we only need to do this comparison for FFR model, according to the explanation in section 2.3. After revising the BM model, the dummy effect will only be reflected in the policy innovation equation (28) in the FFR model, not in the NBR and NBR/TR models.

We observe in the monthly result, the estimated slope $\widehat{\beta}_1$ is equal to 0.840 for period 1959 to 2007 (the second column in Table 4), with the standard deviation (SE) as 0.054. The slope is equal to 0.798 for period 1959 to 2002, and its SE is 0.054. It means the value of the slope with the whole sample data is greater than that with the data of only pre-2003 period. A similar pattern is showed in the quarterly results (Panel B of Table 4), $\widehat{\beta}_1$ for period 1959 to 2007 is 0.468 and the corresponding SE is 0.051. For period from 1959 to 2002, the slope is 0.446 and the SE is 0.052. With both the monthly and quarterly data, the slopes increase when the fixed penalty rate above FFR is charged. It also implies the greater shocks to the funds rate will make the banks to borrow more in the reserves market. The residual of the borrowed reserves caused by the innovation of the federal funds rate is propagated after 2002.

I used equation (30) to test the significance of the difference of these two betas (one beta represents the slope in the equation of the shocks to the borrow reserves for a time period from 1959-2007, the other means that of 1959 to 2002). This equation is suggested by Paternoster (1998) to test the estimated coefficient from different groups. The null hypothesis is "$\widehat{\beta}_1 = \widehat{\beta}_2$", and "SE" as the standard deviation of the corresponding beta.

$$Z = \frac{\hat{\beta}_1 - \hat{\beta}_2}{\sqrt{SE^2_{\beta_1} + SE^2_{\beta_2}}} \tag{30}$$

The Z value is equal to 0.550 for monthly data and 0.302 for quarterly data. For both monthly and quarter results, we reject the null hypothesis that these two betas are the same, and conclude that statistically the slope of the whole sample (1959-2007) is different from the slope of sub-sample (1959-2002) period.

It is worth mentioning that the result shows the alphas in all the models are positive, which is consistent with the meaning of the reserves market model. Since the $-\alpha$ is the slope of FFR in the equation describing the demand of total reserves, the negative slope makes more sense. However, in BM's previous research, their FFR model has negative $\alpha$ for all the sub-periods (from January 1965 to December 1996).

### 3.2.2. Monthly and Quarterly Results

If we compared the estimated coefficient of the quarterly results (Panel B of Table 4) with the monthly results (Panel A of Table 4). Although when apply VAR models in the monetary policy, calibration is not the typical interest, we can still take a look to see the difference of the three versions of BM estimate. In general, the monthly coefficients are greater than those using quarterly data, which indicates the lower frequency data might filter some of the fluctuations of the variants. But the standard errors do not show any big difference with quarterly or monthly data. For example, in the monthly NBR model

(Panel A of Table 4) $\alpha$ is 1.441 with a standard error as 0.062. In the quarterly NBR model, it is 0.793 with a standard error of 0.059.

The IRFs for monthly data are reported in Table 5 and plotted in Figure 7, 8, 9, and quarterly results are reported in Table 6 and plotted in Figure 10, 11, 12. They show that different policy shocks lead to consistent effects on the major variables in all the three models. FFR and NBR models are similar, though the exact value of the parameters in these two models shows some difference in Table 4. Their IRF shows the same pattern of fluctuation following policy shocks.

It worth emphasizing again the policy shock does not always refer to any shock from a single policy instrument. It is a combination of policy indicator and coefficients. For example in equation (25) $v^s = -\phi^d u_{tr} + u_{nbr}$ , policy innovation is a combination of the shocks to total reserves and non-borrowed reserves. The increase of the policy shocks in all the three versions of BM models represents expansionary policy.

All the IRFs of GDP are plotted in the first chart on the first row of each figure. The results of GPD here are consistent as what we see in the Cholesky estimate: the lower FFR and the greater reserves bring up GDP. The monthly graph shows such increase caused by policy shocks in FFR model (Figure 7), in NBR model (Figure 8), and in NBT/TR model (Figure 9). As for the quarterly results (Figure 10, 11, 12), the impulse responses of GDP demonstrate the same increase as the monthly results following the policy. But its impulses demonstrate slightly less magnitude with quarterly data, if we compare the numbers in the quarterly results (the second column of each panel in Table 6) with that of the monthly results (the second column in Table 5). According to the IRFs, the increase of GDP reaches the peak in the twelfth month (in monthly results) or around the fourth quarter (in the quarterly results) in all the three models.

In all the three models, to the expansionary policy shocks, the impulse responses of BNET show the initial fluctuation within the first half of year (from month one to month six) and prolonged decrease after that. The monthly results are demonstrated in the first chart of the second row in Figure 7 to 9, and quarterly results are in Figure 10 to 12. To see the exact magnitude of the responses, we can see the numerical results on the sixth column of Table 5 and 6.

In monthly results, the initial fluctuation of BNET, moves from -49.75 to +52.05 billion in the FFR model (Table 5, Panel A), and from -49.70 to +53.97 billion in the NBR model (Panel B), and from -33.10 to 176.37 billion in the NBR/TR model (Panel C). The decrease after these fluctuations, starting from the seventh month, hits -91.07 in the ninth month in the FFR model and -89.73 in the NBR model, and -115.34 in the NBT/TR model in the ninth month.

Moreover, in the quarterly result, something similar with the monthly result in the FFR and NBR model is that the initial jump of BNET to expansionary policy shocks is smaller relative to its later decrease. Or we can say the decrease dominates the chart in both the monthly and quarterly FFR and NBR model. With the quarter data (the sixth column of Table 6), it jumps to 249.67 billion in the second quarter, and goes down to -315.89 in the fourth quarter in the FFR model, jumps up to 266.64 and goes down to -300.72 in the NBR model, and jumps to 786.69 and goes down to less than -452.30 in the NBR/TR model. The prolonged decrease in FFR and NBR models are very obvious with both the monthly and quarterly data. It is also consistent with the result in the Cholesky estimate, though with different magnitude due to the differently defined innovations. The Cholesky estimate shows more mild decrease following expansionary shocks.

The results from both the GDP deflator and commodity price are mixed. Recall in the Cholesky results, there is no “price puzzle”. Here, the IRF with monthly inputs demonstrates the prize puzzle: the decreased GDP deflator following expansionary policy (the second chart on the first row of Figure 7 to 9). When using quarterly data (the second chart on the first row of Figure 10 to Figure 12), the response of the GDP deflator mainly stays in the positive range after the easy policy shocks in the FFR and NBR model, but not in the NBR/TR model. The quarterly results show the price puzzle only in the NBR/TR model, but in the monthly results the puzzle appears in all the three models. It leaves some question whether we can use the monthly data for macroeconomic models. In these models, we usually use the quarterly data like GDP, and its deflator, while the monthly data are created from interpolation.

Compared with the Cholesky estimates, in BM model the price puzzle is not solved as we expected. But, according to Balke (1994), to add commodity price to solve the price puzzle in the VAR model does not always work. In their research, it only works either when the sample starts from 1980, or covers the time period after 1980. The 1960-1979 period always shows the significant and positively related FFR shocks and price level.

## Chapter 4.

## Conclusion

Two identification methods have been employed to identify the VAR models and to evaluate the impact of monetary policy on business borrowings and other real variables. In both models, FFR and NBR are used as policy instruments. The results of IRF and variance decomposition show: (1) output consistently responds to the two policy instruments, and is more sensitive to the FFR shocks. The FFR shocks account for more of the 12-quarter-ahead forecast errors of GDP and BNET than the NBR shocks. Following the easy monetary policy, the general economy expands and borrowings shrink.

(2) The price puzzle is avoided after including the commodity price in the VAR system in the Cholesky estimate. But it still appears in some models of the BM estimate, where the GDP deflator demonstrates different movements following policy shocks in the three different models. With the BM model some difference can be found between the quarterly results and the monthly results. Overall, though, the Cholesky method is simpler than the more complicated BM models, it works well in demonstrating policy effects.

(3) Equation (26) shows a regression for the residual of the borrowed reserves on the innovation of FFR. After test, the slope of the equation (26) shows some significant difference using the sample data from 1959 to 2002 and using the whole sample from 1959 to 2007. The value of the slope coefficient increases, in both the quarterly and

monthly results. The increased value of the slope shows the FFR shocks will cause greater volatility of the borrowed reserves since 2003, when the discount rate began to be set as a penalty rate above FFR.

(4) Most important, when all the three versions of BM model are employed (FFR, NBR, NBR/TR), the decrease of BNET after the initial fluctuation following the expansionary policy is the same as what we can see in the Cholesky estimates. There are two conjectures that might explain the result. First, given that the net financial borrowings are composed of “financial liabilities minus financial assets”, we can start from the perspective of financial liabilities. Previous research also has focused more on the liability side than the asset side.

Business entities, who in tight money periods face urgent need to take on more liabilities, may have limited flexibility to pay back their borrowings even when the borrowing cost goes higher. For example, Bernanke and Gertler (1995) argue that the intention of firms to finance inventory buildup may cause the increase of demand for new borrowings. Such intention will be more remarkable during the economic downturn. It means firms do not have freedom in bringing down liabilities as they would like, even when facing increasing interest payment obligations (Walsh 2010, page 505). Even if they do not start any new borrowings, given the original financial liabilities which they have already accumulated, obligations will continue to expand due to the rising interest rate. Thus we may not observe the Keynesian mechanism in which rising interest rates would decrease borrowing.

The second conjecture is from the perspective of financial assets: firms might become defensive during a downturn and tend to invest less, especially when they assume the volume of the funds they can borrow in the future are expected to go down following the shocks to nonborrowed reserves. As suggested by Gertler and Gilchrist (1993a), small and large firms will face different difficulties in getting short-term loans. The smaller firms find it harder to get loans, especially when facing more the tightening monetary policies. Therefore they have reasons to be more cautious on their financial acquisitions.

## Tables and Figures

### Figure 1. The Reserve Market

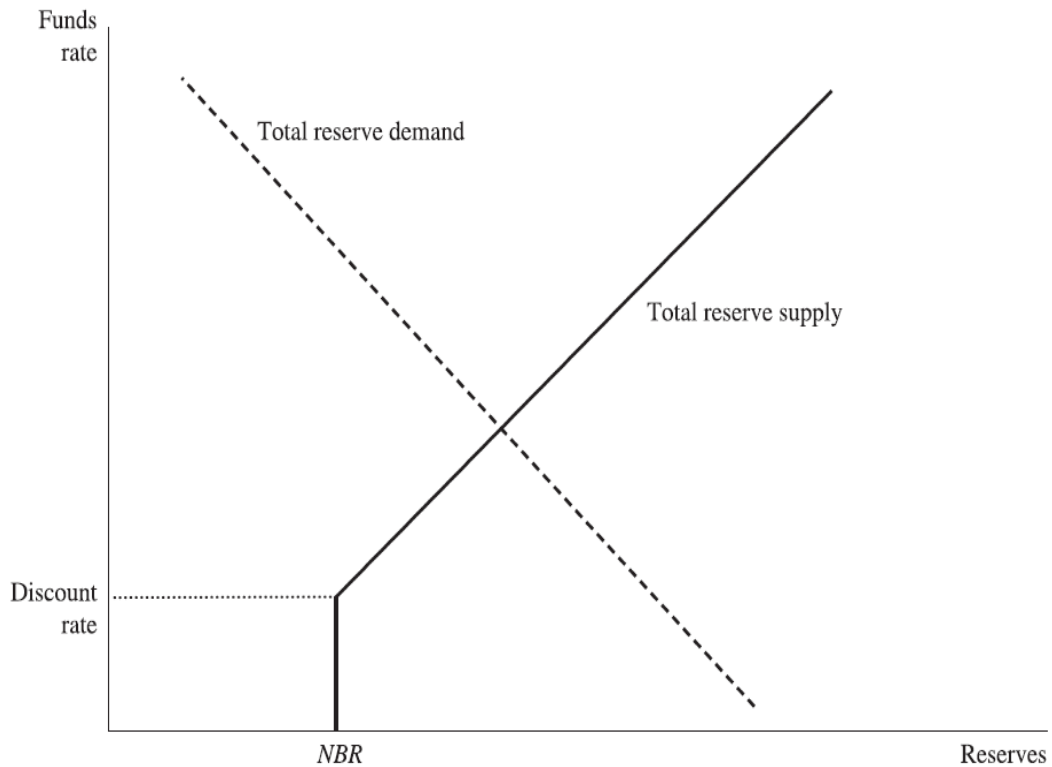
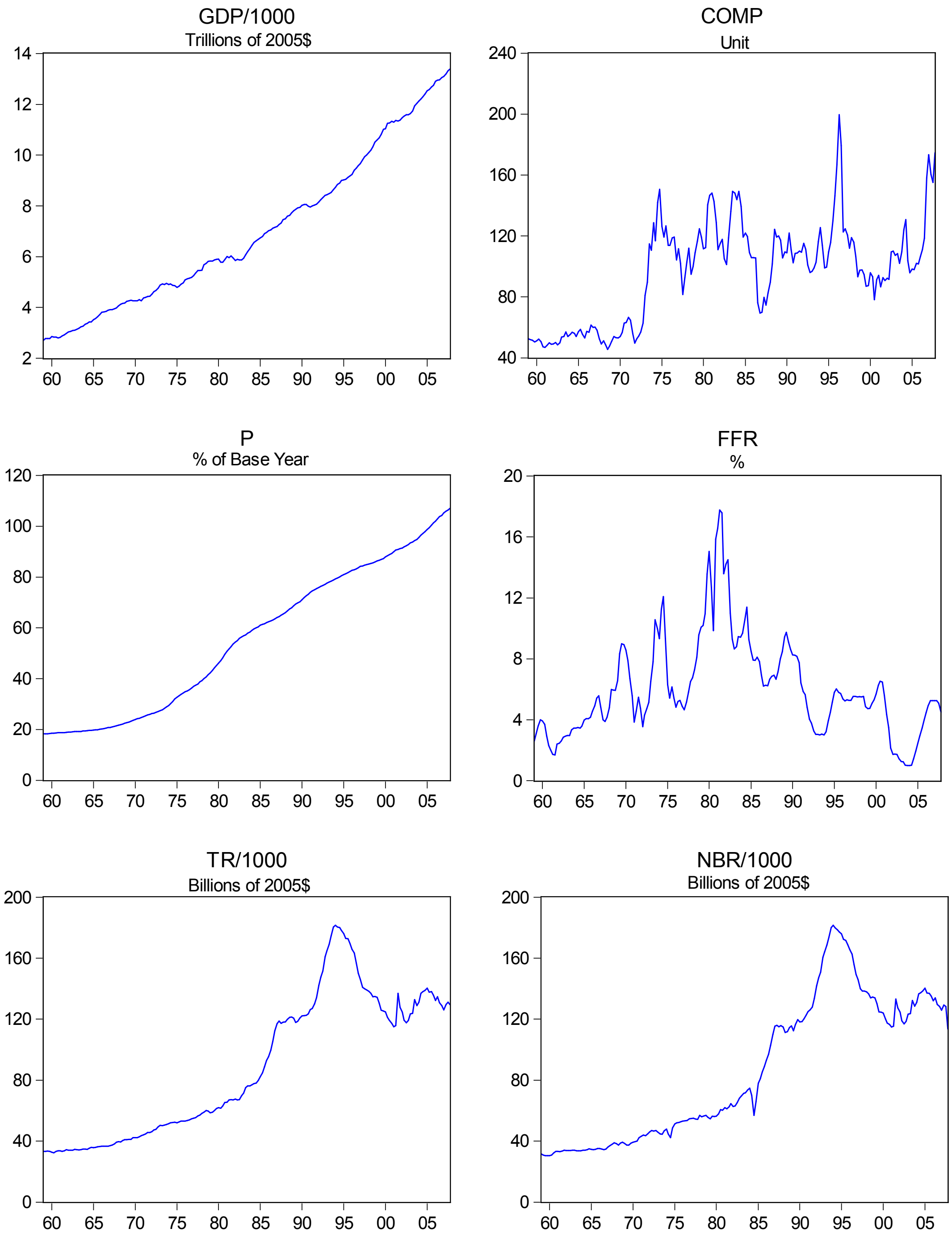
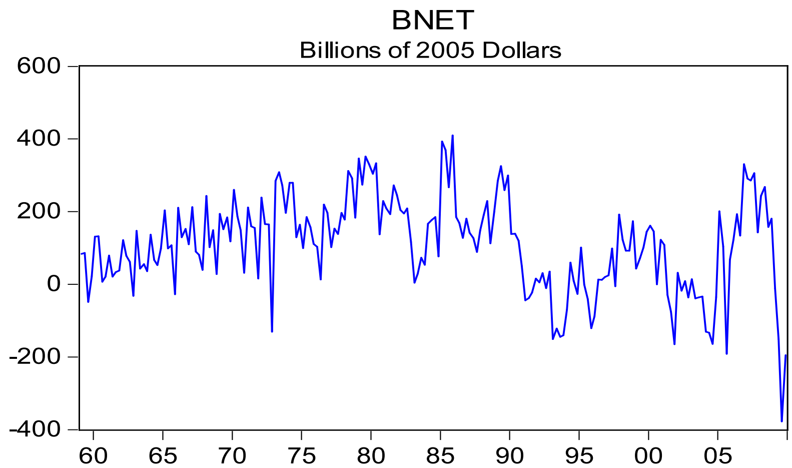
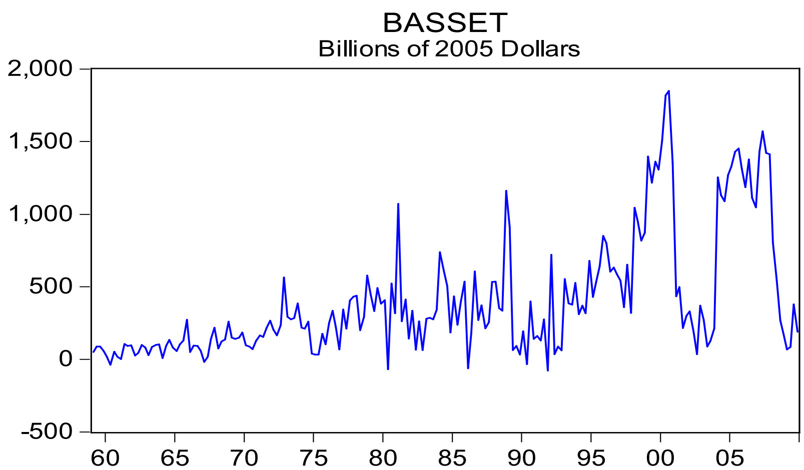


