

1999

Identifying the effects of monetary policy shocks on the farm sector

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Identifying the effects of monetary policy shocks on the farm sector

By

Alaa Kamal AlShawa

**A dissertation submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of
DOCTOR OF PHILOSOPHY**

Major: Economics

Major Professor: Dennis Starleaf

Iowa State University

Ames, Iowa

1999

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ACKNOWLEDGEMENTS

I would like to extend my deepest thanks and gratitude to my Major Professor, Dr. Dennis Starleaf for his valuable guidance, support and encouragement through out my research work. I am also thankful to the other Members of my Committee: Dr. Barry Falk, Dr. Arnie Hallam, Dr. Helen Jensen, and Dr. William Meeker, for their valuable help and useful suggestions. I also owe a special debt of gratitude to the Department of Economics at Iowa State University.

ABSTRACT

This study concerns two potential channels for the transmission of monetary policy to the farm sector in the United States. The first one is the “money” channel where I use a relative-price model to explain the effect of monetary policy shocks on relative farm prices. The second one is the “credit” channel where I use the Flow of Funds Accounts (FOFA) data to assess the effect of monetary policy shocks on net funds raised in the farm sector.

The equilibrium relative-price model provides a linkage between monetary policy shocks and relative farm prices. The model shows that monetary policy can affect relative farm prices if aggregate price information is imperfect and if supply and demand elasticities in the farm and nonfarm sectors are different. The short-run elasticity of supply of farm products is argued to be less than that of nonfarm products because of differences in the production processes. This characteristic of farm production causes relative farm prices to fall initially in response to a contractionary monetary policy shock.

The credit channel for the transmission of monetary policy is another way monetary policy can affect the farm sector. The credit view holds that monetary policy affects the borrowing and lending activities of the farm sector primarily because it affects the extent of financial intermediation. It suggests that the amount of bank loans might also be an important indicator of the tightness of monetary policy.

A “semi-structural” vector autoregression (VAR) model is used to develop two VAR based policy shock measures - the federal funds rate and nonborrowed reserves. The effects of monetary policy shocks on the farm sector are then assessed using dynamic response functions obtained through the VAR model.

Relative farm prices show a steady and persistent decline after a contractionary monetary policy shock, while net funds raised in the farm sector increase for roughly a year then decline. The initial rise in the net funds raised reflects the difficulty for

farmers to quickly alter their nominal expenditures. Eventually, they reduce their nominal expenditures and net funds raised decline as predicted by the credit view.

CHAPTER 1. INTRODUCTION

The Soviet grain purchase in 1972 sparked an unparalleled escalation in farmland values, which some believe set the stage for the farm debt crisis of the 1980s. The perceived agricultural boom in the 1970s came to an end in the 1980s when the export boom collapsed with little warning causing commodity prices and farm income to worsen abruptly. The world of the heavily indebted farmers and their financial institutions crashed with astonishing speed. Not only did their income falter, especially in comparison with the gains they counted on, but also interest rates on their debt had risen to very high levels. And in short order, the value of their farmland, which had been based on expected higher income discounted at lower interest rates, began a rapid descent. As it became increasingly hard for farmers to repay their debts, the financial trouble spread to financial intermediaries with significant involvement in farm lending: commercial banks, life insurance companies, and the Farm Credit System (FCS)¹ (Peoples et al., 1992).

The harsh awakening came when unexpectedly, after farmland values had quadrupled, price began to decline. Few, if any, thought the downturn would last as long as it did, from 1982 through 1986, and that on the average farmland would lose nearly two-thirds of its recorded value attained in 1981. Thousands would be forced off the land, and many banks would close their doors and never reopen.

Most agricultural analysts believe that the farm credit crisis of the 1980s had no single cause, but reflected the compound effects of a number of events and decisions

¹ The FCS consists of a number of regionally based institutions that provide credit to farmers. It issues primarily short-term debt. Financial difficulties at a number of these institutions in the mid-1980s disrupted the system, leading to new legislation to recapitalize and restructure the Federal Farm Credit Bank System. Interest rate spreads over Treasury debt rose sharply during the crisis, peaking at about 200 basis points compared with 1 to 5 basis points before the difficulties developed. As part of this legislation, Congress created the Farm Credit Financial Assistance Corporation (FACO) in 1987, which issued government guaranteed debt until 1992 to assist financially troubled Farm Credit Bank. The banks that borrowed from the agency are obligated to repay the loans in full, although interest payments on the loan are paid partly by the Federal government.

(Peoples et al., 1992), some of which took place within the farm sector such as the export-led boom and bust, and others outside it such as inflation, interest rates, and foreign exchange rate. All of these changes reversed the conditions of the 1970s that had been so favorable to agriculture. However, if any factor stands out from the rest, it is rapid change in the level of real interest rates. Tight monetary policy that led to the collapse of inflation starting in 1980 turned real interest rates from being very low to very high.

Neil Harl is one of the agricultural observers who puts the most blame for the “Farm Belt” economic woes suffered by so many farmers, agribusiness and others during the economic chaos of the 1980s largely on monetary policy pertaining mostly to inflation. Harl (1990) does cite the depression in farmland values as one of the most striking, and devastating, features of the farm debt crisis. “Falling land values cut enormous amounts of collateral value out of farm balance sheets.” (Harl, p. 39).

The downward spiral of the farm credit crisis reached bottom in 1986. A remarkable recovery ensued, based in large part on huge government income payments to farmers and the restoration of the operations and viability of the Farm Credit System. Also significant is Harl’s suggestion that people learn from what happened in the 1980s, and that those lessons learned should help prevent a similar crisis from occurring again.

The relationship between monetary policy and the price level is an important issue in macroeconomics. However, if sectoral prices respond differently, monetary disturbances can also have important relative price effects. Much research effort has been devoted to determine whether and how monetary policy affects relative sectoral prices. The question of interest in this study is whether changes in monetary policy affect relative farm prices - farm output prices relative to nonfarm output prices. The evidence on the response of relative farm prices to monetary policy shocks has been widely mixed (Isaac and Rapach, 1997). Empirical studies differ on whether monetary policy has significant and persistent effects on the agricultural sector. The

mixed findings have been due, in part, to the different theoretical models and empirical techniques that have been used. Examining this issue more closely is important for considering whether farm programs can or should be used to cushion against monetary policy shocks.

Most previous monetary vector autoregression (VAR) studies used broad monetary aggregates such as the monetary base, M1 or M2 to model monetary policy and assess its effects on the farm sector. However, movements in these broad monetary aggregates are not completely determined by the Federal Reserve. The policy measure must be a measure of exogenous disturbances to monetary policy rather than shocks to the demand for monetary aggregates. This shortcoming calls into question the structural inferences made from these models and motivates this study. The “semi-structural” vector autoregression methodology, initially developed by Bernanke and Blinder (1992), grounds structural inference by means of restrictions based on Federal Reserve operating procedures - the Federal Reserve responds to past and current economic conditions when setting its monetary policy, but policy actions feedback to the economy with at least a one-period lag. Following Christiano, Eichenbaum and Evans (1996), it is argued that the federal fund rate and nonborrowed reserves are good measures of monetary policy. Their short-run fluctuations are dominated by shifts in the stance of policy, not by nonpolicy influence.² The reduced-form response of relative farm prices to innovations in the federal funds rate or nonborrowed reserves should measure the effects of monetary policy shocks on the farm sector.

The “credit” channel for the transmission of monetary policy is another way monetary policy can affect the farm sector. The credit view holds that monetary policy affects real economic activity primarily because it affects the extent of financial intermediation (bank assets as well as liabilities and the quantity of money).

² The federal funds rate and nonborrowed reserves both can be controlled by the Federal Reserve.

Nevertheless, the money and the credit views are not mutually exclusive. Open market operations change both the money supply and the amount of loans, so both the money and credit channels are operative. The credit channel is important because it provides an additional reason why monetary policy may have important effects on the economy. Furthermore, the credit view suggests that interest rates and the money supply may not be the only indicators of the tightness of monetary policy; the amount of bank loans might also be an important indicator.

The study proceeds as follows. The next chapter reviews the previous literature on linking monetary policy actions to the relative farm prices. Chapter 3 develops a relative-price model for analyzing the effects of monetary policy shocks on relative farm prices. This is followed by a discussion of the credit view of the monetary transmission mechanism in chapter 4, which includes a model of the credit channel. Chapter 5 reviews the recent literature on monetary policy measures and outlines the VAR methodology used in the analysis. Chapters 6 and 7 assess the monthly and quarterly monetary policy measures and identify their effects on relative farm prices and on net funds raised in the farm sector. A general discussion and concluding remarks are given in chapter 8.

CHAPTER 2. LITERATURE REVIEW

The original source of interest in the dynamic responses of relative farm prices to a change in monetary policy dates back to Cairnes' pioneering study more than a century ago (Devadoss and Meyers, 1987). Cairnes (1873) predicted that prices of crude products with inelastic supply and demand would respond more rapidly than those of manufactured goods in the short run to an increase in money supply. Bordo (1980) extended Cairnes' work to explain the pattern of commodity price adjustments by applying contract theory in a fix-flex price framework (Devadoss and Meyers, 1987). Bordo's findings suggested that agricultural commodity prices are more responsive to monetary changes than are manufactured product prices because agricultural products are traded in well-developed auction markets on shorter contracts.

The events of the early 1980s suggested to many economists that monetary policy affects relative farm prices – contractionary monetary policy has been blamed for falling farm prices and the consequent decline in farm income. However, the effect of monetary policy on the farm sector remains controversial. Studies of the effects of monetary policy on relative farm prices show conflicting results: some find that monetary policy shocks do affect relative farm prices in the short run, and others detect no such effect. Economists offered two possible explanations: overshooting of flexible agricultural prices in the presence of sticky nonagricultural prices, and shifts in relative prices due to imperfect signal extraction. A corresponding body of empirical works attempts to verify this prediction, but it is marked by conflicting results.

Applications of the overshooting model include Frankel (1986) and Stamoulis and Rausser (1988). Frankel formalized the argument by applying Dornbush's (1976) overshooting model of exchange rates to agricultural commodity prices. He found that monetary policy has important effects on agricultural commodity prices because

they are flexible, and other goods prices are sticky. Agricultural commodity prices fall more than proportionately to drop in the money supply; they overshoot their new long run equilibrium.

Applications of the imperfect signal-extraction model include Lapp (1990) and Belongia (1991). Lapp used an imperfect information, rational expectations model of relative farm price determination to test for the relationship between money and relative prices of agricultural commodities. His results indicate that variations in the growth rate of the nominal money supply (whether anticipated or unanticipated) have not been an important influence on the average level of prices received by farmers relative to other prices in the economy over the period of 1951-1985.

Belongia (1991) showed that a variety of model specifications fail to support the importance of money on farm prices over his sample period. He estimated alternative farm prices models using a common sample period and common data transformations and found monetary shocks are not important for farm prices.

Other empirical studies that characterize the controversy differ in specification, data definition, sample frequency, and sample period. Orden and Fackler (1989) found that identifying policy shocks with the quantity of money variable seems particularly inappropriate during their sample period. They argued that if a recursive structure is imposed, it is more reasonable to identify shocks to the interest rates with monetary policy.

The results are very similar to those found by Devadoss and Meyers (1987) who estimate a bivariate VAR in M1 and the index of prices received by farmers for the period 1960-1985. Their empirical results for the U.S. economy strongly support the proposition of Cairnes and Bordo that agricultural prices respond more rapidly than industrial prices to monetary policy shocks.

Chambers (1985) developed a theoretical model of the interdependence between agriculture and financial markets to examine the effects of monetary policy on agriculture. His model shows that a restrictive monetary policy may adversely affect

the competitive position of an export-oriented sector like agriculture. He empirically investigated the results from the theoretical model using VAR techniques. He estimated a dynamic system containing M1 and farm prices using a sample ending in the mid 1980s. His empirical analysis shows that monetary policy can have short run effects on the agricultural sector. Agricultural prices tend to rise more than nonagricultural prices as a result of a monetary expansion.

In an attempt to reconcile the conflicting empirical results of the effects of monetary policy on the agricultural sector, Isaac and Rapach (1997) estimate a set of models based on previous empirical studies. In contrast with Belongia, they retain the model specifications and data transformations used in the previous studies and maintain the beginning-of-sample date. When their versions of the models used in those studies are estimated using samples extending through 1995, M1 shocks cease to be important. Their results suggest that the controversy over the effects of monetary policy shocks is an artifact of the sample periods used in previous studies, which would explain why sample updating alone allowed them to reconcile the conflicting results. They argue that recent outcomes contrast the conventional view that positive monetary shocks boost farm prices - the late 1980s witnessed tight money and rising farm prices, while the early 1990s saw easy money and falling farm prices.

This empirical controversy motivates my work. My primary goal is to identify the effects of monetary policy shocks on the farm sector. I present two alternative measures of monetary policy shocks - the federal funds rate and nonborrowed reserves,³ consider two potential channels for the transmission of monetary policy to the farm sector - the "money" channel and the "credit" channel, and apply VAR methodology to assess the effects of monetary policy shocks on the farm sector.

³ Orden and Fackler speculate about whether interest rates are a better gauge of monetary actions than money growth. Belongia experimented with different measures of monetary policy. His results showed no qualitative change to the results of money growth: neither measure of monetary policy is significantly related to relative farm prices.

CHAPTER 3. THE EQUILIBRIUM-RELATIVE PRICE MODEL

The equilibrium relative-price model provides a linkage between monetary policy shocks and relative farm prices if aggregate price information is imperfect and if supply and demand elasticities in the farm and nonfarm sectors are different. A partial-information/localized-market model of the type employed by Lucas (1973) and Barro (1976) is used. This model links relative prices to the variance of the monetary policy shock. The basic framework is modified by considering each location to be the market of a specific commodity, characterized by particular excess supply elasticity. Because elasticities vary across markets, monetary policy shocks affect each market price differently.

Further, to take account of the “intertemporal” dimension to supply, the supply of output in market i (agricultural products) is specified as primarily determined by the price in market i relative to the expected aggregate price level in the next period.⁴

$$Y_t^s(i) = \alpha(i) \{P_t(i) - E[P_{t+1} | I_t(i)]\} + v_t(i), \quad (3.1)$$

where $\alpha(i) > 0$ is the short-run relative supply elasticity in market i , $P_t(i)$ is the price of output in market i in period t , $E[P_{t+1} | I_t(i)]$ is the expected aggregate price level in period $t+1$ conditional on all the available information in market i at time t , and $v_t(i)$ is a normally distributed shock to supply in market i with zero mean and variance σ_v^2 .

Similarly, the demand in market i is given as

$$Y_t^d(i) = \beta(i) \{P_t(i) - E[P_{t+1} | I_t(i)]\} + \{M_t - E[P_{t+1} | I_t(i)]\} + u_t(i), \quad (3.2)$$

⁴ All variables are expressed in natural logarithms.

where $\beta(i) < 0$ is the short-run relative demand elasticity in market i , $\{M_t - E[P_{t+1} | I_t(i)]\}$ is the expected real balance effect and $v_t(i)$ is a normally distributed shock to demand in market i with zero mean and variance σ_v^2 .