**Figure 2. Plots of Raw Data (1959Q1-2007Q4)**
**(Panel A, Variables of General Economy and Policy Instruments)**



**(Panel B, Variables from FFA: BNET, BLIAB, BASSET)**



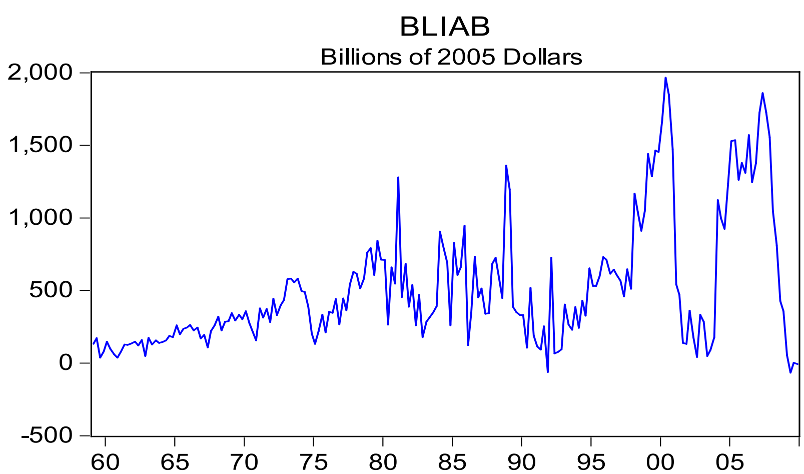



**Table 1. Impulse Responses in Cholesky VARs**
**(Panel A. NBR Model)**

| Period | LOG(GDP) | LOG(P) | LOG(COMP) | BNET | LOG(TR) | LOG(NBR) | FFR |
|---|---|---|---|---|---|---|---|
| 1 | 0.0000 | 0.000 | 0.000 | -9.381 | 0.013 | 0.032 | -0.329 |
| | (0.00000) | (0.00000) | (0.00000) | (5.62542) | (0.00139) | (0.00161) | (0.05841) |
| 2 | 0.0006 | 0.000 | -0.005 | 1.137 | 0.017 | 0.032 | -0.327 |
| | (0.00055) | (0.00020) | (0.00645) | (6.44653) | (0.00228) | (0.00285) | (0.08754) |
| 3 | 0.0015 | 0.000 | -0.010 | -14.750 | 0.017 | 0.023 | -0.210 |
| | (0.00080) | (0.00040) | (0.00930) | (5.77251) | (0.00298) | (0.00364) | (0.10978) |
| 4 | 0.0023 | 0.000 | -0.008 | **-16.030** | 0.016 | 0.018 | -0.100 |
| | (0.00094) | (0.00059) | (0.01047) | (5.42892) | (0.00341) | (0.00403) | (0.12202) |
| 5 | 0.0027 | -0.001 | -0.007 | -13.124 | 0.015 | 0.015 | -0.054 |
| | (0.00101) | (0.00078) | (0.01057) | (4.88041) | (0.00368) | (0.00424) | (0.12675) |
| 6 | 0.0027 | -0.001 | -0.006 | -8.682 | 0.014 | 0.014 | -0.055 |
| | (0.00103) | (0.00094) | (0.00992) | (4.22011) | (0.00377) | (0.00425) | (0.12462) |
| 7 | 0.0026 | -0.001 | -0.006 | -5.737 | 0.012 | 0.013 | -0.073 |
| | (0.00102) | (0.00110) | (0.00916) | (3.73207) | (0.00378) | (0.00420) | (0.12014) |
| 8 | 0.0024 | -0.001 | -0.005 | -4.330 | 0.012 | 0.013 | -0.086 |
| | (0.00103) | (0.00125) | (0.00861) | (3.33693) | (0.00378) | (0.00413) | (0.11600) |
| 9 | 0.0024 | -0.001 | -0.004 | -3.839 | 0.011 | 0.012 | -0.089 |
| | (0.00106) | (0.00139) | (0.00829) | (3.04197) | (0.00378) | (0.00405) | (0.11275) |
| 10 | 0.0024 | -0.001 | -0.004 | -3.617 | 0.010 | 0.011 | -0.086 |
| | (0.00109) | (0.00153) | (0.00809) | (2.84846) | (0.00379) | (0.00399) | (0.11027) |
| 11 | 0.0023 | -0.001 | -0.004 | -3.371 | 0.010 | 0.010 | -0.079 |
| | (0.00113) | (0.00167) | (0.00795) | (2.71665) | (0.00380) | (0.00396) | (0.10820) |
| 12 | 0.0023 | -0.001 | -0.003 | -3.054 | 0.009 | 0.010 | -0.073 |
| | (0.00118) | (0.00180) | (0.00784) | (2.61396) | (0.00381) | (0.00395) | (0.10627) |

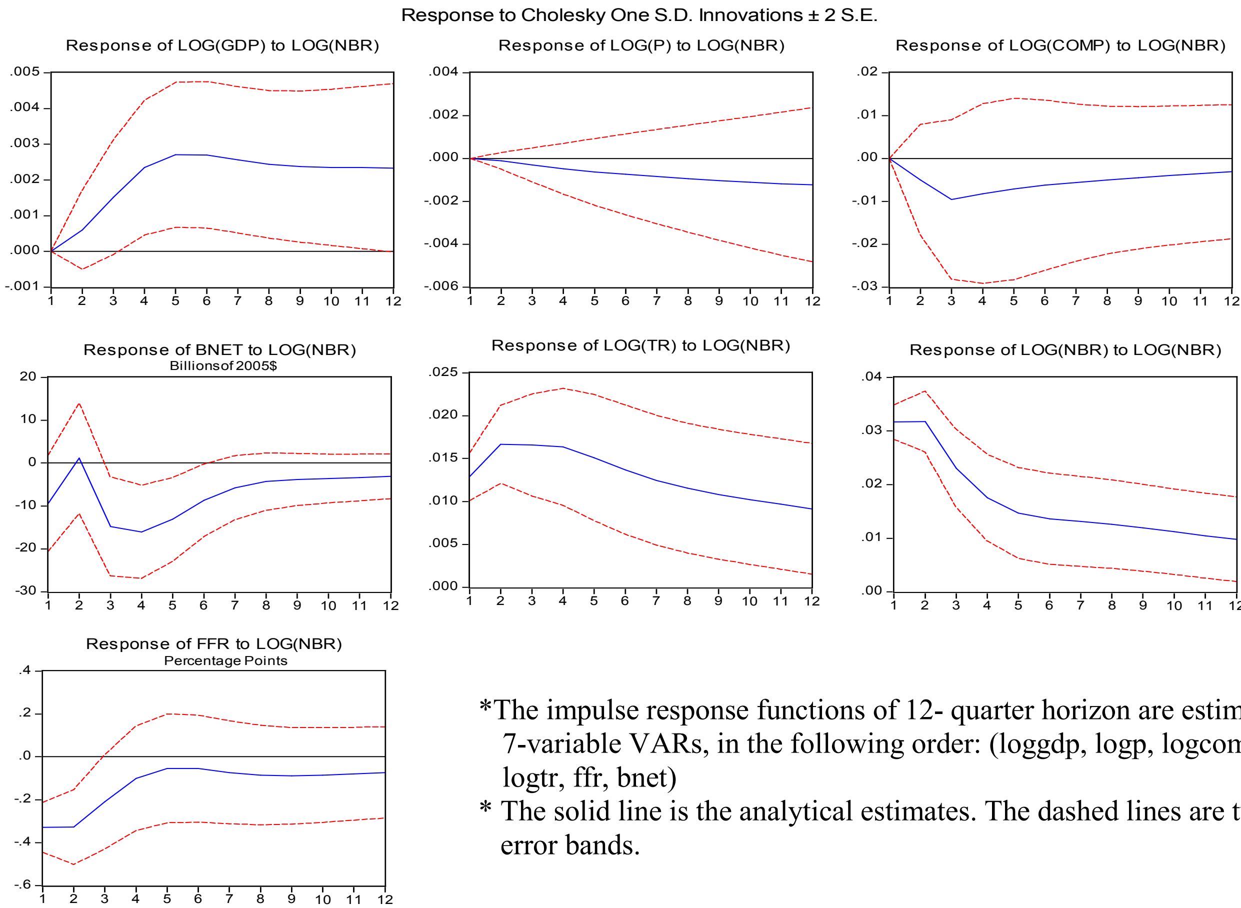
Cholesky Ordering: LOG(GDP) LOG(P) LOG(COMP) LOG(NBR) LOG(TR) FFR BNET
Standard Errors (the rows with numbers in parenthesis)

**(Panel B. FFR Model)**

| Period | LOG(GDP) | LOG(P) | LOG(COMP) | BNET | LOG(TR) | LOG(NBR) | FFR |
|---|---|---|---|---|---|---|---|
| 1 | 0.0000 | 0.000 | 0.000 | 14.334 | -0.001 | -0.012 | 0.846 |
| | (0.00000) | (0.00000) | (0.00000) | (5.59845) | (0.00154) | (0.00218) | (0.04296) |
| 2 | -0.0001 | 0.000 | -0.004 | 15.283 | -0.006 | -0.016 | 0.877 |
| | (0.00055) | (0.00019) | (0.00644) | (6.38644) | (0.00241) | (0.00317) | (0.07707) |
| 3 | -0.0014 | 0.001 | 0.000 | **21.363** | -0.007 | -0.013 | 0.777 |
| | (0.00073) | (0.00037) | (0.00844) | (4.95148) | (0.00292) | (0.00350) | (0.09533) |
| 4 | -0.0027 | 0.002 | 0.003 | 18.852 | -0.008 | -0.011 | 0.665 |
| | (0.00085) | (0.00055) | (0.00939) | (4.82132) | (0.00327) | (0.00376) | (0.10710) |
| 5 | -0.0036 | 0.002 | 0.006 | 15.362 | -0.007 | -0.010 | 0.586 |
| | (0.00094) | (0.00072) | (0.00981) | (4.68918) | (0.00354) | (0.00405) | (0.11511) |
| 6 | -0.0043 | 0.003 | 0.009 | 11.814 | -0.006 | -0.009 | 0.534 |
| | (0.00101) | (0.00089) | (0.01008) | (4.51811) | (0.00378) | (0.00425) | (0.12098) |
| 7 | -0.0048 | 0.003 | 0.011 | 9.425 | -0.006 | -0.008 | 0.495 |
| | (0.00107) | (0.00107) | (0.01026) | (4.33914) | (0.00399) | (0.00439) | (0.12554) |
| 8 | -0.0053 | 0.003 | 0.013 | 7.964 | -0.005 | -0.008 | 0.458 |
| | (0.00112) | (0.00126) | (0.01038) | (4.19205) | (0.00417) | (0.00451) | (0.12943) |
| 9 | -0.0057 | 0.004 | 0.013 | 7.038 | -0.005 | -0.007 | 0.422 |
| | (0.00118) | (0.00144) | (0.01046) | (4.05376) | (0.00434) | (0.00462) | (0.13264) |
| 10 | -0.0060 | 0.004 | 0.014 | 6.311 | -0.004 | -0.006 | 0.387 |
| | (0.00124) | (0.00163) | (0.01049) | (3.91840) | (0.00448) | (0.00473) | (0.13500) |
| 11 | -0.0063 | 0.004 | 0.014 | 5.635 | -0.003 | -0.005 | 0.353 |
| | (0.00130) | (0.00182) | (0.01048) | (3.78995) | (0.00459) | (0.00482) | (0.13643) |
| 12 | -0.0065 | 0.005 | 0.014 | 4.981 | -0.003 | -0.004 | 0.323 |
| | (0.00136) | (0.00200) | (0.01043) | (3.67245) | (0.00469) | (0.00490) | (0.13700) |

Cholesky Ordering: LOG(GDP) LOG(P) LOG(COMP) FFR LOG(TR) LOG(NBR) BNET
Standard Errors(the rows with numbers in parenthesis)