The nominal money supply is determined by the monetary authority according to the following process:

$$M_t = M_{t-1} + m_t, \quad (3.3)$$

where m_t is a normally distributed, serially uncorrelated monetary policy shock with zero mean and variance σ_m^2 . We shall assume that m_t is not known at the beginning of period t .⁵ The price in market i moves to equate supply and demand in each period. The market equilibrium condition allows us to combine (3.1) and (3.2) to obtain the equilibrium price in market i in period t .

$$P_t(i) = \{1 - 1/[\alpha(i) - \beta(i)]\} E[P_{t+1} | I_t(i)] + 1/[\alpha(i) - \beta(i)] M_t + 1/[\alpha(i) - \beta(i)] [v_t(i) - v_t(i)], \quad (3.4)$$

where $[\alpha(i) - \beta(i)]$ is the relative excess-supply elasticity in market i . Equation (3.4) can be written as

$$P_t(i) = [1 - \gamma(i)] E[P_{t+1} | I_t(i)] + \gamma(i) [M_t + \varepsilon_t(i)], \quad (3.5)$$

⁵ An objection to this assumption is that people need not be ignorant of monetary shocks as monetary figures are published regularly. However, they are also revised regularly, and as is well known, the Federal Reserve changes its operating procedures over time. The Federal Open Market Committee (FOMC) makes decisions on open market operations. The FOMC, composed of the Federal Reserve Board of Governors and regional banks presidents, meets eight times a year to review monetary policy. The FOMC's reports on its policy stance are often vague. Typically, its reports mention targets for the federal funds rate or a monetary aggregate such as M1 or M2. The directives of the committee are not explicit for the quantities of government bonds to buy or sell. Nevertheless, there is little evidence that the Federal Reserve has paid much attention to its announced targets. So people acting on the available

where $\gamma(i) = 1/[\alpha(i) - \beta(i)]$ and $\varepsilon_t(i) = [u_t(i) - v_t(i)]$ is a normally distributed relative shock to market i with zero mean and variance σ_ε^2 . Substituting (3.3) for M_t in (3.5) yields

$$P_t(i) = [1 - \gamma(i)] E[P_{t+1} | I_t(i)] + \gamma(i) [M_{t-1} + m_t + \varepsilon_t(i)]. \quad (3.6)$$

The method of undetermined coefficients is used to solve for the price in market i , $P_t(i)$. The solution for $P_t(i)$ in terms of all the predetermined variables and exogenous shock is

$$P_t(i) = \mu_1 M_{t-1} + \mu_2 m_t + \mu_3 \varepsilon_t(i). \quad (3.7)$$

Since only M_{t-1} is known at time t , it follows that observation of $P_t(i)$ amounts to observation of $[\mu_2 m_t + \mu_3 \varepsilon_t(i)]$. Equation (3.7) implies that the aggregate price level can be obtained by averaging $P_t(i)$ across all markets.

$$P_t = \mu_1 M_{t-1} + \mu_2 m_t. \quad (3.8)$$

Updating (3.8) by one period and taking the rational but conditional expectations of P_{t+1} , we have

$$\begin{aligned} E[P_{t+1} | I_t(i)] &= \mu_1 E[M_t | I_t(i)] = \mu_1 E[(M_{t-1} + m_t) | I_t(i)] \\ &= \mu_1 M_{t-1} + \mu_1 E[m_t | I_t(i)]. \end{aligned} \quad (3.9)$$

information would nonetheless still mistake monetary shocks for real ones. If so, monetary shocks will affect relative prices.

⁶ The average value of $\varepsilon_t(i)$ across all markets is approximately zero.

Inference on the unobserved monetary shock is made rationally based on the stochastic character of the economy. The optimal forecast of m_t conditional on $I_t(i)$, which includes σ_m^2 and σ_ε^2 , is

$$E[m_t | I_t(i)] = [\sigma_m^2 / (\sigma_m^2 + \sigma_\varepsilon^2)] [m_t + \varepsilon_t(i)].^7 \quad (3.10)$$

Equation (3.10) shows that as the uncertainty associated with monetary policy σ_m^2 is relatively large, more of $[m_t + \varepsilon_t(i)]$ is attributed to the monetary policy shock and less to the relative real shock. Substituting (3.10) into (3.9),

$$E[P_{t+1} | I_t(i)] = \mu_1 M_{t-1} + \mu_1 \{[\sigma_m^2 / (\sigma_m^2 + \sigma_\varepsilon^2)] [m_t + \varepsilon_t(i)]\} \quad (3.11)$$

then, substituting (3.11) into (3.6),

$$P_t(i) = [1 - \gamma(i)] \{ \mu_1 M_{t-1} + \mu_1 \{[\sigma_m^2 / (\sigma_m^2 + \sigma_\varepsilon^2)] [m_t + \varepsilon_t(i)]\} \} + \gamma(i) [M_{t-1} + m_t + \varepsilon_t(i)]. \quad (3.12)$$

Now, comparing (3.12) to (3.7), we have

$$\mu_1 = 1.$$

and

$$\mu_2 = \mu_3 = [\sigma_m^2 + \gamma(i) \sigma_\varepsilon^2] / (\sigma_m^2 + \sigma_\varepsilon^2).$$

The equilibrium price in market i is

$$P_t(i) = M_{t-1} + \{[\sigma_m^2 + \gamma(i) \sigma_\varepsilon^2] / (\sigma_m^2 + \sigma_\varepsilon^2)\} [m_t + \varepsilon_t(i)]. \quad (3.13)$$

⁷ The conditional expectation of m_t is the optimal forecast of m_t that minimizes the expected mean square error, $E\{m_t - E[m_t | I_t(i)] | I_t(i)\}^2$. Using a linear forecasting rule for m_t , such that $E[m_t | I_t(i)] = \lambda [m_t + \varepsilon_t(i)]$, the expected MSE is minimized with respect to λ and obtain $\lambda = \sigma_m^2 / (\sigma_m^2 + \sigma_\varepsilon^2)$.

Averaging (3.13) across all markets yields the aggregate price level,

$$P_t = M_{t-1} + [(\sigma_m^2 + \gamma \sigma_\varepsilon^2)/(\sigma_m^2 + \sigma_\varepsilon^2)] m_t, \quad (3.14)$$

where γ is the average value of $\gamma(i)$ across all markets. Subtracting (3.14) from (3.13) yields the relative price in market i ,

$$P_t(i) - P_t = \{[\gamma(i) - \gamma] \sigma_\varepsilon^2 / (\sigma_m^2 + \sigma_\varepsilon^2)\} m_t + \{[\sigma_m^2 + \gamma(i) \sigma_\varepsilon^2] / (\sigma_m^2 + \sigma_\varepsilon^2)\} \varepsilon_t(i). \quad (3.15)$$

Equation (3.15) shows that monetary policy shocks can affect the relative price in market i if $\gamma(i) \neq \gamma$. If supply in the farm sector is less elastic than the average, as is usually expected, then monetary policy shocks will have a discernible effect on relative farm prices. This interpretation of the model is based on differences in the structure of the farm and nonfarm markets. The short-run elasticity of supply of farm products is argued to be less than that of nonfarm products because of differences in the production processes. With long lags between production and marketing decisions, the ability to adjust farm output in the short run is limited. This characteristic of farm production cause relative farm prices to fall initially in response to a negative monetary policy shock. The predictions of the model are consistent with the view that the relative price of farm products will fall under a contractionary monetary policy (see Figure 3.1).

A contractionary monetary policy shock reduces aggregate demand as people find themselves with a shortage of real money balances and an excess supply of goods. To restore equilibrium, they reduce spending and cause aggregate demand to shift to the left. The shift lowers output and income temporarily and the price level permanently.