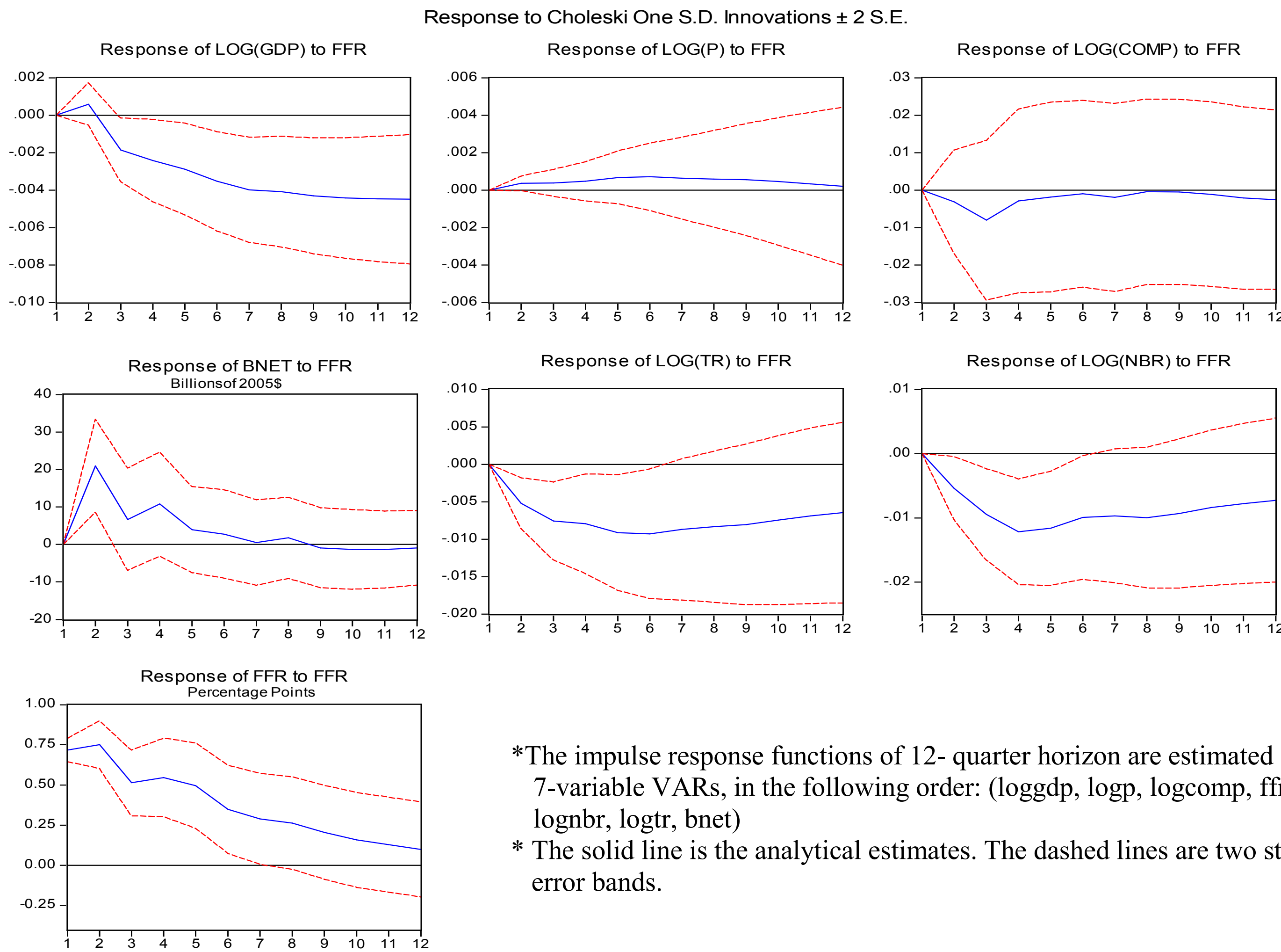
# Figure 3. Impulse Responses to NBR Shocks in Cholesky VAR




*The impulse response functions of 12- quarter horizon are estimated from 7-variable VARs, in the following order: (loggdp, logp, logcomp, lognbr, logtr, ffr, bnet)

* The solid line is the analytical estimates. The dashed lines are two standard error bands.

# Figure 4. Impulse Responses to FFR Shocks in Cholesky VAR




*The impulse response functions of 12- quarter horizon are estimated from 7-variable VARs, in the following order: (loggdp, logp, logcomp, ffr, lognbr, logtr, bnet)

* The solid line is the analytical estimates. The dashed lines are two standard error bands.

**Table 2. Policy Shocks to 12-Quarter Ahead Forecast Errors of GDP**

**(Panel A. NBR Shocks)**

| Period | S.E. | LOG(GDP) | LOG(P) | LOG(COMP) | BNET | LOG(TR) | **LOG(NBR)** | FFR |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.008 | 100.000 | 0.000 | 0.000 | 0.000 | 0.000 | **0.000** | 0.000 |
| 2 | 0.012 | 98.795 | 0.024 | 0.411 | 0.406 | 0.043 | **0.271** | 0.049 |
| 3 | 0.014 | 96.458 | 0.052 | 0.824 | 0.517 | 0.682 | **1.294** | 0.174 |
| 4 | 0.017 | 92.509 | 0.048 | 0.931 | 0.615 | 2.117 | **2.970** | 0.809 |
| 5 | 0.018 | 88.007 | 0.042 | 0.909 | 0.759 | 3.690 | **4.564** | 2.030 |
| 6 | 0.020 | 83.596 | 0.083 | 0.866 | 0.975 | 4.937 | **5.704** | 3.839 |
| 7 | 0.021 | 79.305 | 0.227 | 0.838 | 1.261 | 5.812 | **6.409** | 6.147 |
| 8 | 0.023 | 75.013 | 0.512 | 0.830 | 1.603 | 6.444 | **6.827** | 8.771 |
| 9 | 0.024 | 70.691 | 0.945 | 0.836 | 1.985 | 6.957 | **7.076** | 11.509 |
| 10 | 0.025 | 66.404 | 1.508 | 0.849 | 2.393 | 7.424 | **7.227** | 14.196 |
| 11 | 0.027 | 62.245 | 2.164 | 0.863 | 2.814 | 7.871 | **7.312** | 16.732 |
| 12 | 0.028 | 58.298 | 2.875 | 0.874 | 3.239 | 8.301 | **7.346** | 19.066 |

Cholesky Ordering: LOG(GDP) LOG(P) LOG(COMP) **LOG(NBR)** LOG(TR) FFR BNET

**(Panel B. FFR Shocks)**

| Period | S.E. | LOG(GDP) | LOG(P) | LOG(COMP) | BNET | LOG(TR) | LOG(NBR) | **FFR** |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.008 | 100.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | **0.000** |
| 2 | 0.012 | 98.795 | 0.024 | 0.411 | 0.406 | 0.022 | 0.338 | **0.004** |
| 3 | 0.014 | 96.458 | 0.052 | 0.824 | 0.517 | 0.015 | 1.220 | **0.915** |
| 4 | 0.017 | 92.509 | 0.048 | 0.931 | 0.615 | 0.053 | 2.572 | **3.272** |
| 5 | 0.018 | 88.007 | 0.042 | 0.909 | 0.759 | 0.126 | 3.614 | **6.544** |
| 6 | 0.020 | 83.596 | 0.083 | 0.866 | 0.975 | 0.207 | 4.047 | **10.226** |
| 7 | 0.021 | 79.305 | 0.227 | 0.838 | 1.261 | 0.281 | 4.043 | **14.043** |
| 8 | 0.023 | 75.013 | 0.512 | 0.830 | 1.603 | 0.354 | 3.841 | **17.846** |
| 9 | 0.024 | 70.691 | 0.945 | 0.836 | 1.985 | 0.433 | 3.581 | **21.528** |
| 10 | 0.025 | 66.404 | 1.508 | 0.849 | 2.393 | 0.523 | 3.320 | **25.004** |
| 11 | 0.027 | 62.245 | 2.164 | 0.863 | 2.814 | 0.626 | 3.076 | **28.212** |
| 12 | 0.028 | 58.298 | 2.875 | 0.874 | 3.239 | 0.739 | 2.855 | **31.119** |

Cholesky Ordering: LOG(GDP) LOG(P) LOG(COMP) **FFR** LOG(TR) LOG(NBR) BNET

**Table 3. Policy Shocks to 12-Quarter Ahead Forecast Errors of BNET Using Cholesky Decomposition**

**(Panel A. NBR Shocks)**

| Period | S.E. | **LOG(GDP)** | LOG(P) | LOG(COMP) | **BNET** | LOG(TR) | **LOG(NBR)** | FFR |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.008 | **10.463** | 0.058 | 1.378 | **84.555** | 0.038 | **1.254** | 2.253 |
| 2 | 0.012 | **14.731** | 0.309 | 1.102 | **73.625** | 2.064 | **1.013** | 7.156 |
| 3 | 0.014 | **15.908** | 1.205 | 1.399 | **67.743** | 1.914 | **2.994** | 8.836 |
| 4 | 0.017 | **16.579** | 2.150 | 1.887 | **62.868** | 2.262 | **4.982** | 9.272 |
| 5 | 0.018 | **16.942** | 2.951 | 2.404 | **59.706** | 2.460 | **6.084** | 9.453 |
| 6 | 0.020 | **17.211** | 3.622 | 2.796 | **57.821** | 2.414 | **6.442** | 9.694 |
| 7 | 0.021 | **17.354** | 4.202 | 3.076 | **56.536** | 2.350 | **6.523** | 9.959 |
| 8 | 0.023 | **17.409** | 4.709 | 3.281 | **55.546** | 2.325 | **6.533** | 10.197 |
| 9 | 0.024 | **17.423** | 5.145 | 3.444 | **54.746** | 2.318 | **6.539** | 10.386 |
| 10 | 0.025 | **17.424** | 5.508 | 3.584 | **54.088** | 2.316 | **6.551** | 10.529 |
| 11 | 0.027 | **17.426** | 5.800 | 3.708 | **53.546** | 2.319 | **6.565** | 10.635 |
| 12 | 0.028 | **17.433** | 6.030 | 3.818 | **53.100** | 2.328 | **6.576** | 10.715 |

Cholesky Ordering: LOG(GDP) LOG(P) LOG(COMP) **LOG(NBR)** LOG(TR) FFR BNET

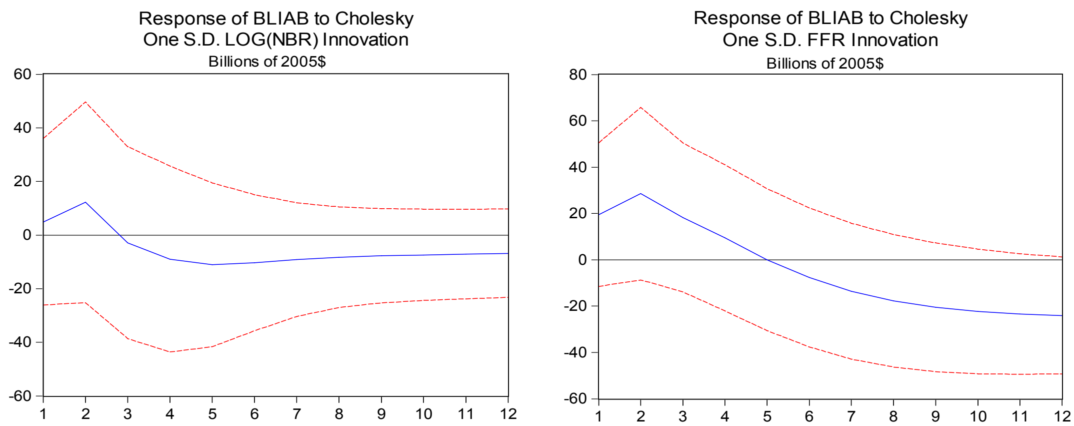
**(Panel B. FFR Shocks)**

| Period | S.E. | **LOG(GDP)** | LOG(P) | LOG(COMP) | **BNET** | LOG(TR) | LOG(NBR) | **FFR** |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.008 | 10.463 | 0.058 | 1.378 | 84.555 | 0.617 | 0.000 | **2.927** |
| 2 | 0.012 | 14.731 | 0.309 | 1.102 | 73.625 | 1.540 | 3.712 | **4.980** |
| 3 | 0.014 | 15.908 | 1.205 | 1.399 | 67.743 | 1.601 | 3.406 | **8.737** |
| 4 | 0.017 | 16.579 | 2.150 | 1.887 | 62.868 | 1.528 | 3.937 | **11.051** |
| 5 | 0.018 | 16.942 | 2.951 | 2.404 | 59.706 | 1.475 | 4.233 | **12.289** |
| 6 | 0.020 | 17.211 | 3.622 | 2.796 | 57.821 | 1.483 | 4.156 | **12.911** |
| 7 | 0.021 | 17.354 | 4.202 | 3.076 | 56.536 | 1.537 | 4.044 | **13.250** |
| 8 | 0.023 | 17.409 | 4.709 | 3.281 | 55.546 | 1.614 | 3.978 | **13.464** |
| 9 | 0.024 | 17.423 | 5.145 | 3.444 | 54.746 | 1.692 | 3.933 | **13.618** |
| 10 | 0.025 | 17.424 | 5.508 | 3.584 | 54.088 | 1.764 | 3.896 | **13.736** |
| 11 | 0.027 | 17.426 | 5.800 | 3.708 | 53.546 | 1.831 | 3.865 | **13.823** |
| 12 | 0.028 | 17.433 | 6.030 | 3.818 | 53.100 | 1.895 | 3.842 | **13.882** |

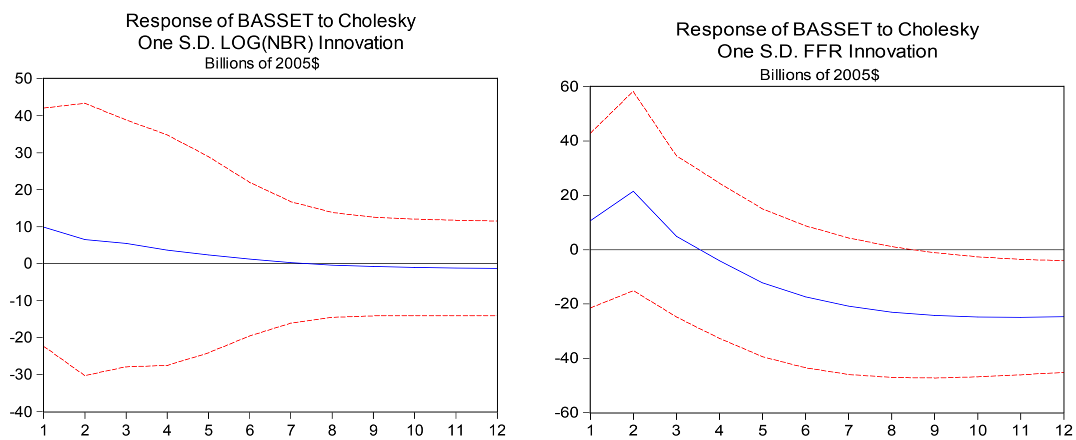
Cholesky Ordering: LOG(GDP) LOG(P) LOG(COMP) **FFR** LOG(TR) LOG(NBR) BNET

**Figure 5. Impulse Responses to Policy Shocks in Cholesky VAR**

**(Panel A. Responses of Business Financial Liabilities)**




**(Panel B. Responses of Business Financial Assets)**



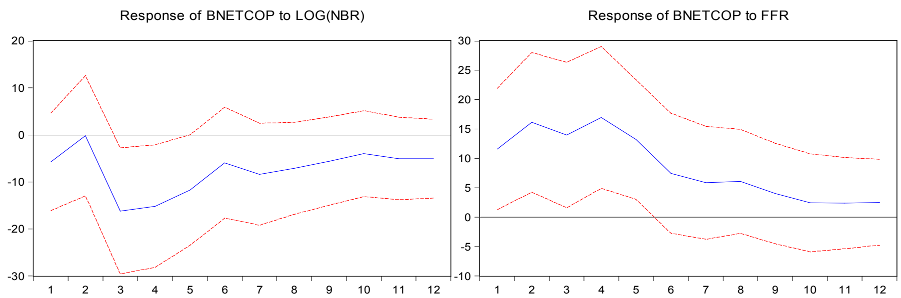

*The impulse response functions of 12- quarter horizon are estimated from 7-variable VARs, in the following order: (loggdp, logp, logcomp, ffr or lognbr, logtr, bliab/basset of the corresponding sector)

*The first column of each panel demonstrates the responses to shocks to nonborrowed reserves. The second column demonstrates the responses to shocks to the federal funds rates.