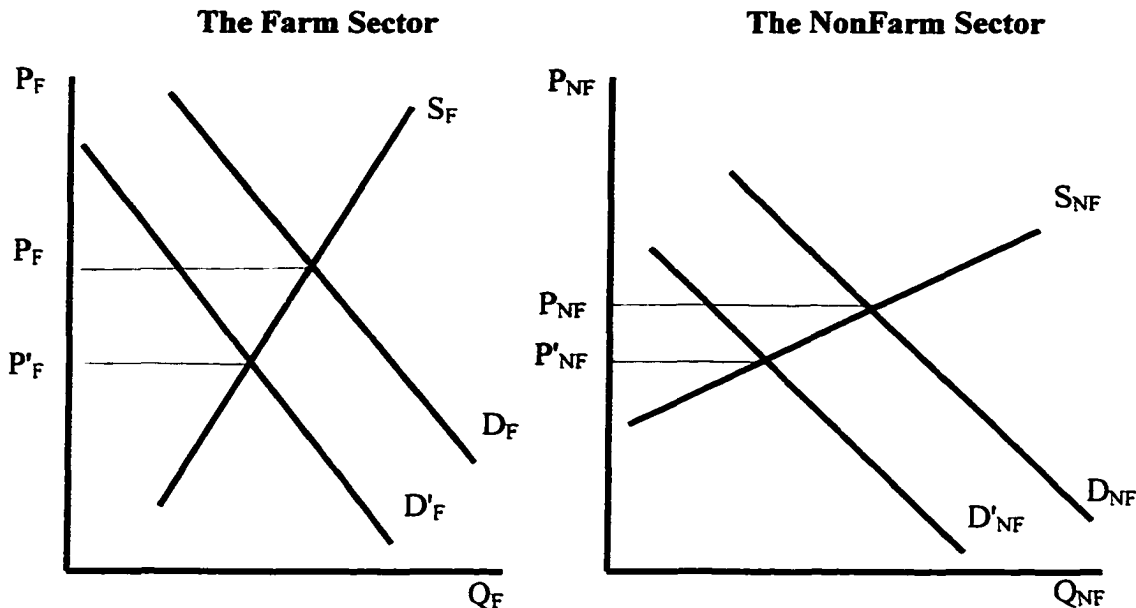


Figure 3.1 The Effects of Monetary Policy Shocks on Relative Farm Prices

A contractionary monetary policy shock shifts the demand for both farm and nonfarm products (equally) to the left. A lower elasticity of supply for farm products will cause a larger change in farm prices relative to nonfarm prices, and relative farm prices (P_F/P_{NF}) will fall.

Equation (3.15) also implies that monetary policy shocks do not have a long-lasting effect on the farm sector as relative farm prices are not affected by past monetary shocks. Past shocks are not mistaken for real shocks and, therefore, do not affect supply or demand. When it is realized that the general decline in aggregate demand was due to a contractionary monetary policy shock and not a real shock, the aggregate price level will fall to restore the original equilibrium and relative prices. The shock is reflected only in a lower aggregate price level in the long run and the neutrality of monetary policy is preserved. The direction of change in relative farm prices, whether they return to their original values in the long run and the length of the adjustment process must be determined empirically.

CHAPTER 4. THE CREDIT VIEW OF MONETARY TRANSMISSION MECHANISM

The debate on how monetary policy affects the economy focuses on whether it occurs through a "money" channel or a "credit" channel. The money channel is the conventional view in which monetary policy works by affecting bank deposits and the money supply. However, there is disagreement between the traditional Keynesian and Monetarist approaches on how changes in the quantity of money affect the economy. Monetarists believe that excess money balances have a powerful direct influence on expenditures, whereas Keynesians argue that this generates persistent changes in interest rates, which lead to changes in the levels of investment and aggregate output. However, the traditional literature contains little empirical evidence to support these views.

The "credit" channel for the transmission of monetary policy is another way monetary policy can affect the economy. Blinder and Stiglitz (1983) argued that monetary policy could also matter by affecting the availability of bank credit in contrast to the traditional view. Monetary policy affects real economic activity primarily because it affects the extent of financial intermediation (bank assets as well as liabilities and the quantity of money). This transmission mechanism arises to the extent that the level of bank reserves constrains bank lending, and that the central bank can control the real quantity of reserves, say, due to temporary price stickiness.

The basic credit view of the monetary transmission mechanism is described as follows. Suppose that the Federal Reserve conducts open market purchases to stimulate the economy. An open market purchase (which raises the monetary base and the money supply) increases the quantity of bank loans available. Bank loans may play a special role in the economy because certain borrowers such as farmers rely heavily on bank credit. This will be the case if banks have special expertise in solving

asymmetric information problems. The increase in loans will cause investment and possibly consumption expenditures to rise.

Nevertheless, the money and the credit views of how monetary policy affects the economy are by no means mutually exclusive. Open market operations change both the money supply and the amount of loans, so both the money and credit channels are operative. The credit channel is important because it provides an additional reason why monetary policy may have important effects on the economy. Furthermore, the credit view suggests that interest rates and the money supply may not be the only indicators of the tightness of monetary policy; the amount of bank loans might also be an important indicator.⁸

To be more precise, the credit view requires two assumptions: First, when the Federal Reserve changes the reserves of the banking system, banks change their lending and do not just change their holdings of securities. This will occur as long as loans and securities are not perfect substitutes for banks. Second, bank loans are special and are not perfect substitutes for other types of credit for borrowers such as farmers. If this were not the case, a decrease in bank loans would not imply decreased spending because borrowers would just increase their borrowings elsewhere when bank loans decrease.

Bernanke and Gertler (1987) develop a simple general equilibrium model of banking and macroeconomic behavior that stresses the role of banks in easing credit flows and emphasizes the importance of the financial sector. It has a different setting than the Arrow-Debreu world underlying the Modigliani and Miller theorem (1958). The Modigliani and Miller theorem asserts that, given perfect capital markets, real economic decisions do not depend on financial structure. An implication of the theorem is that financial intermediaries do not affect real activities. Bernanke and Gertler analysis shows that the banking sector is important to the macroeconomy and that

⁸ This justifies using a measure of bank reserves such as nonborrowed reserves or total reserves as measures of monetary policy.

monetary policy matters for real activities by affecting the flow of bank credit. Banks play an important role in real allocation of resource and are not merely financial veils. The key characteristic feature of the banking sector is its cost advantage in loan evaluation and monitoring, which allows banks to provide intermediary services between lenders and borrowers. Information gained from loan evaluation and monitoring remains with the bank to motivate the heavy reliance on banks for debt financing.

As argued by Gurley and Shaw (1956), the traditional analysis of bank liabilities becomes less relevant as the number of substitutes for conventionally defined money increases. The alternative approach is to consider bank assets as well as bank liabilities. The credit view emphasizes the availability of bank credit and eliminates any specialness of bank liabilities. It focuses on the implications of possible nonsubstitutability between bank and non-bank credit. This is potentially useful for understanding the macroeconomic effects of contractionary monetary policy that would force a reduction in bank loans. Borrowers such as farmers who rely on bank credit might not be able to acquire funds at all.⁹ Factors that affect the ability of banks to provide loans will decide the scale of banking and the flow of bank credit and will have real effects.

Currently, there is an active debate on the relative importance of the money and credit channels, and much new research is being conducted on this topic. Although the importance of the credit channel has not yet been fully established, research on it is giving us a richer view on the channels through which monetary policy affects the economy. Whether monetary policy matters by affecting bank assets or bank liabilities is an empirical issue. The empirical evidence thus far is mixed. Part of the

⁹ An important implication of the credit view is that monetary policy will affect smaller borrowers, who are more dependent on bank loans, more than large borrower who can access the credit markets directly without going through banks. This result is exactly what Gertler and Gilchris (1994) have found.

problem may be due to the general difficulty in discerning structural relationships from the data.

A Model of the Credit Channel

The model embodies the credit view of the monetary transmission mechanism. It takes a step toward quantifying the role of credit market imperfections in the transmission of monetary policy shocks to the farm sector, and provides additional understanding of the role of financial intermediaries in farming activities.

The broad credit channel for monetary policy will be considered here instead of the “bank-lending” channel. This version of the credit channel focuses on the supply of funds from all financial intermediaries and has no special role for banks. This seems more appropriate for the farm sector, which relies heavily on borrowing from intermediaries such as the Farm Credit System (FCS), insurance companies and the Farmer Home Administration (FmHA) as well as commercial banks.

The broad credit channel stresses that all forms of external finance are imperfect substitutes for internal funds. Information asymmetries induce a cost premium for external funds as compensation to lenders for the expected costs of monitoring and evaluation. Importantly, the size of this premium depends on the stance of monetary policy. In particular, a tightening of policy raises the opportunity cost of funds for lenders, and also increases the premium for all types of external funds, thus depressing the volume of lending. This rise in the premium occurs because the tighter policy causes borrower’s balance sheet to deteriorate, reducing the collateral that could be offered to a potential lender.

The model is designed to illustrate how credit market imperfections may amplify the impact of monetary policy shocks on the farm sector. The objective here is to explore the consequences of a monetary policy shock on credit flow to the farm sector. This is done by investigating changes in the production and borrowing

decisions of farmers as a result of changes in monetary policy. The model also looks for changes in the relationship between internal finance (balance sheet conditions) and input expenditure after a monetary policy shock.

The broad credit view is illustrated in a simple partial equilibrium model of farmer investment decision adapted from Gertler and Hubbard (1988). It is intended for expository purposes to capture some of the basic aspects of investment and financial decisions of farmers and trace the effects of monetary policy shocks on the farm sector.

To motivate the demand for credit, we assume there is a one-period delay between expenditure of inputs and realization of output. The representative farmer uses labor L and (possibly) capital K (machinery) to produce a random quantity of output Y , which becomes available to sell in the next period. Output is the numeraire good, and each input has its price normalized at unity. There are two possible output states - “good” with probability π_g and “bad” with probability π_b - which are realized after the expenditure decision is made.

The farmer can improve the probability of a good output realization if he uses enough capital with a given quantity of labor to improve the productivity of labor. Output in the next period is given by

$$Y = \begin{cases} F(L), & \text{with likelihood } \pi_g \\ \alpha F(L), & \text{with likelihood } \pi_b \end{cases}, \quad \text{if } K = \beta L,$$

and (4.1)

$$Y = \alpha F(L), \quad \text{if } K = 0.$$

The production function $F(L)$ is twice continuously differentiable, strictly increasing and strictly concave with $F(0) = 0$, $F'(0) = \infty$ and $F'(\infty) = 0$; $\pi_g + \pi_b = 1$; $0 < \alpha < 1$; $\beta > 0$; and the random output realization is specific to the farmer.

The farmer will either use βL units of capital or none at all. If the expected gain in output is more than the associated cost, for any level of labor employed, then it is efficient to use capital. Formally, this requires one to assume that

$$(\pi_g + \pi_b \alpha) F(L) - (L + \beta L) > \alpha F(L) - L.$$

If there are no informational asymmetry, the farmer expenditure decision is to choose L to satisfy

$$(\pi_g + \pi_b \alpha) F'(L) - (1 + \beta) r = 0, \quad (4.2)$$

where r is the gross interest rate. Equation (4.2) simply states that, at the optimum, the expected marginal benefit from an additional unit of labor (given a complementary addition of β units of capital) equals the marginal cost of investing. The value of L that satisfies equation (4.2), L^* , does not depend on any financial variables, and the Modigliani and Miller theorem applies.

The conventional money view of the monetary transmission mechanism is easy to illustrate in this case. To the extent that an open market sale raises the required rate of return on lending r , investment demand falls. This is the usual interest rate channel often identified with the money view.

However, under asymmetric information, the intermediary understands there is a temptation to misuse the borrowed funds and thus modifies the loan contract to reduce such incentives. One consequence of this modification is that actual labor, L , may be less than desired labor, L^* , and this gap will depend inversely on the farmer's net worth. The farmer has some initial liquid asset position W and collateralizable land X worth a present value of X/r . Hence, the farmer's initial net worth is $[W + (X/r)]$. So long as $W < L^*$, the farmer may have to borrow from a competitive

financial intermediary to finance his input expenditure. The quantity borrowed B is given by

$$B = [(1+\beta) L - W].$$

The loan contract specifies a payment p_g to the intermediary in the event of the "good" output level, and a payment p_b in the event of the "bad" output level.

The competitive intermediary's expected return R^e from the loan contract must equal its opportunity cost of funds, which equals the interest rate r times the quantity borrowed B . Given L , R^e must satisfy

$$\pi_g p_g + \pi_b p_b = r [(1+\beta) L - W].^{10} \quad (4.3)$$

Given the underlying incentive problem, the contract must give the farmer the incentive to invest in capital as a complementary input to labor. It must satisfy the "incentive constraint"

$$(\pi_g + \pi_b \alpha) F(L) - (\pi_g p_g + \pi_b p_b) > [\alpha F(L) - p_b] + r \beta L. \quad (4.4)$$

Equation (4.4) states that the farmer expected gain from using βL units of capital exceeds the gain from diverting the borrowed funds to other uses.

One way in which the intermediary could reduce the farmer's temptation to divert the borrowed funds is to increase the amount of p_b that the farmer must pay it in the event of a bad outcome. The farmer, however, can only credibly promise to pay available assets in the "bad" state. These are the sum of the gross revenue he earns in

¹⁰ It is assumed, for simplicity, that the intermediary simply channels funds from lenders to borrowers, and uses no resources.

the “bad” state and the market value of his land. The following “feasibility condition” influences the contract:

$$p_b \leq \alpha F(L) + X. \quad (4.5)$$

The farmer's borrowing and production problem is to choose L , p_g and p_b that maximize his expected profits $\pi^e(L; W; r; \beta)$,

$$\pi^e(L; W; r; \beta) = \text{Max.}_L \{(\pi_g + \pi_b \alpha) F(L) - \pi_g p_g - \pi_b p_b\}, \quad (4.6)$$

subject to equations (4.3), (4.4) and (4.5) - the feasibility condition that he can never pay the intermediary more than his realized output.

As long as the incentive constraint in equation (4.4) does not bind, actual labor expenditure L simply adjusts to desired one L^* and the pattern of contract payments is indeterminate. When the incentive constraint binds, financial and investment decisions are no longer independent. First, when the incentive constraint binds, it is desirable to raise p_b to the maximum extent possible; therefore, the limited liability constraint in equation (4.5) also binds. Using (4.3) and (4.5), one can eliminate p_g and p_b from equation (4.4), and thereby obtain a relation among L , r and internal net worth:

$$[(\pi_g + \pi_b \alpha) F(L)] - (1+2\beta) r L + r [W + (X/r)] = 0. \quad (4.7)$$

When equation (4.7) holds, input expenditure is an increasing function of the farmer's net worth $[W + (X/r)]$, holding investment opportunities constant:

$$dL/d[W + (X/r)] = \{(1+2\beta) - (\pi_g + \pi_b \alpha) [F'(L)/r]\}^{-1} > 0. \quad (4.8)$$

The explanation for this effect is that, when the incentive constraint binds, an increase in internal net worth increases the amount of feasible investment.

The existence of the “broad” credit channel precludes neither the traditional interest rate channel nor the bank-lending channel. To see the former, note an increase in lender’s opportunity cost of funds on account of a monetary contraction reduces desired investment L^* (since L^* is determined by $(\pi_g + \pi_b \alpha) F'(L) = (1+\beta) r$). To see the latter, to the extent that banks face a higher marginal opportunity cost of funds because of a less than perfectly elastic supply schedule for managed liabilities (and farmers lack access to nonbank finance), the increase in r lowers both desired and actual spending.

This simple framework is consistent with the description of the financial accelerator mechanism: The cost of uncollateralized external finance exceeds that for internal finance. This gap varies inversely with the internal net worth of the farmer and a decline in net worth reduces the farmer’s spending, given everything equal. The framework also yields simple testable predictions related to these money view and credit view arguments.

It is also useful to note that L depends inversely on the gross interest rate r , even when the incentive condition constraints expenditure below the first-best optimum. The rise in r magnifies the incentive problem by worsening the farmer’s financial position, thus increasing his gains from cheating (relative to being honest) and the level of expenditure L declines accordingly.

Furthermore, the asymmetry of information between farmers and intermediaries adds a premium to the cost of borrowing. The opportunity cost of borrowing r can be decomposed into a risk-free interest rate r_{RF} , which is taken as the monetary policy instrument, and a risk premium $\Omega(B, r_{RF})$ to compensate the intermediaries for costs incurred in evaluating and monitoring farmers:

$$r = r_{RF} + \Omega(B, r_{RF}).$$

The size of Ω increases with the level of borrowing and the level of the risk-free rate. In part because increase in the rate lower the discounted value of farmers' net worth, thereby increasing the expected default cost.

The dependence of Ω on the risk-free rate implies that credit market imperfections can act to magnify the effect of monetary policy shocks on the farm sector. This increase in the cost of borrowing causes investment decisions to be more sensitive to fluctuations in net worth after a monetary contraction.