* The solid line is the analytical estimates. The dashed lines are two standard error bands.

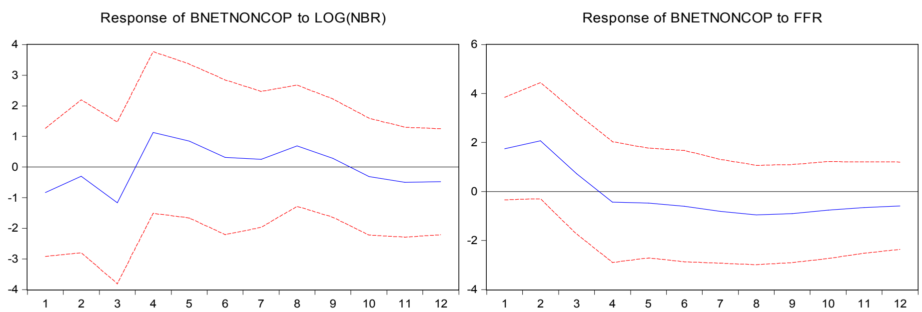
**Figure 6. Impulse Responses of BNET of Different Sectors in Cholesky VAR (Panel A. Corporate Sector)**

Billions of 2005$



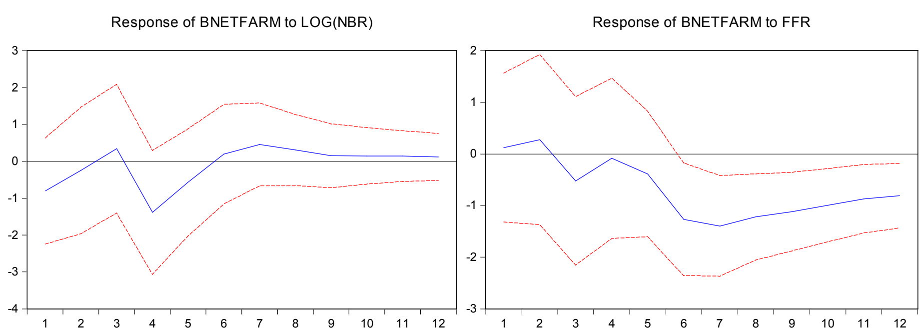

**(Panel B. Noncorporate Sector)**

Billions of 2005$




**(Panel C. Farm Sector)**

Billions of 2005$




*The impulse response functions of 12- quarter horizon are estimated from 7-variable VARs, in the following order: (loggdp, logp, logcomp, ffr or lognbr, lognbr, logtr, bnet of the corresponding sector)

*The first column of each panel demonstrates the responses to shocks to nonborrowed reserves. The second column demonstrates the responses to shocks to the federal funds rates.

* The solid line is the analytical estimates. The dashed lines are two standard error bands.

## Table 4. B&M VARs Model

### (Panel A. (Monthly) Parameter Estimates for All Models with 2 Sub-Periods)

| | Sample 1959 to 2007 | | | | | | | | | | Sample 1959 to 2002 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **FFR Model** | | | **NBR Model** | | | **TR/NBR Model** | | | | **FFR Model** | | |
| | Coefficient | Std. Error | Prob. | Coefficient | Std. Error | Prob. | Coefficient | Std. Error | Prob. | | Coefficient | Std. Error | Prob. |
| $\alpha$ | 0.829 | 0.054 | 0.000 | 1.441 | 0.062 | 0.000 | 0 | | | $\alpha$ | 0.786 | 0.054 | 0.000 |
| $\beta$ | **0.840** | 0.054 | 0.000 | 1.452 | 0.062 | 0.000 | 2.048 | 0.048 | 0.000 | $\beta$ | **0.798** | 0.054 | 0.000 |
| $\phi^d$ | 1 | | | 0 | | | 0.616 | 0.041 | 0.000 | $\phi^d$ | 1 | | |
| $\phi^b$ | -1 | | | 0 | | | 0 | | | $\phi^b$ | -1 | | |
| | Log likelihood -91279.42 | | | Log likelihood -90858.11 | | | Log likelihood -91159.39 | | | | Log likelihood -72669.37 | | |
| | LR test for over-identification: | | | | | | | | | | LR test for over-identification: | | |
| | Chi-square(26) 194634 | | | Chi-square(26) 192991 | | | Chi-square(26) 194394 | | | | Chi-square(26) 156688 | | |
| | Probability 0.000 | | | Probability 0.000 | | | Probability 0.000 | | | | Probability 0.000 | | |

### (Panel B. (Quarterly) Parameter Estimates for All Models with 2 Sub-Periods)

| | Sample 1959 to 2007 | | | | | | | | | | Sample 1959 to 2002 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **FFR Model** | | | **NBR Model** | | | **TR/NBR Model** | | | | **FFR Model** | | |
| | Coefficient | Std. Error | Prob. | Coefficient | Std. Error | Prob. | Coefficient | Std. Error | Prob. | | Coefficient | Std. Error | Prob. |
| $\alpha$ | 0.454 | 0.051 | 0.000 | 0.793 | 0.059 | 0.000 | 0 | | | $\alpha$ | 0.432 | 0.052 | 0.000 |
| $\beta$ | **0.468** | 0.051 | 0.000 | 0.806 | 0.059 | 0.000 | 1.133 | 0.046 | 0.000 | $\beta$ | **0.446** | 0.052 | 0.000 |
| $\phi^d$ | 1 | | | 0 | | | 0.644 | 0.072 | 0.000 | $\phi^d$ | 1 | | |
| $\phi^b$ | 1 | | | 0 | | | 0 | | | $\phi^b$ | 1 | | |
| | Log likelihood -682145.2 | | | Log likelihood -612375.9 | | | Log likelihood -682104.6 | | | | Log likelihood -537765.9 | | |
| | LR test for over-identification: | | | | | | | | | | LR test for over-identification: | | |
| | Chi-square(26) 1366904 | | | Chi-square(26) 1227408 | | | Chi-square(26) 1366822 | | | | Chi-square(26) 1077901 | | |
| | Probability 0.0000 | | | Probability 0.0000 | | | Probability 0.0000 | | | | Probability 0.0000 | | |

## Table 5. Impulse Responses in B&M VARs (Monthly)

## (Panel A. FFR Model)

| Period | LOG(GDP) | LOG(P) | LOG(COMP) | BNET | LOG(TR) | LOG(NBR) | FFR |
|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.497 | 1.000 | -0.599 |
| 2 | 0.008 | 0.002 | -0.215 | -49.750 | 0.391 | 1.059 | -4.202 |
| 3 | 0.013 | 0.001 | -0.213 | -40.967 | 0.337 | 0.935 | -4.184 |
| 4 | 0.008 | 0.000 | -0.208 | 24.141 | 0.338 | 0.923 | -3.856 |
| 5 | 0.020 | 0.000 | -0.264 | **52.052** | 0.350 | 0.854 | -3.502 |
| 6 | 0.031 | -0.003 | -0.274 | 11.919 | 0.337 | 0.727 | -2.095 |
| 7 | 0.031 | -0.005 | -0.301 | -41.185 | 0.320 | 0.612 | -0.604 |
| 8 | 0.040 | -0.005 | -0.338 | -80.938 | 0.316 | 0.514 | 0.431 |
| 9 | 0.050 | -0.007 | -0.328 | **-91.069** | 0.312 | 0.429 | 1.307 |
| 10 | 0.052 | -0.009 | -0.309 | -89.532 | 0.304 | 0.363 | 1.977 |
| 11 | 0.057 | -0.009 | -0.296 | -84.803 | 0.297 | 0.319 | 2.337 |
| 12 | **0.060** | -0.011 | -0.285 | -83.916 | 0.289 | 0.290 | 2.499 |
| 13 | 0.059 | -0.012 | -0.272 | -82.154 | 0.281 | 0.274 | 2.507 |
| 14 | 0.060 | -0.011 | -0.261 | -76.365 | 0.274 | 0.267 | 2.339 |
| 15 | 0.059 | -0.012 | -0.248 | -66.677 | 0.268 | 0.265 | 2.073 |
| 16 | 0.057 | -0.014 | -0.235 | -57.238 | 0.262 | 0.267 | 1.793 |
| 17 | 0.056 | -0.013 | -0.223 | -49.244 | 0.256 | 0.269 | 1.500 |
| 18 | 0.054 | -0.014 | -0.214 | -43.614 | 0.250 | 0.271 | 1.209 |
| 19 | 0.051 | -0.015 | -0.205 | -39.398 | 0.245 | 0.272 | 0.971 |
| 20 | 0.050 | -0.014 | -0.195 | -35.729 | 0.240 | 0.271 | 0.767 |
| 21 | 0.048 | -0.015 | -0.187 | -32.574 | 0.235 | 0.268 | 0.582 |
| 22 | 0.046 | -0.016 | -0.178 | -30.256 | 0.231 | 0.264 | 0.452 |
| 23 | 0.045 | -0.015 | -0.169 | -28.515 | 0.227 | 0.259 | 0.357 |
| 24 | 0.044 | -0.015 | -0.161 | -27.358 | 0.223 | 0.253 | 0.267 |
| 25 | 0.000 | 0.000 | 0.000 | 0.000 | 0.497 | 1.000 | -0.599 |
| 26 | 0.008 | 0.002 | -0.215 | -49.750 | 0.391 | 1.059 | -4.202 |
| 27 | 0.013 | 0.001 | -0.213 | -40.967 | 0.337 | 0.935 | -4.184 |
| 28 | 0.008 | 0.000 | -0.208 | 24.141 | 0.338 | 0.923 | -3.856 |
| 29 | 0.020 | 0.000 | -0.264 | 52.052 | 0.350 | 0.854 | -3.502 |
| 30 | 0.031 | -0.003 | -0.274 | 11.919 | 0.337 | 0.727 | -2.095 |
| 31 | 0.031 | -0.005 | -0.301 | -41.185 | 0.320 | 0.612 | -0.604 |
| 32 | 0.040 | -0.005 | -0.338 | -80.938 | 0.316 | 0.514 | 0.431 |
| 33 | 0.050 | -0.007 | -0.328 | -91.069 | 0.312 | 0.429 | 1.307 |
| 34 | 0.052 | -0.009 | -0.309 | -89.532 | 0.304 | 0.363 | 1.977 |
| 35 | 0.057 | -0.009 | -0.296 | -84.803 | 0.297 | 0.319 | 2.337 |
| 36 | 0.060 | -0.011 | -0.285 | -83.916 | 0.289 | 0.290 | 2.499 |

* The sample covers data from 1959Q1 to 2007Q4

**(Panel B. NBR Model)**

| Period | LOG(GDP) | LOG(P) | LOG(COMP) | BNET | LOG(TR) | LOG(NBR) | FFR |
|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.498 | 1.000 | -0.346 |
| 2 | 0.007 | 0.002 | -0.214 | -49.703 | 0.392 | 1.058 | -3.856 |
| 3 | 0.014 | 0.001 | -0.214 | -39.401 | 0.337 | 0.933 | -3.850 |
| 4 | 0.008 | 0.000 | -0.210 | 26.040 | 0.338 | 0.922 | -3.567 |
| 5 | 0.020 | 0.000 | -0.264 | **53.973** | 0.349 | 0.853 | -3.245 |
| 6 | 0.031 | -0.002 | -0.276 | 13.291 | 0.337 | 0.726 | -1.852 |
| 7 | 0.031 | -0.005 | -0.302 | -39.900 | 0.319 | 0.612 | -0.365 |
| 8 | 0.040 | -0.005 | -0.338 | -79.700 | 0.316 | 0.513 | 0.664 |
| 9 | 0.049 | -0.007 | -0.329 | **-89.736** | 0.312 | 0.428 | 1.531 |
| 10 | 0.051 | -0.009 | -0.309 | -88.316 | 0.304 | 0.362 | 2.193 |
| 11 | 0.056 | -0.009 | -0.296 | -83.708 | 0.296 | 0.317 | 2.545 |
| 12 | **0.060** | -0.010 | -0.284 | -82.967 | 0.289 | 0.289 | 2.700 |
| 13 | 0.059 | -0.012 | -0.271 | -81.256 | 0.281 | 0.273 | 2.701 |
| 14 | 0.059 | -0.011 | -0.260 | -75.501 | 0.274 | 0.266 | 2.527 |
| 15 | 0.058 | -0.012 | -0.247 | -65.826 | 0.268 | 0.264 | 2.254 |
| 16 | 0.056 | -0.013 | -0.233 | -56.426 | 0.262 | 0.265 | 1.968 |
| 17 | 0.055 | -0.012 | -0.221 | -48.469 | 0.255 | 0.268 | 1.669 |
| 18 | 0.053 | -0.013 | -0.211 | -42.875 | 0.250 | 0.270 | 1.372 |
| 19 | 0.050 | -0.014 | -0.202 | -38.680 | 0.245 | 0.270 | 1.127 |
| 20 | 0.049 | -0.013 | -0.192 | -35.031 | 0.240 | 0.270 | 0.918 |
| 21 | 0.047 | -0.014 | -0.184 | -31.896 | 0.235 | 0.267 | 0.728 |
| 22 | 0.045 | -0.015 | -0.175 | -29.603 | 0.231 | 0.263 | 0.593 |
| 23 | 0.044 | -0.014 | -0.166 | -27.886 | 0.226 | 0.258 | 0.493 |
| 24 | 0.043 | -0.014 | -0.158 | -26.753 | 0.222 | 0.252 | 0.399 |
| 25 | 0.041 | -0.015 | -0.151 | -25.878 | 0.218 | 0.247 | 0.340 |
| 26 | 0.041 | -0.014 | -0.142 | -24.940 | 0.214 | 0.241 | 0.300 |
| 27 | 0.040 | -0.015 | -0.135 | -24.038 | 0.210 | 0.235 | 0.248 |
| 28 | 0.039 | -0.016 | -0.128 | -23.190 | 0.207 | 0.229 | 0.220 |
| 29 | 0.039 | -0.015 | -0.120 | -22.255 | 0.203 | 0.224 | 0.199 |
| 30 | 0.038 | -0.015 | -0.113 | -21.380 | 0.200 | 0.219 | 0.162 |
| 31 | 0.037 | -0.016 | -0.108 | -20.519 | 0.196 | 0.214 | 0.142 |
| 32 | 0.037 | -0.015 | -0.100 | -19.559 | 0.193 | 0.210 | 0.128 |
| 33 | 0.036 | -0.015 | -0.095 | -18.664 | 0.190 | 0.206 | 0.097 |
| 34 | 0.035 | -0.016 | -0.090 | -17.829 | 0.187 | 0.202 | 0.082 |
| 35 | 0.035 | -0.015 | -0.083 | -16.950 | 0.183 | 0.198 | 0.073 |
| 36 | 0.034 | -0.016 | -0.079 | -16.173 | 0.180 | 0.194 | 0.048 |