CHAPTER 5. MEASURES OF MONETARY POLICY SHOCKS

The VAR Methodology

The relative-price model provides a linkage between monetary policy shocks and agricultural activity. The “credit” view adds another channel for the transmission of monetary policy to the farm sector. A general econometric methodology is presented to obtain quantitative measures of the direction, size and persistence of this linkage and channel. The method builds on the “semi-structural” VAR approach, used in this context by Bernanke and Blinder (1992); Strongin (1992); and Christiano, Eichenbaum, and Evans (1996), among others. The semi-structural VAR model leaves the relationships among variables in the system unrestricted, but imposes contemporaneous identifying restrictions on a set of policy variables relevant to the conduct of monetary policy. It extracts information about monetary policy from the market for bank reserves. The “semi-structural” VAR yields impulse responses and variance decompositions that can be given structural interpretations. It helps unlock economic information embedded in the reduced-form model.

This method involves three basic steps. First, based on institutional analysis of Federal Reserve operating procedures, a policy variable or combination of variables that measure the stance of policy are identified. Bernanke and Blinder (1992) chose the federal funds rate. Strongin (1992) used a measure closely related to the ratio of nonborrowed reserves to total reserves. Christiano, Eichenbaum and Evans (1996) chose both the federal funds rate and nonborrowed reserves as measures of monetary policy. Second, a standard VAR system including the relevant macroeconomic variables and the policy variables with policy variables ordered last is estimated. This structure imposes the restriction that the Federal Reserve responds to contemporaneous information, but that policy shocks feedback to the economy with at least a one-period delay. Finally, the impulse response functions for the nonpolicy

variables in the system are calculated. These provide estimates of the dynamic response of the variables in the VAR system to monetary policy shocks.

The standard linear, simultaneous equations model is a useful starting point for understanding the semi-structural VAR approach. A simultaneous equations system models the dynamic relationship between endogenous and exogenous variables. The dynamic structural system can be written as¹¹

$$\mathbf{A} \mathbf{X}_t = \mathbf{B}(L) \mathbf{X}_{t-1} + \mathbf{E}_t, \quad (5.1)$$

where \mathbf{X}_t is an n -vector of endogenous variables, \mathbf{A} is an $n \times n$ matrix of the structural parameters on the contemporaneous endogenous variables, $\mathbf{B}(L)$ is a k^{th} degree matrix polynomial in the lag operator L , that is, $\mathbf{B}(L) = \mathbf{B}_0 + \mathbf{B}_1 L + \mathbf{B}_2 L^2 + \dots + \mathbf{B}_k L^k$, where all the \mathbf{B} matrices are square, and \mathbf{E}_t is an n -vector of serially uncorrelated structural disturbances to the structural equations. Solving for \mathbf{X}_t yields the “reduced-form” VAR representation for \mathbf{X}_t ,

$$\mathbf{X}_t = \mathbf{C}(L) \mathbf{X}_{t-1} + \mathbf{U}_t, \quad (5.2)$$

where $\mathbf{C}(L) = \mathbf{A}^{-1} \mathbf{B}(L)$ and $\mathbf{U}_t = \mathbf{A}^{-1} \mathbf{E}_t$. Equation (5.2) shows how reduced-form VAR coefficients are related to the underlying structural coefficients, which are not separately identifiable.

The VAR approach uses ordinary least squares (OLS) to estimate (5.2). An estimate of the variance-covariance matrix of the VAR disturbances, $\Sigma_U = E(\mathbf{U}_t \mathbf{U}_t')$, is readily obtained from the OLS residuals. Since $\mathbf{U}_t = \mathbf{A}^{-1} \mathbf{E}_t$, then

$$\Sigma_U = \mathbf{A}^{-1} \Sigma_E \mathbf{A}^{-1'}, \quad (5.3)$$

¹¹ Boldface letters indicate vectors or matrices of variables or coefficients.

where the variance-covariance matrix of the structural disturbances $\Sigma_E = E(\mathbf{E}_t \mathbf{E}_t')$.

A particular specification for the structural disturbances \mathbf{E}_t is required to identify the structural shocks. The Choleski factorization assumes that Σ_E is diagonal and \mathbf{A}^{-1} is lower triangular with the main diagonal elements normalized to one. The structural shocks are identified since $\mathbf{E}_t = \mathbf{A} \mathbf{U}_t$.¹²

The dynamic response of the variables in the system to the policy shocks can then be measured by the impulse response functions. These functions can be interpreted as the true structural responses to policy changes (assuming that the linear structure is invariant).¹³ They are based upon the moving average representation (VMA) for \mathbf{X}_t . The VMA for the VAR is obtained by a simple transformation of the VAR for \mathbf{X}_t . Take the VAR model for \mathbf{X}_t from (5.2) and subtract $\mathbf{C}(L) \mathbf{X}_{t-1}$ from both sides of equation (5.2),

$$\mathbf{X}_t - \mathbf{C}(L) \mathbf{X}_{t-1} = \mathbf{U}_t.$$

¹² However, the Choleski factorization suffers from the problem of imposing a “semi-structural” interpretation on a mechanical procedure. Bernanke (1986) and Sims (1986) have proposed alternative ways of looking at the factorization problem, which impose more of an economic structure. The innovation model is

$$\mathbf{U}_t = \mathbf{A}^{-1} \mathbf{E}_t, \text{ where } \Sigma_E \text{ is a diagonal matrix.}$$

We need to minimize with respect to the free parameters in \mathbf{A}^{-1} and Σ_E the likelihood-based function:

$$-2 \log|\mathbf{A}| + \log|\mathbf{S}_E| + \text{Trace}(\mathbf{S}_E^{-1} \mathbf{A} \mathbf{S}_U \mathbf{A}'),$$

where \mathbf{S}_U is the sample variance-covariance matrix of the VAR disturbances. Concentrating out \mathbf{S}_E simplifies this to minimizing

$$-2 \log|\mathbf{A}| + \sum \log(\mathbf{A} \mathbf{S}_U \mathbf{A}')_{ii}.$$

¹³ It is also important to construct confidence intervals for the estimates. One way to do this is the Monte Carlo integration technique. This is a Bayesian procedure that presumes that the structural shocks \mathbf{E} in equation (5.1) are independently and identically, normally distributed.

Then factor \mathbf{X}_t using the lag operator,

$$[\mathbf{I} - \mathbf{C}(L) L] \mathbf{X}_t = \mathbf{U}_t$$

and multiply both sides of this equation by the inverse of $[\mathbf{I} - \mathbf{C}(L) L]$,

$$\mathbf{X}_t = [\mathbf{I} - \mathbf{C}(L) L]^{-1} \mathbf{U}_t.$$

Now, insert the expression for $\mathbf{U}_t (= \mathbf{A}^{-1} \mathbf{E}_t)$ into this last equation,

$$\mathbf{X}_t = [\mathbf{I} - \mathbf{C}(L) L]^{-1} \mathbf{A}^{-1} \mathbf{E}_t = \Theta(L) \mathbf{E}_t, \quad (5.4)$$

where $\Theta(L) = \sum_{i=0}^{\infty} \Theta_i L^i$, and each Θ_i is an $n \times n$ matrix of parameters from the structural model. Equation (5.4) implies that the response of \mathbf{X}_{t+i} to \mathbf{E}_t is Θ_i . Hence, the sequence of Θ_i from $i = 0, 1, 2, \dots$, illustrates the dynamic response of the variables to the shocks. If the variable in \mathbf{X} is stationary, then the impulse response must approach zero as i becomes larger.