* The sample covers data from 1959Q1 to 2007Q4

## (Panel C. NBR/TR Model)

| Period | LOG(GDP) | LOG(P) | LOG(COMP) | BNET | LOG(TR) | LOG(NBR) | FFR |
|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | -0.488 |
| 2 | 0.011 | 0.002 | -0.294 | -33.108 | 0.040 | 1.257 | -6.562 |
| 3 | 0.028 | -0.002 | -0.285 | 25.897 | 0.047 | 1.108 | -6.401 |
| 4 | 0.024 | -0.006 | -0.225 | **176.366** | 0.000 | 0.989 | -5.314 |
| 5 | 0.042 | -0.006 | -0.354 | 165.650 | 0.007 | 0.837 | -4.263 |
| 6 | 0.063 | -0.011 | -0.415 | 65.314 | -0.005 | 0.620 | -1.911 |
| 7 | 0.064 | -0.016 | -0.477 | -51.827 | -0.027 | 0.410 | 0.571 |
| 8 | 0.079 | -0.017 | -0.525 | -105.566 | -0.029 | 0.235 | 2.313 |
| 9 | 0.096 | -0.020 | -0.513 | **-115.341** | -0.030 | 0.090 | 3.666 |
| 10 | 0.101 | -0.025 | -0.479 | -107.144 | -0.039 | -0.015 | 4.661 |
| 11 | 0.108 | -0.024 | -0.465 | -106.821 | -0.049 | -0.082 | 5.122 |
| 12 | **0.113** | -0.026 | -0.452 | -108.279 | -0.057 | -0.120 | 5.196 |
| 13 | 0.111 | -0.029 | -0.436 | -106.484 | -0.065 | -0.136 | 4.999 |
| 14 | 0.111 | -0.028 | -0.417 | -93.065 | -0.072 | -0.137 | 4.526 |
| 15 | 0.110 | -0.029 | -0.398 | -75.089 | -0.077 | -0.129 | 3.897 |
| 16 | 0.105 | -0.032 | -0.378 | -58.570 | -0.083 | -0.117 | 3.274 |
| 17 | 0.103 | -0.030 | -0.361 | -46.691 | -0.088 | -0.104 | 2.661 |
| 18 | 0.099 | -0.031 | -0.348 | -38.237 | -0.092 | -0.093 | 2.065 |
| 19 | 0.094 | -0.033 | -0.336 | -32.018 | -0.096 | -0.084 | 1.574 |
| 20 | 0.093 | -0.031 | -0.321 | -26.194 | -0.099 | -0.079 | 1.166 |
| 21 | 0.090 | -0.032 | -0.308 | -21.611 | -0.102 | -0.078 | 0.799 |
| 22 | 0.086 | -0.034 | -0.296 | -18.589 | -0.104 | -0.079 | 0.536 |
| 23 | 0.086 | -0.032 | -0.282 | -16.734 | -0.106 | -0.082 | 0.343 |
| 24 | 0.084 | -0.032 | -0.270 | -15.651 | -0.108 | -0.086 | 0.161 |
| 25 | 0.082 | -0.034 | -0.259 | -14.894 | -0.109 | -0.091 | 0.042 |
| 26 | 0.082 | -0.032 | -0.246 | -13.873 | -0.111 | -0.095 | -0.041 |
| 27 | 0.081 | -0.033 | -0.235 | -12.900 | -0.113 | -0.101 | -0.144 |
| 28 | 0.079 | -0.035 | -0.225 | -11.998 | -0.114 | -0.105 | -0.208 |
| 29 | 0.080 | -0.033 | -0.212 | -10.920 | -0.116 | -0.108 | -0.254 |
| 30 | 0.079 | -0.034 | -0.202 | -9.873 | -0.117 | -0.112 | -0.330 |
| 31 | 0.077 | -0.035 | -0.194 | -8.832 | -0.118 | -0.115 | -0.378 |
| 32 | 0.078 | -0.033 | -0.183 | -7.582 | -0.119 | -0.117 | -0.411 |
| 33 | 0.077 | -0.034 | -0.174 | -6.429 | -0.120 | -0.119 | -0.476 |
| 34 | 0.075 | -0.035 | -0.166 | -5.386 | -0.121 | -0.121 | -0.513 |
| 35 | 0.076 | -0.033 | -0.157 | -4.251 | -0.122 | -0.122 | -0.535 |
| 36 | 0.075 | -0.034 | -0.149 | -3.270 | -0.123 | -0.124 | -0.587 |

* The sample covers data from 1959Q1 to 2007Q4

**Table 6. Impulse Responses in B&M VARs (Quarterly)**
**(Panel A. FFR model)**

| Period | LOG(GDP) | LOG(P) | LOG(COMP) | BNET | LOG(TR) | LOG(NBR) | FFR |
|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.492 | 1.000 | -1.138 |
| 2 | 0.022 | 0.006 | -0.211 | 249.665 | 0.590 | 0.990 | -0.462 |
| 3 | 0.035 | 0.010 | -0.307 | -249.489 | 0.608 | 0.754 | 2.985 |
| 4 | **0.043** | 0.015 | -0.176 | **-315.885** | 0.613 | 0.604 | 5.706 |
| 5 | 0.038 | 0.019 | -0.024 | -268.767 | 0.586 | 0.525 | 6.261 |
| 6 | 0.024 | 0.022 | 0.102 | -177.566 | 0.550 | 0.496 | 5.351 |
| 7 | 0.007 | 0.025 | 0.181 | -120.333 | 0.516 | 0.486 | 3.945 |
| 8 | -0.007 | 0.027 | 0.223 | -94.084 | 0.491 | 0.479 | 2.684 |
| 9 | -0.019 | 0.029 | 0.242 | -87.191 | 0.472 | 0.471 | 1.775 |
| 10 | -0.027 | 0.030 | 0.248 | -86.428 | 0.458 | 0.461 | 1.188 |
| 11 | -0.033 | 0.031 | 0.249 | -85.833 | 0.445 | 0.450 | 0.816 |
| 12 | -0.038 | 0.032 | 0.247 | -83.847 | 0.433 | 0.439 | 0.570 |

**(Panel B. NBR model)**

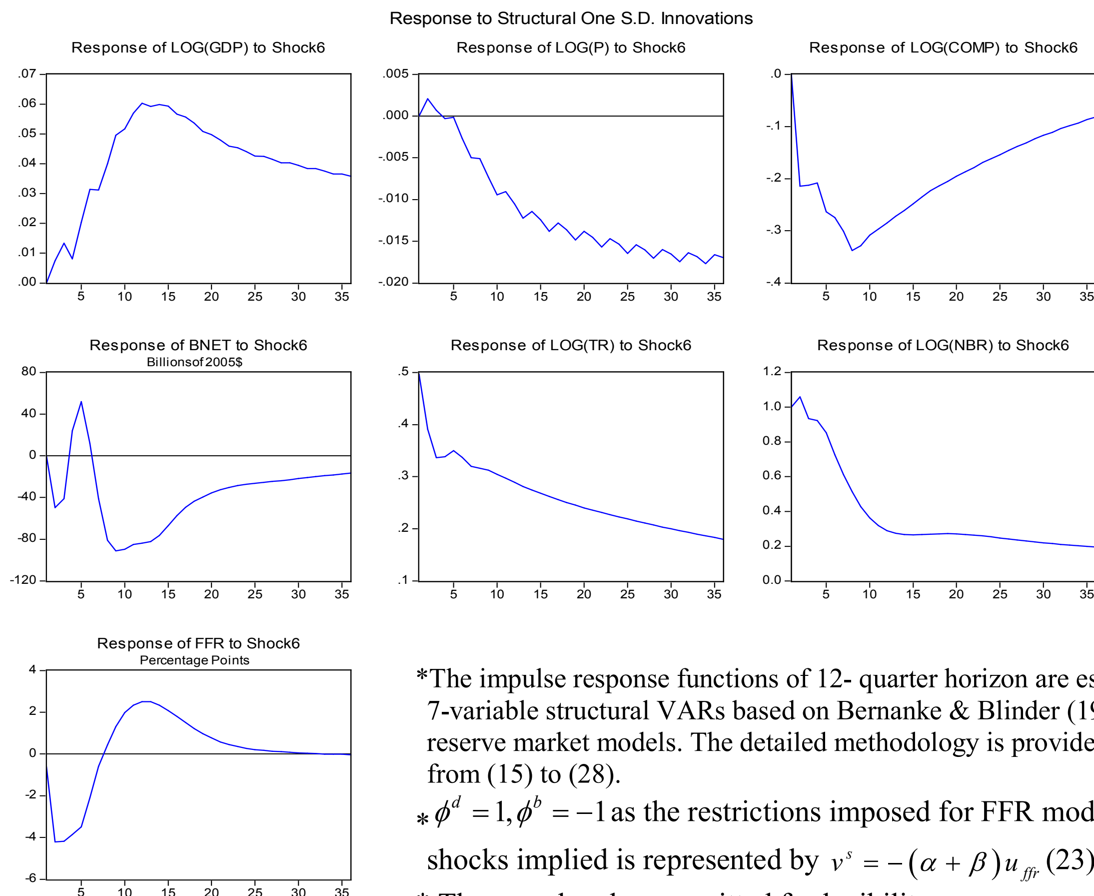
| Period | LOG(GDP) | LOG(P) | LOG(COMP) | BNET | LOG(TR) | LOG(NBR) | FFR |
|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.496 | 1.000 | -0.625 |
| 2 | 0.019 | 0.003 | -0.259 | 266.635 | 0.563 | 0.953 | -0.088 |
| 3 | 0.034 | 0.004 | -0.356 | -211.169 | 0.553 | 0.695 | 2.903 |
| 4 | **0.046** | 0.005 | -0.260 | **-300.720** | 0.544 | 0.536 | 5.397 |
| 5 | 0.045 | 0.007 | -0.170 | -247.746 | 0.509 | 0.458 | 6.055 |
| 6 | 0.036 | 0.010 | -0.097 | -143.568 | 0.468 | 0.432 | 5.386 |
| 7 | 0.023 | 0.013 | -0.044 | -75.640 | 0.433 | 0.422 | 4.299 |
| 8 | 0.012 | 0.015 | -0.002 | -48.607 | 0.407 | 0.411 | 3.384 |
| 9 | 0.005 | 0.017 | 0.031 | -45.468 | 0.388 | 0.396 | 2.794 |
| 10 | -0.001 | 0.019 | 0.056 | -48.427 | 0.372 | 0.378 | 2.445 |
| 11 | -0.006 | 0.021 | 0.074 | -49.387 | 0.358 | 0.362 | 2.214 |
| 12 | -0.010 | 0.023 | 0.087 | -47.353 | 0.345 | 0.347 | 2.023 |

**(Panel C. NBR/TR model)**

| Period | LOG(GDP) | LOG(P) | LOG(COMP) | BNET | LOG(TR) | LOG(NBR) | FFR |
|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | -0.882 |
| 2 | 0.030 | -0.005 | -0.197 | 786.694 | -0.046 | 0.775 | -0.126 |
| 3 | 0.065 | -0.012 | -0.418 | -225.893 | -0.111 | 0.191 | 5.093 |
| 4 | 0.097 | -0.016 | -0.323 | **-452.301** | -0.118 | -0.155 | 9.683 |
| 5 | **0.104** | -0.016 | -0.245 | -375.223 | -0.163 | -0.309 | 10.640 |
| 6 | 0.092 | -0.013 | -0.181 | -160.065 | -0.213 | -0.333 | 8.874 |
| 7 | 0.073 | -0.009 | -0.136 | -9.306 | -0.251 | -0.312 | 6.281 |
| 8 | 0.057 | -0.006 | -0.097 | 54.585 | -0.269 | -0.291 | 4.157 |
| 9 | 0.046 | -0.003 | -0.065 | 62.587 | -0.273 | -0.281 | 2.855 |
| 10 | 0.041 | -0.001 | -0.038 | 53.658 | -0.270 | -0.280 | 2.182 |
| 11 | 0.038 | 0.002 | -0.019 | 47.541 | -0.265 | -0.279 | 1.829 |
| 12 | 0.036 | 0.004 | -0.005 | 48.012 | -0.260 | -0.277 | 1.588 |

* The sample covers data from 1959Q1 to 2007Q4

# Figure 7. Impulse Responses of FFR Model (Monthly)

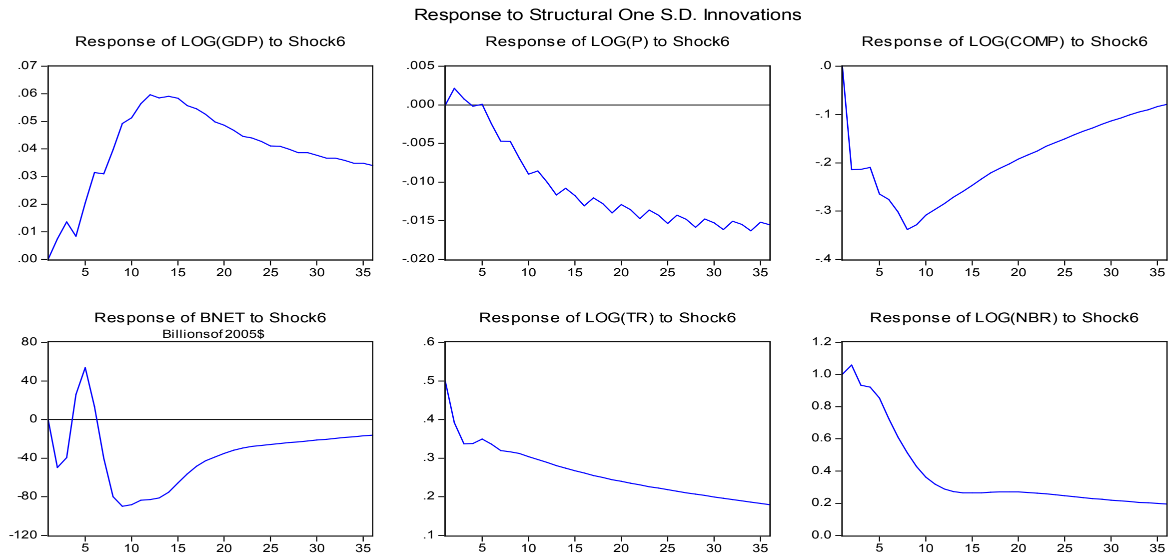


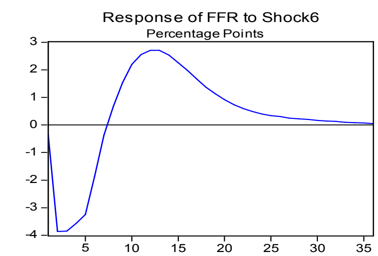

*The impulse response functions of 12- quarter horizon are estimated from 7-variable structural VARs based on Bernanke & Blinder (1992) and reserve market models. The detailed methodology is provided in equations from (15) to (28).

* $\phi^d = 1, \phi^b = -1$ as the restrictions imposed for FFR model, the policy shocks implied is represented by $v^s = -(\alpha + \beta) u_{ffr}$ (23).

* The error bands are omitted for legibility.

# Figure 8. Impulse Response of NBR Model (Monthly)



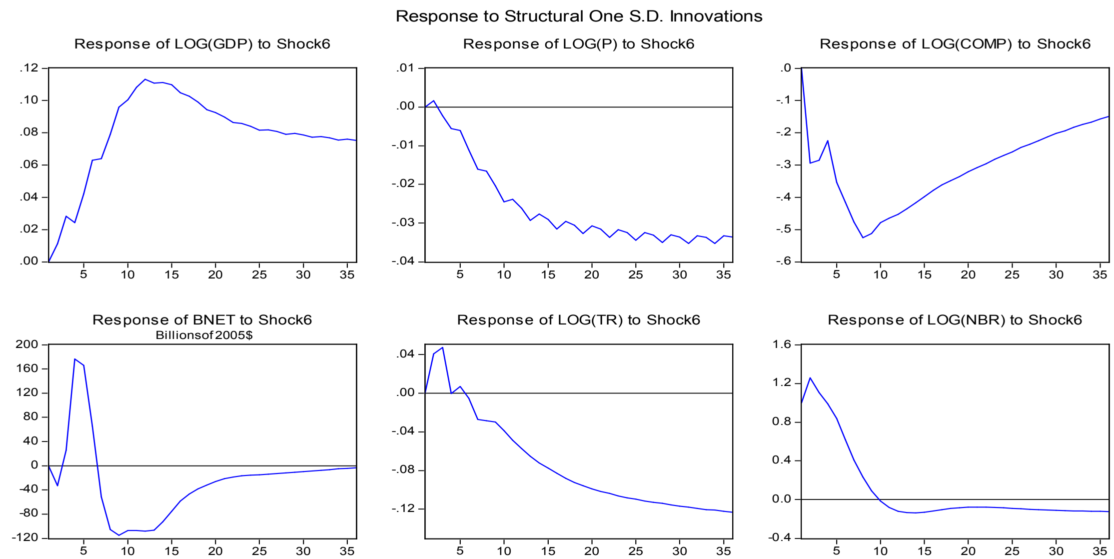



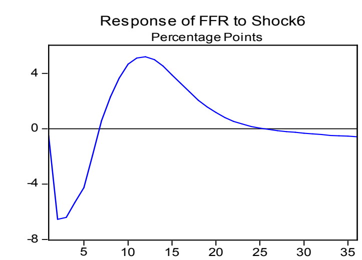

*The impulse response functions of 12- quarter horizon are estimated from 7-variable structural VARs based on Bernanke & Blinder (1992) and reserve market models. The detailed methodology is provided in equations from (15) to (28).