Variance decompositions allocate each variable's forecast error variance to the policy shocks. These statistics measure the quantitative effect that the shocks have on the variables. If $E_{t-j} \mathbf{X}_t$ is the expected value of \mathbf{X}_t based on all information available at time $t-j$, the forecast error is

$$\mathbf{X}_t - E_{t-j} \mathbf{X}_t = \sum_{i=0}^{j-1} \Theta_i \mathbf{E}_{t-i},$$

since the information at time $t-j$ includes all \mathbf{E} occurring at or before time $t-j$ and the conditional expectation of future \mathbf{E} is zero because the shocks are serially

uncorrelated. The forecast error variances for the individual series are the diagonal elements in the following matrix:

$$E(\mathbf{X}_t - E_{t-j} \mathbf{X}_t) (\mathbf{X}_t - E_{t-j} \mathbf{X}_t)' = \sum_{i=0}^{j-1} \Theta_i \Sigma_E \Theta_i'$$

If θ_{ivs} is the (v, s) element in θ_i and σ_s is the standard deviation for disturbance s ($s = 1, \dots, n$), the j -step-ahead percentage of forecast variance of the v^{th} variable is

$$E(\mathbf{X}_t - E_{t-j} \mathbf{X}_t)^2 = \sum_{i=0}^{j-1} \sum_{s=1}^n \theta_{ivs}^2 \sigma_s^2, \quad v = 1, 2, \dots, n.$$

The variance decomposition function (Φ) shows the j -step-ahead percentage of forecast error variance for variable v attributable to the k^{th} shock.

$$\Phi(v, k, j) = \left\{ \sum_{i=0}^{j-1} \theta_{ivk}^2 \sigma_k^2 \right\} / \left\{ \sum_{i=0}^{j-1} \sum_{s=1}^n \theta_{ivs}^2 \sigma_s^2 \right\} * 100.$$

The above strategy will be applied to measure the dynamic effects of monetary policy shocks on the farm sector. The reduced-form VAR system of equation (5.2) can be partitioned in the following way

$$\begin{bmatrix} \mathbf{Y}_t \\ \mathbf{P}_t \end{bmatrix} = \begin{bmatrix} \mathbf{C}_{11}(\mathbf{L}) & \mathbf{C}_{12}(\mathbf{L}) \\ \mathbf{C}_{21}(\mathbf{L}) & \mathbf{C}_{22}(\mathbf{L}) \end{bmatrix} \begin{bmatrix} \mathbf{Y}_{t-1} \\ \mathbf{P}_{t-1} \end{bmatrix} + \begin{bmatrix} \mathbf{U}_{Yt} \\ \mathbf{U}_{Pt} \end{bmatrix}, \quad (5.5)$$

where \mathbf{Y}_t is an n_1 -vector of macroeconomic variables. It describes a set of structural relationships in the economy. While \mathbf{P}_t is an n_2 -vector of policy variables measuring

monetary policy. It may be interpreted as the Federal Reserve reaction function based on a structural model for the bank reserves market, and $n_1 + n_2 = n$.

To identify the dynamic effects of monetary policy shocks on the various nonpolicy variables Y , without necessarily having to identify the entire model structure, the VAR system of equation (5.5) is written as

$$\begin{bmatrix} \mathbf{U}_{Yt} \\ \mathbf{U}_{Pt} \end{bmatrix} = \begin{bmatrix} \mathbf{A}_Y^{-1} & [0] \\ [1] & \mathbf{A}_P^{-1} \end{bmatrix} \begin{bmatrix} \mathbf{E}_{Yt} \\ \mathbf{E}_{Pt} \end{bmatrix}. \quad (5.6)$$

The nonpolicy shocks \mathbf{E}_Y and the policy shock \mathbf{E}_P are serially uncorrelated structural shocks - the independence from contemporaneous economic conditions is part of the definition of an exogenous policy shock. Further, this partitioning of the \mathbf{A}^{-1} matrix imposes a recursive contemporaneous structure that can be given a particular economic rationale - monetary policy shocks affect the economy with at least a one-period lag.

The nonpolicy variables Y depend on their current and lagged values and on only the lagged values of the policy variables P , that is, \mathbf{A}_P^{-1} is lower triangular with the main diagonal elements normalized to one.¹⁴ This assumes the nonpolicy innovations to the policy shocks do not feed back into the rest of the economy during the current period. This assumption is obviously more plausible if the time period is short, and if the nonpolicy variables do not include variables that are likely to respond quickly to policy changes such as interest rates.

¹⁴ An alternative identifying assumption discussed by Bernanke and Blinder (1992) is that the policy-maker does not respond to contemporaneous information. Christiano, Eichenbaum, and Evans (1996) compare the results obtained by these two alternative assumptions; they prefer the assumption that policy does not feedback to the economy within the period, although most of their results do not depend strongly on which assumption is used. I found my estimates to be relatively invariant to the identifying assumption, suggesting that the policy shock is not highly contemporaneously correlated with other disturbances in the system.

The policy measure \mathbf{P} depends on current and lagged values of \mathbf{Y} and \mathbf{P} . It provides an overall measure of the policy stance. The exogenous policy shock \mathbf{E}_p is given by

$$\mathbf{U}_p = \mathbf{E}_Y + \mathbf{A}_p^{-1} \mathbf{E}_p. \quad (5.7)$$

This is a standard semi-structural VAR system that relates observable VAR residuals \mathbf{U}_p to the unobserved structural shocks \mathbf{E}_Y and \mathbf{E}_p , thus allowing the recovery of the structural monetary policy shocks \mathbf{E}_p . This method can give robust and plausible measures of the behavior of many macroeconomic variables to a monetary policy shock despite the minimal identifying assumptions. However, one important caveat should be offered. Measuring monetary policy accurately is important for evaluating alternative monetary transmission mechanisms, and estimating the effects of monetary policy. The VAR methodology depends on the choice of monetary policy measure being a valid one. It should depend on the Federal Reserve operating procedures - whether the Federal Reserve targets interest rates or reserve aggregates.

Federal Reserve Operating Procedures

Traditionally, changes in the stance of monetary policy were measured by changes in the growth rate of monetary aggregates such as M1 or M2. However, the growth rates of monetary aggregates typically depend on a variety of nonpolicy influences. For example, if the Federal Reserve operating procedure involves some smoothing of short-term interest rates, as has been the case for most of the past thirty years, then shocks to money demand will be partially accommodated by the Federal Reserve. As a result, growth rates of monetary aggregates will reflect changes in money demand as well as changes in monetary policy. Changes in velocity caused by

financial innovation and deregulation are a further barrier to using growth rates of monetary aggregates as measures of monetary policy.

In choosing an operating strategy, the Federal Reserve attempts to achieve a desired degree of monetary policy restraint, ease or tightness, by focusing on the reserve market conditions - reserve supply relative to demand, and the associated level of the federal funds rate. The considered reserve levels are based on the Federal Reserve's desire to induce short-run monetary and financial conditions that will help to achieve policy goals for the economy.

In principle, the Federal Reserve can directly control the quantity of reserves by not accommodating observed fluctuations in the demand for reserves. However, this will result in free movements in the federal funds rate. Alternatively, the Federal Reserve can control the federal funds rate by adjusting the supply of reserves to meet all changes in the demand for reserves. This will allow the quantity of reserves to vary freely. Over the years, the actual approach has been adapted to changing circumstances. Sometimes the emphasis has been on controlling the quantity of reserves; other times, the federal funds rate.

Considering the Federal Reserve's operating procedures overtime will give us a feeling for the evolution of the monetary policy process and an understanding of some of the subtleties of how the procedures were implemented overtime. By the late 1960s, the rising criticism of procyclical monetary policy and concerns about inflation finally led the Federal Reserve to abandon its focus on money market conditions.¹⁵ In the early 1970s the Federal Reserve stated that it was committing itself to the use of monetary aggregates as intermediate targets. But monetary policy did not cease to be procyclical. It was as procyclical in the 1970s as in the 1950s and 1960s. The conduct of monetary policy did not improve because the Federal Reserve operating

¹⁵ The result after a few years of monetary expansion was high and rising inflation. Inflation rose from less than 2% in 1960 to nearly 6% in 1969.

procedures during the period suggest that its commitment to targeting monetary aggregates was not very strong.

The Federal Reserve would set target ranges for the growth rate of various monetary aggregates such as M1 and would determine what federal funds rate (the interest rate on overnight loans between banks of their deposits at Federal Reserve Banks) it thought consistent with these aims. The Federal Reserve would then try to meet both sets of targets. But interest-rate targets and monetary aggregate targets might not be compatible. The federal funds rate may begin to climb out of its target band when the demand for M1 is growing too rapidly. In this case, the Federal Reserve would give precedence to the federal funds rate target.