*The policy shocks implied is represented by $\phi^d = \phi^b = 0, v^s = u_{nbr}$ (24).

* The error bands are omitted for legibility.

# Figure 9. Impulse Responses of NBR/TR Model (Monthly)



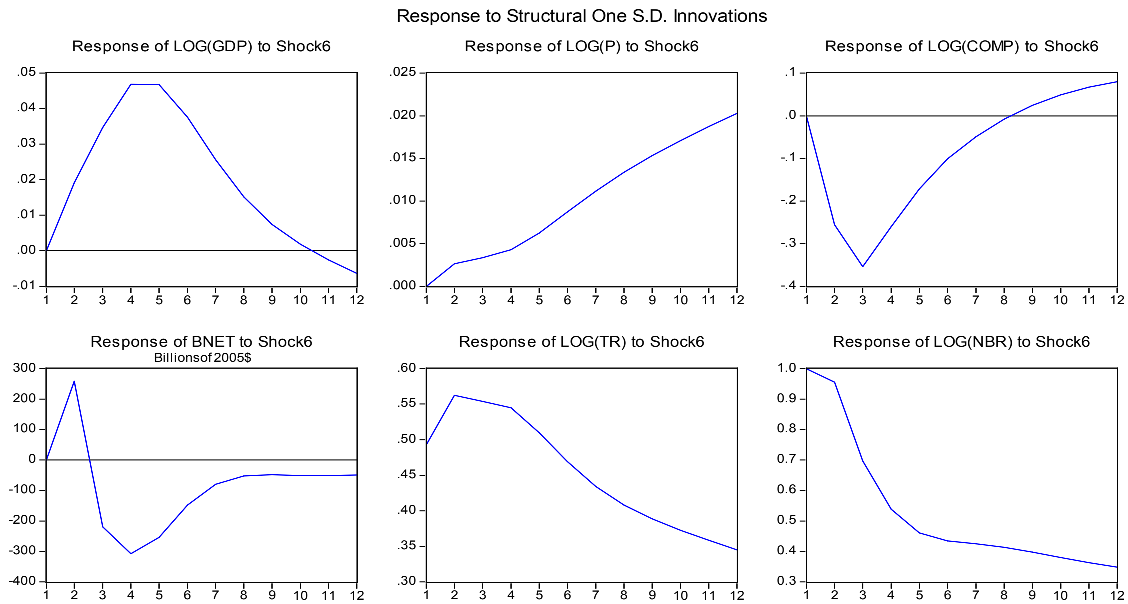



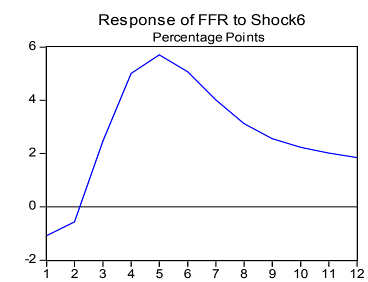

*The impulse response functions of 12- quarter horizon are estimated from 7-variable structural VARs based on Bernanke & Blinder (1992) and reserve market models. The detailed methodology is provided in equations from (15) to (28).

*The policy shocks implied is represented by $v^s = -\phi^d u_{tr} + u_{nbr}$ (25).

* The error bands are omitted for legibility.

# Figure 10. Impulse Responses of FFR Model (Quarterly)



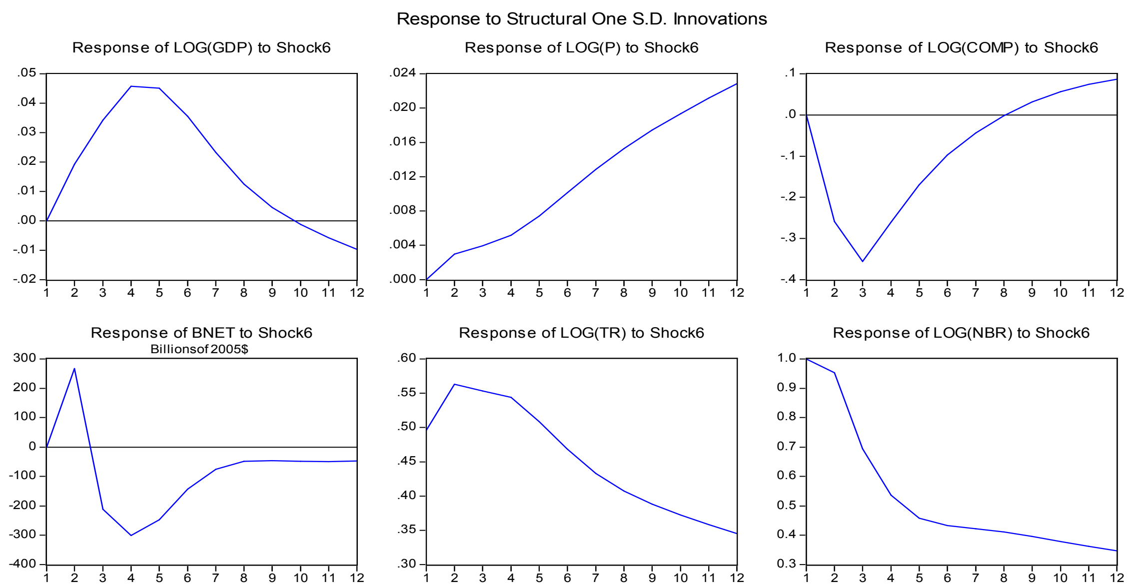



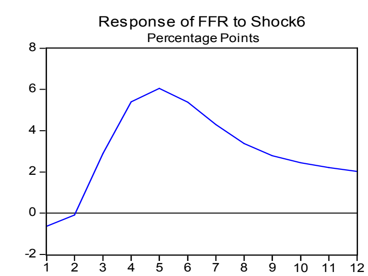

*The impulse response functions of 12- quarter horizon are estimated from 7-variable structural VARs based on Bernanke & Blinder (1992) and reserve market models. The detailed methodology is provided in equations from (15) to (28).

* $\phi^d = 1, \phi^b = -1$ as the restrictions imposed for FFR model, the policy shocks implied is represented by $v^s = -(\alpha + \beta)u_{ffr}$ (23).

* The error bands are omitted for legibility.

# Figure 11. Impulse Responses of NBR Model (Quarterly)



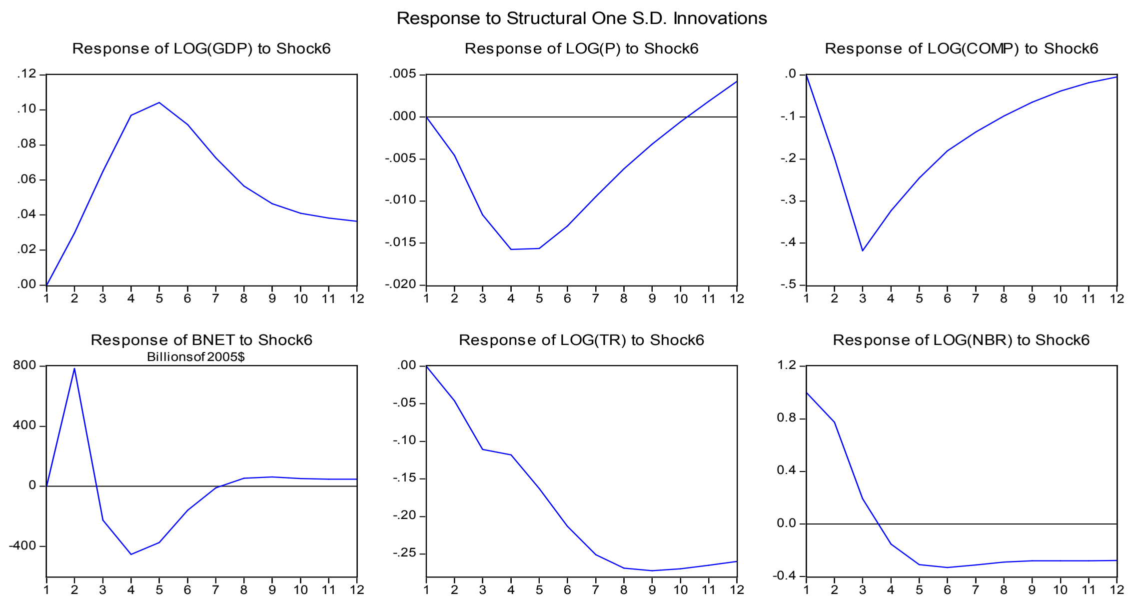



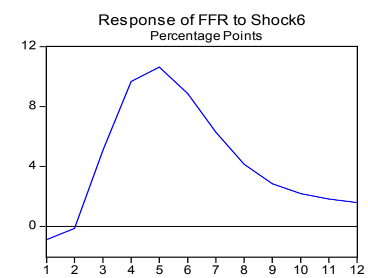

*The impulse response functions of 12- quarter horizon are estimated from 7-variable structural VARs based on Bernanke & Blinder (1992) and reserve market models. The detailed methodology is provided in equations from (15) to (28).

*The policy shocks implied is represented by $\phi^d = \phi^b = 0, v^s = u_{nbr}$ (24).

* The error bands are omitted for legibility.

## Figure 12. Impulse Responses of NBR/TR Model (Quarterly)




*The impulse response functions of 12- quarter horizon are estimated from 7-variable structural VARs based on Bernanke & Blinder (1992) and reserve market models. The detailed methodology is provided in equations from (15) to (28).

*The policy shocks implied is represented by $v^s = -\phi^d u_{tr} + u_{nbr}$ (25).

* The error bands are omitted for legibility.

## Appendix 1. Data Source and Variable Computation

The majority of model estimation is done in Eviews. When convert the GDP, GDP deflator, and commodity price from quarterly to monthly, use the "constant match average method". When convert the BNET variables, the "constant match sum method" is used, since it is a flow variable. Only FFR has weekly data, both TR and NBR have only monthly data, GDP and deflator are only available in quarterly frequency. Initially, all the data are collected from 1959/01 to 2009/12,

1. (loggdp), log of the quarterly real GDP in billions of 2005 dollars from Bureau of Economic Analysis (BEA) with data series ID: GDPC96. The monthly data is converted from quarterly one in BM estimate.
2. (logp), log of the quarterly GDP deflator as the general price index, comes from FRED. The implicit Price deflator is used (not the chain type).
3. (logcomp), log of the quarterly commodity prices, which comes from IFS, the database of IMF. All the monthly data is converted to quarterly ones in order to be consistent with the quarterly GDP.
4. (ffr), the Federal Funds rate is collected from the Broad of Governor's of the Federal Reserve (BGFR) data file H15, in a monthly form. To average the monthly value to convert the date to quarterly.
5. (logtr), total reserves, is get from the BGFR H3 table, in monthly form (in millions). The sum of the monthly value is used to get the quarterly stock value.
6. (lognbr), the nonborrowed reserves variable which is also monthly (in millions) and collected from the BGFR's H3 form. The sum of the monthly value is used to get the quarterly stock value.

7. BNET[16] , net financial borrowings, (Negative line 10 of Table F101). It is in quarterly form, and get from the flows of funds account provided by the BGFR. It is also equal to line 26 "net increase in liabilities" minus line 11 "net acquisition of financial assets". In BM model, quarterly converted to monthly, using "constant match sum method", which is just the arithmetic average of the quarterly flow amount.

   ***(The following equations 8 -11 are based on Table F101 of FFA. Data explanations are provided by Guide to Flow of Funds Accounts March2010)***

8. BLIAB (FA144190005[17], line 26) = **credit market instruments** (FA144104005, line 27) + trade payables (FA143170005, line 35) + taxes payable, (FA143178005, line 36) + miscellaneous liabilities (FA143190005, line 37) + proprietors' net investment (FA143180005, line 38).

9. **credit market instruments[18]** for business liabilities (FA144104005, line 27) = commercial paper (FA103169700, line 28) + municipal securities (FA103162005, line 29) + corporate bonds (FA103163003, line 30), Bank loans (FA143168005, line 31), other loans and advances (FA143169255, line 32) + mortgages (FA143165005, line 33) + corporate equities for corporate business (FA103164003, line 34).

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[16] It's a combination of three sectors: nonfarm nonfinancial corporate business (sector10), nonfarm noncorporate business (sector11), and farm business (sector13). For the first two sectors, seasonally adjusted data is used. But for the liability of farm business only its "computed inputs" is used because the "seasonal adjusted" data is not available.

[17] This 9 digits code refers to the corresponding account from table F.101 of Fed's Guide to Flow of Funds Accounts. The first 2- figure code means the section number, ex. 14 means business sector. The last two means how the data get recorded and organized. Ex. computed input is ended with 5.

[18] Credit market instruments, is a major account of both business liabilities and assets, but no significant result from IRF of this variable following the policy shocks.

10. BASSET[19] (Line 11 of Table F.101. Net acquisition of financial assets) = **credit market instruments** (FA124004005 , line 18) + foreign deposits (FA103091003, line 12) + checkable deposits and currency (FA143030005, line 13) + time and savings deposit (FA143030005, line 14) + money market funds (FA123034005, line 15) + security RPs (FA102050003, line 16) + Mutual fund shares (FA103064203, line 23) + trade payable (FA143070005, line 24) + miscellaneous assets (FA143090005, line 25).

11. **Credit market instruments for business assets** (FA124004005, line 17) = commercial paper (FA103069100, line 18) + U.S government securities (FA143061005, line 19) + municipal securities (FA103062003, line 20), mortgages (FA123065005, line 21) + consumer credit (FA123066005, line 22).

[19] Some of the individual variables are only available since 1975, for example the change of foreign deposits and checkable deposits. And this non-economic change makes the data of business assets show significant jump since 1975.

## Appendix 2. Derivation of Innovations Based on Reserve Market Model

### A2.1. Innovations of Original Model

$$u_{tr} = -\alpha u_{ffr} + v^d \quad \text{(A1)}$$

$$u_{br} = \beta\left(u_{ffr} - u_{disc}\right) + v^b \quad \text{(A2)}$$

$$u_{nbr} = \phi^d v^d + \phi^b v^b + v^s \quad \text{(A3)}$$

Use the equation TR=BR+NBR, total reserves are equal to the borrowed reserves plus the non-borrowed reserves, and assume discount is zero without innovations. Here i, TR, NBR represent $u_{ffr}$, $u_{tr}$, $u_{nbr}$. The inverse of B matrix (or the C matrix) in equation (11) $\mu_t = B^{-1} * v_t$ or $\mu_t = C * v_t$ is the 3×3 matrix below:

$$\begin{bmatrix} i \\ TR \\ NBR \end{bmatrix} = \begin{bmatrix} -\dfrac{\phi(b)+1}{\alpha+b} & -\dfrac{-1+\phi(d)}{\alpha+b} & -\dfrac{1}{\alpha+b} \\ \dfrac{\alpha\,\phi(b)+\alpha}{\alpha+b} & \dfrac{\alpha\,\phi(d)+b}{\alpha+b} & \dfrac{\alpha}{\alpha+b} \\ \phi(b) & \phi(d) & 1 \end{bmatrix} \begin{bmatrix} vb \\ vd \\ vs \end{bmatrix} \quad \text{(A4)}$$

Or we can re-organize the matrix in the following way (with discount rate kept):

$$BR = -\frac{(b\,\phi(b) - \alpha)\,vb}{\alpha + b} - \frac{(-b + b\,\phi(d))\,vd}{\alpha + b} - \frac{b\,vs}{\alpha + b} - \frac{b\,id\,\alpha}{\alpha + b},\ NBR = \phi(d)\,vd + \phi(b)\,vb + vs,\ TR = -\frac{(-\alpha\,\phi(d) - b)\,vd}{\alpha + b} - \frac{(-\alpha - \alpha\,\phi(b))\,vb}{\alpha + b} + \frac{\alpha\,vs}{\alpha + b} - \frac{b\,id\,\alpha}{\alpha + b},\ i = \frac{(-\phi(d) + 1)\,vd}{\alpha + b} + \frac{(-1 - \phi(b))\,vb}{\alpha + b} - \frac{vs}{\alpha + b} + \frac{b\,id}{\alpha + b} \quad \text{(A5)}$$

The relationship between the structural innovation and the disturbances is as equation A6. The B matrix is pre-multiplied with $\begin{bmatrix} i & TR & NBR \end{bmatrix}$'.

$$\begin{bmatrix} vb \\ vd \\ vs \end{bmatrix} = \begin{bmatrix} -b & 1 & -1 \\ \alpha & 1 & 0 \\ -\alpha\,\phi(d) + b\,\phi(b) & -\phi(d) - \phi(b) & \phi(b) + 1 \end{bmatrix} \begin{bmatrix} i \\ TR \\ NBR \end{bmatrix} \quad \text{(A6)}$$

The Vs in equation (A6) shows the policy target, with the 4 coefficients controlling the interest rate and reserves levels:

$$v^s = -(\phi^d + \phi^b)u_{tr} + (1 + \phi^b)u_{nbr} - (\alpha\phi^d - \beta\phi^b)u_{ffr} \quad \text{(A7)}$$

1. FFR model is to impose $\phi^d = 1, \phi^b = -1$, Bernanke & Blinder (1992).

$$\left\{BR = vb - \frac{b\,vs}{\alpha + b},\ NBR = vd - vb + vs,\ TR = vd + \frac{\alpha\,vs}{\alpha + b},\ i = -\frac{vs}{\alpha + b}\right\}$$

$$vs = \left[\ (-\alpha - b)\ i\ \right] \tag{A8}$$

2. NBR model is to impose $\phi^d = \phi^b = 0$, Christiano and Eichenbaum (1992)

$$BR = \frac{\alpha\, vb}{\alpha + b} + \frac{b\ vd}{\alpha + b} - \frac{b\ vs}{\alpha + b}, NBR = vs, TR = \frac{\alpha\, vb}{\alpha + b} + \frac{b\ vd}{\alpha + b} + \frac{\alpha\ vs}{\alpha + b}, i = -\frac{vb}{\alpha + b} + \frac{vd}{\alpha + b} - \frac{vs}{\alpha + b}$$

$$vs = \left[\ NBR\ \right] \tag{A9}$$

3. NBR/TR model is to impose $\alpha = 0, \phi^b = 0$ by Strongin (1995).

$$BR = -\frac{(-b + b\,\phi(d))\ vd}{b} - vs, NBR = \phi(d)\ vd + vs, TR = vd, i = -\frac{vb}{b} + \frac{(-\phi(d) + 1)\ vd}{b} - \frac{vs}{b}$$

$$vs = \left[\ -\phi(d)\ TR + NBR\ \right] \tag{A10}$$

4. BR model is to impose $\phi^d = 0, \phi^b = \alpha / \beta$, by Cosimano and Sheehan (1994).

(This one is not shown in the paper, but it worth taking a look when using borrowed reserves as a policy indicator).

$$BR = -\frac{b\,vs}{\alpha + b},\ NBR = vd + \frac{\alpha\,vb}{b} + vs,\ TR = vd + \frac{\alpha}{b}vb + \frac{\alpha\,vs}{\alpha + b},\ i = \frac{vb}{b} - \frac{vs}{\alpha + b}$$

$$vs = \left[\ \left(-1 - \frac{\alpha}{b}\right) TR + \left(\frac{\alpha}{b} + 1\right) NBR\ \right] = \left[\ \left(-1 - \frac{\alpha}{b}\right) BR\ \right] \tag{A11}$$

### A2.2. Innovations of Revised Model after Policy Change

Equation (18) changes to (26, also A12 below) to add a dummy into the model, also assuming $u_{disc} = 0$ as before, the previous set of three equations for reserves market becomes the following:

$$u_{tr} = -\alpha u_{ffr} + v^d \tag{A1}$$

$$u_{br} = \beta_1 u_{ffr} + \beta_2 * D * u_{ffr} + v^b \tag{A12}$$

$$u_{nbr} = \phi^d v^d + \phi^b v^b + v^s \tag{A2}$$

With such dummy added in, the system can be more flexibly reflect the policy changes. Rearrange the three functions we can get the following equations:

$$\Big\{ BR = -\frac{\big(b(1)\,\phi(b) + b(2)\,\mathrm{D}\,\phi(b) - \alpha\big)\,vb}{b(1) + b(2)\,\mathrm{D} + \alpha} - \frac{\big(b(1)\,\phi(d) - b(1) + b(2)\,\mathrm{D}\,\phi(d) - b(2)\,\mathrm{D}\big)\,vd}{b(1) + b(2)\,\mathrm{D} + \alpha} - \frac{(b(1) + b(2)\,\mathrm{D})\,vs}{b(1) + b(2)\,\mathrm{D} + \alpha}, NBR = \phi(d)\,vd + \phi(b)\,vb + vs, TR = \frac{\big(\alpha\,\phi(b) + \alpha\big)\,vb}{b(1) + b(2)\,\mathrm{D} + \alpha} + \frac{\big(\alpha\,\phi(d) + b(2)\,\mathrm{D} + b(1)\big)\,vd}{b(1) + b(2)\,\mathrm{D} + \alpha} + \frac{\alpha\,vs}{b(1) + b(2)\,\mathrm{D} + \alpha}, i = -\frac{\big(1 + \phi(b)\big)\,vb}{b(1) + b(2)\,\mathrm{D} + \alpha} - \frac{\big(\phi(d) - 1\big)\,vd}{b(1) + b(2)\,\mathrm{D} + \alpha} - \frac{vs}{b(1) + b(2)\,\mathrm{D} + \alpha} \Big\} \tag{A13}$$

As the revised form of the previous C matrix, the matrix C' becomes the one pre-multiplied by V matrix as follows:

$$\begin{bmatrix} i \\ TR \\ NBR \end{bmatrix} = \begin{bmatrix} -(1+\phi(b))/(b(1)+b(2)\,\mathrm{D}+\alpha) & -(\phi(d)-1)/(b(1)+b(2)\,\mathrm{D}+\alpha) & -1/(b(1)+b(2)\,\mathrm{D}+\alpha) \\ (\alpha\,\phi(b)+\alpha)/(b(1)+b(2)\,\mathrm{D}+\alpha) & (\alpha\,\phi(d)+b(2)\,\mathrm{D}+b(1))/(b(1)+b(2)\,\mathrm{D}+\alpha) & \alpha/(b(1)+b(2)\,\mathrm{D}+\alpha) \\ \phi(b) & \phi(d) & 1 \end{bmatrix} \begin{bmatrix} vb \\ vd \\ vs \end{bmatrix} \tag{A14}$$

The corresponding B' matrix, as the revised form of the previous B matrix, is:

$$\begin{bmatrix} -b(1)-b(2)\,\mathrm{D} & 1 & -1 \\ \alpha & 1 & 0 \\ -\alpha\,\phi(d)+\phi(b)\,b(2)\,\mathrm{D}+\phi(b)\,b(1) & -\phi(d)-\phi(b) & 1+\phi(b) \end{bmatrix} \tag{A15}$$

All the intermediate steps related to the funds rate is presented in a more general form, no matter that the discount rate is targeted with and without pegging on funds rate. The relationship between policy shocks and the shocks to other policy instruments can be described in the following equation:

$$vs := [(-\alpha\,\phi(d)+\phi(b)\,b(2)\,\mathrm{D}+\phi(b)\,b(1))\,i + (-\phi(d)-\phi(b))\,TR + (1+\phi(b))\,NBR] \quad . \tag{A16}$$

The policy shocks (Vs equation) in the second and third model, the NBR and NBT/TR model, stay the same, and only in the first FFR model and fourth BR model show some difference. But the other equations of the four models are different.

1. FFR' model with $\phi^d = 1, \phi^b = -1$: (Here an apostrophe is added to show the revised equations for innovation models)

$$BR = -\frac{(-b(1) - b(2)\,\mathrm{D} - \alpha)\,vb}{b(1) + b(2)\,\mathrm{D} + \alpha} - \frac{(b(1) + b(2)\,\mathrm{D})\,vs}{b(1) + b(2)\,\mathrm{D} + \alpha}, NBR = vd - vb + vs, TR = vd + \frac{\alpha\,vs}{b(1) + b(2)\,\mathrm{D} + \alpha}, i = -\frac{vs}{b(1) + b(2)\,\mathrm{D} + \alpha}$$

$$vs = \left[\,(-b(1) - b(2)\,\mathrm{D} - \alpha)\,i\,\right]. \tag{A17}$$

2. NBR' model with $\phi^d = \phi^b = 0$:

$$\left\{BR = -\frac{(-b(1) - b(2)\,\mathrm{D})\,vd}{b(1) + b(2)\,\mathrm{D} + \alpha} + \frac{\alpha\,vb}{b(1) + b(2)\,\mathrm{D} + \alpha} - \frac{(b(1) + b(2)\,\mathrm{D})\,vs}{b(1) + b(2)\,\mathrm{D} + \alpha}, NBR = vs, TR = \frac{(b(1) + b(2)\,\mathrm{D})\,vd}{b(1) + b(2)\,\mathrm{D} + \alpha} + \frac{\alpha\,vb}{b(1) + b(2)\,\mathrm{D} + \alpha} + \frac{\alpha\,vs}{b(1) + b(2)\,\mathrm{D} + \alpha}, i = \frac{vd}{b(1) + b(2)\,\mathrm{D} + \alpha} - \frac{vb}{b(1) + b(2)\,\mathrm{D} + \alpha} - \frac{vs}{b(1) + b(2)\,\mathrm{D} + \alpha}\right\}$$

$$vs = [\,NBR\,]. \tag{A18}$$

This innovation function is the same as the one in (A9), but the intermediate steps are different.

3. NBR/TR' model with $\alpha = 0, \phi^b = 0$:

$$BR = -\frac{\left(b(2)\,\mathrm{D}\,\phi(d) - b(2)\,\mathrm{D} + b(1)\,\phi(d) - b(1)\right) vd}{b(1) + b(2)\,\mathrm{D}} - vs,$$

$$NBR = \phi(d)\ vd + vs,\ TR = vd,\ i = -\frac{\left(\phi(d) - 1\right) vd}{b(1) + b(2)\,\mathrm{D}} - \frac{vb}{b(1) + b(2)\,\mathrm{D}} - \frac{vs}{b(1) + b(2)\,\mathrm{D}}$$

$$vs = \left[\ -\phi(d)\ TR + NBR\ \right]. \tag{A19}$$

4. The BR' model with $\phi^d = 0, \phi^b = \alpha / \beta$ :

$$BR = -\frac{(b(1) + b(2)\,\mathrm{D})\ vs}{b(1) + b(2)\,\mathrm{D} + \alpha},\ NBR = vd + \frac{\alpha\ vb}{b(1) + b(2)\,\mathrm{D}} + vs,\ TR = vd + \frac{\alpha\ vb}{b(1) + b(2)\,\mathrm{D}} + \frac{\alpha\ vs}{b(1) + b(2)\,\mathrm{D} + \alpha},\ i = -\frac{vb}{b(1) + b(2)\,\mathrm{D}} - \frac{vs}{b(1) + b(2)\,\mathrm{D} + \alpha}$$

$$vs = \left[\ \left(-1 - \frac{\alpha}{b(1) + b(2)\,\mathrm{D}}\right) BR\ \right]. \tag{A20}$$

## Appendix 3. Nonborrowed Reserves (NBR)

Figure A1 shows the individually plotted variables. The real GDP and its deflator have obvious trends, while the federal funds rate demonstrates more fluctuation. The most worthy explaining variable is the NBR, which is relatively stable before 2008 and very volatile after that. In the Figure A2, the NBR of time period from 1960Q1 to 2007Q4 is named as NBRbf2008 and plotted to see what the regular range of NBR. It looks more like a series with trend. Before 2008, all the nonborrowed reserves are positive, and the quarterly data increased by time and was never greater than 200 billion. Historically, nonborrowed reserves account for around 90% of total reserves.

But during 2008, the sum of nominal nonborrowed reserves of Q1, Q2, Q3, and Q4 were $-69.774, -328.372, -430.790, and -254.733 billion respectively and the total reserves should never be zero. Not only were they negative but also extremely big. Oct of 2008 alone, it hit -332.789 billion. In 2009, the numbers went back to positive range but appeared to be more extreme. For 2009, the quarterly sum of NBR of Q1, Q2, and Q3 were 579.290, 1068.708, 1540.672 billion respectively.

The abnormal number of nonborrowed reserves was explained by the Fed as the result of the implementation of its Term Auction Facility[20] (TAF), which gives banks funding if they post collateral. From the perspective of the borrowers, the banks, benefited from getting the lower-than-interbank-market rates by using the TAF. In the Fed's words, "The negative level of nonborrowed reserves is an arithmetic result of

[20] On the website of Federal Reserve's more detailed information about the factors affecting the reserve balances is available.http://www.federalreserve.gov/RELEASES/H3/nonborrowedreserves.htm

the fact that TAF borrowings are larger than total reserves." Because technically, the funds from TAF is categorized as borrowed reserves, though they are not from the discount windows. Since "nonborrowed reserves = total reserves - borrowed reserves" as mentioned before, when TAF, as one of facilities (together with the borrowings through the Fed's discount window) for banks to get the "borrowed" reserves, went up, with the balance of the above equation hold, the non borrowed reserves went down. Therefore the huge negative nonborrowed reserves were created.

But the motivation of the Fed to suddenly launch this program in mid-Dec of 2007 is mysterious (according to NBER, the Dec of 2007[21] is also the time it considered as the beginning of the 2008's recession). However, the auctioned-based interest rate in this TAF program is lower[22] than the FFR interbank rate, which can be considered as a sign that the Fed was intended to relieve the pressure of interbank fund market. The time of this program was launched far before the official bailout program TARP[23] (Troubled Asset relief program) for the financial crisis which happened in Sep 2008 following the crash of Lehman Brother, AIG, etc. Probably the Fed diagnosed the potential crisis much earlier (more than half a year before) than it really happened.

[21] http://www.nber.org/cycles/cyclesmain.html

[22] http://www.forbes.com/feeds/afx/2008/01/29/afx4586588.html
01.29.08 Fed's TAF auctions 30 billion USD 28-day loans at 3.123 pct

[23] http://www.federalreserve.gov/bankinforeg/tarpinfo.htm

## Appendix 4. Lag Length Tests

### A4.1. Lag Length Test for Quarterly Data

VAR Lag Order Selection Criteria
Endogenous variables: LOG(GDP) LOG(P) LOG(COMP) BNET LOG(TR) LOG(NBR) FFR
Exogenous variables: C
Date: 04/19/12 Time: 18:13
Sample: 1959Q1 2007Q4
Included observations: 184

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | -1009.046 | NA | 0.000148 | 11.04398 | 11.16629 | 11.09356 |
| 1 | 1160.755 | 4150.925 | 1.44e-14 | -12.00821 | -11.02975* | -11.61163 |
| **2** | **1286.880** | **231.6863** | **6.23e-15*** | **-12.84652*** | **-11.01191** | **-12.10293*** |
| 3 | 1329.570 | 75.17132 | 6.71e-15 | -12.77794 | -10.08717 | -11.68734 |
| 4 | 1372.861 | 72.93511 | 7.22e-15 | -12.71588 | -9.168963 | -11.27827 |
| 5 | 1417.440 | 71.71463 | 7.70e-15 | -12.66783 | -8.264761 | -10.88321 |
| 6 | 1471.334 | 82.59899 | 7.49e-15 | -12.72103 | -7.461810 | -10.58940 |
| 7 | 1511.736 | 58.84647 | 8.53e-15 | -12.62757 | -6.512202 | -10.14893 |
| 8 | 1553.693 | 57.91797 | 9.68e-15 | -12.55101 | -5.579489 | -9.725364 |
| 9 | 1597.354 | 56.95016 | 1.09e-14 | -12.49298 | -4.665314 | -9.320331 |
| 10 | 1657.222 | 73.53291 | 1.06e-14 | -12.61111 | -3.927287 | -9.091448 |
| 11 | 1725.776 | 78.98655* | 9.48e-15 | -12.82366 | -3.283683 | -8.956986 |
| 12 | 1773.327 | 51.16817 | 1.10e-14 | -12.80790 | -2.411774 | -8.594219 |

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

## A4.2. Lag Length Test for Monthly Data

VAR Lag Order Selection Criteria
Endogenous variables: LOG(GDP) LOG(P) LOG(COMP) BNET LOG(TR) LOG(NBR) FFR
Exogenous variables: C
Date: 04/19/12 Time: 22:10
Sample: 1959M01 2007M12
Included observations: 576

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | -2682.196 | NA | 2.68e-05 | 9.337485 | 9.390423 | 9.358130 |
| 1 | 5036.465 | 15222.91 | 7.28e-17 | -17.29328 | -16.86977 | -17.12812 |
| 2 | 5203.471 | 325.3141 | 4.83e-17 | -17.70302 | -16.90894 | -17.39334 |
| 3 | 5545.818 | 658.5426 | 1.75e-17 | -18.72159 | -17.55694 | -18.26739 |
| **4** | **6045.370** | **948.8019** | **3.65e-18** | **-20.28601** | **-18.75078*** | **-19.68729*** |
| 5 | 6074.616 | 54.83586 | 3.92e-18 | -20.21742 | -18.31162 | -19.47418 |
| 6 | 6105.437 | 57.04103 | 4.17e-18 | -20.15430 | -17.87793 | -19.26654 |
| 7 | 6207.951 | 187.2303 | 3.47e-18 | -20.34011 | -17.69317 | -19.30783 |
| 8 | 6234.767 | 48.32467 | 3.75e-18 | -20.26308 | -17.24557 | -19.08629 |
| 9 | 6262.713 | 49.68195 | 4.05e-18 | -20.18998 | -16.80189 | -18.86866 |
| 10 | 6365.227 | 179.7553* | 3.37e-18* | -20.37579* | -16.61713 | -18.90996 |
| 11 | 6383.341 | 31.32140 | 3.76e-18 | -20.26854 | -16.13932 | -18.65819 |
| 12 | 6415.140 | 54.21269 | 4.01e-18 | -20.20882 | -15.70902 | -18.45395 |

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

**References**


1) Balke, Nathan and Emery, Kenneth M.. "Understanding the price puzzle." *Economic and Financial Policy Review*, no. Q IV (1994): 15-26.

2) Bernanke, Ben and Gertler, Mark. "Agency Costs, Net Worth, and Business Fluctuations." *The American Economic Review* 79, no. 1 (1989): 14-31.

3) Bernanke, Ben, Gertler, Mark and Gilchrist, Simon. "The Financial Accelerator and the Flight to Quality." *The Review of Economics and Statistics* 78, no. 1 (1996): 1-15.

4) Bernanke, Ben S. and Blinder, Alan S.. "Credit, Money, and Aggregate Demand." *The American Economic Review* 78, may. no. 2 (1988): 435-439.

5) Bernanke, Ben S. and Blinder, Alan S.. "The Federal Funds Rate and the Channels of Monetary Transmission." *The American Economic Review* 82, no. 4 (1992): 901-921.

6) Bernanke, Ben S. and Gertler, Mark. "Inside the Black Box: The Credit Channel of Monetary Policy Transmission." *The Journal of Economic Perspectives* 9, no. 4 (1995): pp. 27-48.

7) Bernanke, Ben S., Gertler, Mark and Gilchrist, Simon. "The financial accelerator in a quantitative business cycle framework." *Handbook of Macroeconomics* 1 (1999): 1341-1393.

8) Bernanke, Ben S. and Mihov, Ilian. "Measuring Monetary Policy." *The Quarterly Journal of Economics* 113, no. 3 (1998): 869-902.

9) Boivin, Jean and Giannoni, Marc. "Assessing changes in the monetary transmission mechanism: a VAR approach." *Economic Policy Review*, no. May (2002): 97-111.

10) Boschen, John F and Mills, Leonard O. "The Effects of Countercyclical Monetary Policy on Money and Interest Rates: An Evaluation of Evidence from FOMC." *Federal Reserve Bank of Philadelphia* Working Paper 91-20 (1991).

11) Boschen, John F and Mills, Leonard O. "The Relation between Narrative and Money Market Indicators of Monetary Policy." *Economic Inquiry* 33, no. 1 (1995): 24-44.

12) Chari, Varadarajan. V., Christiano, Lawrence J. and Eichenbaum, Martin. "Inside Money, Outside Money and Short Term Interest Rates." *Journal of Money, Credit and Banking* 27, no. 4 (1995): 1396-1401.

13) Christiano, Lawrence, Motto, Roberto and Rostagno, Massimo. "Financial factors in economic fluctuations." *European Central Bank*, no. 1192 (2010) .

14) Christiano, Lawrence, Motto, Roberto and Rostagno, Massimo. "Shocks, structures or monetary policies? The Euro Area and US after 2001." *Journal of Economic Dynamics and Control* 32, no. 8 (2008): 2476 - 2506.

15) Christiano, Lawrence J. and Eichenbaum, Martin. "Liquidity Effects, Monetary Policy, and the Business Cycle." *Journal of Money, Credit and Banking* 27, no. 4 (1995): 1113-1136.

16) Christiano, Lawrence J. and Eichenbaum, Martin. "Liquidity Effects and the Monetary Transmission Mechanism." *The American Economic Review* 82, no. 2 (1992): 346-353.

17) Christiano, Lawrence J., Eichenbaum, Martin and Evans, Charles. "The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds." *The Review of Economics and Statistics* 78, no. 1 (1996): 16-34.

18) Christiano, Lawrence J., Eichenbaum, Martin and Evans, Charles L.. "Monetary Policy Shocks: What Have We Learned and to What End?." *National Bureau of Economic Research, Inc*, no. 6400 (1998).

19) Christiano, Lawrence J., Eichenbaum, Martin and Vigfusson, Robert. "What happens after a technology shock?." *Board of Governors of the Federal Reserve System (U.S.)*, no. 768 (2003).

20) Christiano, Lawrence J., Motto, Roberto and Rostagno, Massimo. "The Great Depression and the Friedman-Schwartz hypothesis." *Proceedings* (2003): 1119-1215.

21) Cooley, Thomas F. and Quadrini, Vincenzo. "Monetary Policy and the Financial Decisions of Firms." *Economic Theory* 27, no. 1 (2006): 243-270.

22) Cosimano, Thomas F. and Sheehan, Richard G.. "The federal reserves operating procedure, 1984-1990: An empirical analysis." *Journal of Macroeconomics* 16, no. 4 (1994): 573 - 588.

23) Den Haan, Wouter J., Sumner, Steven W. and Yamashiro, Guy M.. "Bank loan portfolios and the monetary transmission mechanism." *Journal of Monetary Economics* 54, no. 3 (2007): 904-924.

24) Ehrmann, Michael and Fratzscher, Marcel. "Taking stock: monetary policy transmission to equity markets." *European Central Bank*, no. 354 (2004) .

25) Eichenbaum, Martin and Singleton, Kenneth J.. "Do Equilibrium Real Business Cycle Theories Explain Postwar U. S. Business Cycles?." *NBER Macroeconomics Annual* 1 (1986): pp. 91-135.

26) Favero, Carlo A.. *Applied macroeconometrics*. Oxford University Press, 2001.

27) Fisher, Irving. "The Debt-Deflation Theory of Great Depressions." *Econometrica* 1, no. 4 (1933): 337-357.

28) Fisher, Irving. *The Purchasing Power of Money*. Macmillan, New York, 1911.

29) Fisher, Jonas D. M.. "Credit Market Imperfections and the Heterogeneous Response of Firms to Monetary Shocks." *Journal of Money, Credit and Banking* 31, no. 2 (1999): 187-211.

30) Fratzscher, Marcel, Saborowski, Christian and Straub, Roland. "Monetary Policy Shocks and Portfolio Choice." *European Central Bank* Dec, no. 1122 (2009).

31) Friedman, Milton, Anna Jacobson Schwartz. *A Monetary History of the United States*. Princeton University Press, 1971.

32) Fuerst, Timothy S.. "The availability doctrine." *Journal of Monetary Economics* 34, no. 3 (1994a): 429-443.

33) Fuerst, Timothy S.. "Monetary Policy and Financial Intermediation." *Journal of Money, Credit and Banking* 26, no. 3 (1994b): 362-376.

34) Gertler, Mark. "Financial Structure and Aggregate Economic Activity: An Overview." *Journal of Money, Credit and Banking* 20, no. 3 (1988): 559-588.

35) Gertler, Mark and Gilchrist, Simon. "The Role of Credit Market Imperfections in the Monetary Transmission Mechanism: Arguments and Evidence." *The Scandinavian Journal of Economics* 95, no. 1 (1993a): 43-64.

36) Gertler, Mark and Gilchrist, Simon. "The cyclical behavior of short term business lending: implications for financial propagation mechanisms." *Board of Governors of the Federal Reserve System (U.S.)*, no. 93-6 (1993b).

37) Gertler, Mark and Gilchrist, Simon. "Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms." *The Quarterly Journal of Economics, May.* no. 109-2 (1994): 309-40.

38) Goodfriend, Marvin. "Discount window borrowing, monetary policy, and the post-October 6, 1979 Federal Reserve operating procedure." *Federal Reserve Bank of Richmond*, no. 81-02 (1981).

39) Hoover, Kevin D. and Perez, Stephen J.. "Post hoc ergo propter once more an evaluation of 'does monetary policy matter?' in the spirit of James Tobin." *Journal of Monetary Economics* 34, no. 1 (1994): 47-74.

40) Jaffee, Dwight and Stiglitz, Joseph. "Credit Rationing." *Handbook of Monetary Economics* 2 (1990): 837-888.

41) Jaffee, Dwight M. and Russell, Thomas. "Imperfect Information, Uncertainty,

and Credit Rationing." *The Quarterly Journal of Economics* 90, no. 4 (1976): 651-666.

42) Kashyap, Anil K, Stein, Jeremy C. and Wilcox, David W.. "Monetary Policy and Credit Conditions: Evidence From the Composition of External Finance." 18, no. 1 (1993): 78–98.

43) King, Stephen R.. "Monetary Transmission: Through Bank Loans or Bank Liabilities?." *Journal of Money, Credit and Banking* 18, no. 3 (1986): 290-303.

44) Lutkepohl, Helmut and Reimers, Hans-Eggert. "Impulse Response Analysis in Cointegrated Systems." *Journal of Economic Dynamics and Control* 16 (1992): 53-78.

45) McCallum, Bennett T.. "A reconsideration of Sims' evidence concerning monetarism." *Economics Letters* 13, no. 2-3 (1983): 167-171.

46) Meh, Cesaire A. and Moran, Kevin. "The role of bank capital in the propagation of shocks." *Journal of Economic Dynamics and Control* 34, no. 3 (2010): 555-576.

47) Mishkin, Frederic S.. *The Economics of Money, Banking and Financial Markets*. Edited by 8th. Addison Wesley, 2007.

48) Paternoster, Raymond., Brame, R., Mazerolle, P., & Piquero, A. " *Using the correct statistical test* for the equality of regression coefficients. " *Criminology* 36, no. 4 (1998): 859-866.

49) Ramey, Valerie. "How important is the credit channel in the transmission of monetary policy?" *Carnegie-Rochester Conference Series on Public Policy* 39, no. 1 (1993): 1-45.

50) Romer, Christina D. and Romer, David H.. "Does Monetary Policy Matter A New Test in the Spirit of Friedman and Schwartz." *NBER Macroeconomics Annual* 4 (1989): 121-184.

51) Sims, Christopher A.. "Macroeconomics and Reality." *Econometrica* 48, no. 1 (1980b): 1-48.

52) Sims, Christopher A.. "Comparison of Interwar and Postwar Business Cycles: Monetarism Reconsidered." *The American Economic Review* 70, no. 2 (1980a): 250-257.

53) Sims, Christopher A.. "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy." *European Economic Review* 36, no. 5 (1992): 975-1000.

54) Sims, Christopher A.. "Are forecasting models usable for policy analysis?." *Quarterly Review*, no. Win (1986): 2-16.

55) Sims, Christopher A. "Money, Income, and Causality." *American Economic Review* 62, no. 4 (1972): 540-52.

56) Sims, Christopher A., Stock, James H. and Watson, Mark W.. "Inference in Linear Time Series Models with some Unit Roots." *Econometrica* 58, no. 1 (1990): 113-144.

57) Sims, Christopher A. and Zha, Tao. "Were There Regime Switches in U.S. Monetary Policy?" *American Economic Review, American Economic Association* 96, no. 1 (2006).

58) Stiglitz, Joseph E. and Weiss, Andrew. "Credit Rationing in Markets with Imperfect Information." *The American Economic Review* 71, no. 3 (1981): 393-410.

59) Strongin, S.. "The Identification of monetary policy disturbances - Explaining the liquidity puzzle." *Journal of Monetary Economics* 35 (1995): 463–97.

60) Walsh Carl E. *Monetary theory and policy 3*. Edited by 3rd.: MIT Press, 2010.

61) Williamson, Stephen D.. "Financial Intermediation, Business Failures, and Real Business Cycles." *The Journal of Political Economy* 95, no. 6 (1987a): 1196-1216.

62) Williamson, Stephen D.. "Costly Monitoring, Loan Contracts and Equilibrium Credit Rationing." *Quarterly Journal of Economics* 102, no. 1 (1987b): 135-145.

63) Williamson, Stephen D.. "Search, Limited Participation, and Monetary Policy." *International Economic Review* 47, no. 1 (2006): 107-128.

64) Williamson, Stephen D.. "Costly monitoring, financial intermediation, and equilibrium credit rationing." *Journal of Monetary Economics* 18, no. 2 (1986): 159-179.