The Federal Reserve was actually using the federal funds rate as its operating target. So an unexpected rise in income (which would cause the federal funds rate to hit the top of its target band) would then induce open market purchases and a too rapid growth of the money supply. The Federal Reserve then would try to bring money supply growth back on track by raising the target range on the federal funds rate. However, if income continued to rise unexpectedly, money growth would overshoot again. This is exactly what happened from June 1972 to June 1973, when the economy boomed unexpectedly: M1 growth greatly exceeded its target, increasing at approximately an 8% rate, while the federal funds rate climbed from 4½% to 8½%. The economy soon became overheated, and inflationary pressures began to mount.

The opposite chain of events occurred at the end of 1974, when the economic contraction, from the Organization of Petroleum Exporting Countries (OPEC) raising the price of oil in 1973, was far more severe than anyone had predicted. The federal funds rate fell dramatically from over 12% to 5% and persistently bumped against the bottom of its target range. The Federal Reserve conducted open market sales to keep the federal funds rate from falling, and money growth dropped precipitously, actually turning negative by the beginning of 1975. Clearly, this sharp drop in money growth

when the United States was experiencing one of the worst economic contractions of the postwar era was a serious mistake.

Using the federal funds rate as an operating target promoted a procyclical monetary policy despite the Federal Reserve lip service to monetary aggregate targets. If the Federal Reserve really intended to pursue monetary aggregate targets, it seems peculiar that it would have chose an interest rate for an operating target rather than a reserve aggregate.¹⁶ The explanation for why the Federal Reserve chose an interest rate as an operating target is that it was still very concerned with achieving interest-rate stability and was reluctant to relinquish control over interest-rate movements. The incompatibility of the Federal Reserve policy procedure with its stated intent of targeting monetary aggregates had become very clear by October 1979, when the Federal Reserve policy procedures underwent drastic revision.

Concerned over rapidly accelerating inflation in the late 1970s, the Federal Reserve sought changes in its operating procedures in order to control money growth more effectively. In October 1979, the Federal Reserve began targeting nonborrowed reserves (supply of reserves excluding discount loans), which the Federal Reserve would set after estimating the volume of discount loans the banks would borrow. The Federal Reserve allowed the federal funds rate to fluctuate freely within a wide and flexible range. Under this approach, the targeted path for nonborrowed reserves was based on the Federal Reserve's growth objectives for M1. M1 growth in excess of the Federal Reserve's objectives would cause the depository institutions' demand for reserves to outpace the nonborrowed reserves target, putting upward pressures on the funds rate and other short-term rates. The rise in interest rates, in turn, would reduce the growth in checkable deposits and other low-yielding instruments, bringing money stock growth back toward the Federal Reserve's objectives.

¹⁶ The success of Japanese monetary policy in the 1978-1987 period using an interest rate as an operating target, in contrast to the lack of success in the 1970-1979 period in the United States when the Federal Reserve used a similar operating procedure, suggest that using an interest rate as an operating target is not necessarily a barrier to successful monetary policy.

Controlling the money supply was never really the intent of the Federal Reserve's policy shift. Despite the Federal Reserve's statements about the need to target monetary aggregates, it was not committed to these targets. Rather, it was far more concerned with using interest-rate movements to wring inflation out of the economy. The Federal Reserve's primary reason for changing its operating procedures was to free its hand to manipulate interest rates in order to fight inflation. It was necessary to abandon interest-rate targets if the Federal Reserve were able to raise interest rates sharply when a slowdown in the economy was required to dampen inflation. Not surprisingly, the federal funds rate underwent much greater fluctuations after it was deemphasized as an operating target.

The interest-rate movements reflected the change in Federal Reserve's strategy. After the October 1979 announcement, interest rates soared, with the prime rate averaging 15.3% in 1980. With the imposition of credit controls in March 1980 and the rapid decline in real GDP in the second quarter of 1980, the Federal Reserve eased up on its policy and allowed interest rates to decline sharply. When recovery began in July 1980, inflation remained persistent, still exceeding 10%. Because the inflation fight was not yet won, the Federal Reserve tightened the screws again, sending short-term rates above the 15% level for a second time. The prime rate averaged 18.9% in 1981 and 14.9% in 1982. The 1981-1982 recession and its large decline in output and high unemployment began to bring inflation down. Inflation fell from 13.5% in 1980 to 1.9% in 1986 (aided by a decline in oil prices). With inflationary psychology apparently broke, interest rates were allowed to fall.

The reserve targeting procedure from 1979 to 1982 gradually came to provide assurance to financial markets and the public that the Federal Reserve is committed to fight inflation. Monetary policy was instrumental in sharply lowering the inflation rate, albeit a significant increase in interest rate volatility and a marked decline in output.

The historical relationship between M1 and the economy broke down in the early 1980s, leading the Federal Reserve to deemphasize its control of M1 during 1982. In late 1982, the Federal Reserve abandoned the formal reserve targeting procedure and moved toward accommodating short-run fluctuations in the demand for reserves, while limiting their effects on the federal funds rate. Subsequently, ongoing deregulation and financial innovation precluded a return to the use of numerical objectives for M1 and the nonborrowed reserve targeting procedure.

As a consequence, since 1982 the Federal Reserve's operating procedures have focused on achieving a particular degree of tightness or ease in reserve market conditions rather than on the quantity of reserves. Specifically, the Federal Reserve expresses its operating directives in terms of a desired degree of reserve pressure (the costs and the availability of reserves to the banking system) which is associated with an average level of the federal funds rate. The approach for evaluating the degree of reserve pressure, however, has changed over time. Discount window borrowing targets were used as the main factor for assessing reserve availability conditions during 1983-87, but they have not played a significant role through much of the subsequent period.

Under the current approach, the Federal Reserve uses the federal funds rate as the principal guide for evaluating reserve availability conditions and indicates a desired level of the federal funds rate. This judgmental approach involves estimating the demand for and supply of reserves, and accommodating all significant changes in the demand for reserves through adjustments in the supply of nonborrowed reserves. It allows for only modest variations in the funds rate around the level intended by the Federal Reserve.

Recent attempts to provide measures of monetary policy have fallen into two general categories: First, following Friedman and Schwartz (1963), Romer and Romer (1989) used the minutes of the Federal Open Market Committee to determine changes in the Federal Reserve policy position. An appealing aspect of their approach is that

it attempts to use additional information about the Federal Reserve intentions to identify monetary policy shocks. Their strategy has the advantage of being "nonparametric". It does not require any modeling of the Federal Reserve operating procedures and is potentially robust to changes in them. However, a disadvantage of this approach, beside its inherent subjectivity, is the difficulty in distinguishing between endogenous and exogenous policy changes (Bernanke and Mihov, 1995), which is necessary for identifying the effects of monetary policy on the economy.

A second general strategy is to use information about the Federal Reserve operating procedures to develop measures of monetary policy. For example, Bernanke and Blinder (1992) argue that over much of the past thirty years (particularly before 1979) the Federal Reserve has implemented policy changes primarily through changes in the federal funds rate. They argue that the funds rate (or the spread between the funds rate and a long-term bond rate) may be used as a measure of monetary policy.

Christiano and Eichenbaum (1992), among several studies, argued that innovations in broad monetary aggregates primarily reflect shocks to money demand rather than shocks to money supply, considering the actual operating procedures of the Federal Reserve. Pursuing alternative assumptions for identifying monetary policy shocks, they provide empirical evidence in support of the federal funds rate as a measure of monetary policy. They also proposed using nonborrowed reserves (the instrument that is perhaps the most directly controlled by the Federal Reserve) as a measure of monetary policy. They found that the responses of interest rates and other macro variables to innovations in nonborrowed reserves matched prior notions of how monetary policy shocks are supposed to affect the economy.

A potential problem with the Bernanke-Blinder and Christiano-Eichenbaum measures of monetary policy is that each presumes a constant set of operating procedures by the Federal Reserve. Strongin (1992) proposed a measure that could accommodate some changes in the operating procedures. He identifies monetary

policy shocks as innovations to nonborrowed reserves, holding total reserves fixed. He motivates his measure by arguing that the Federal Reserve is constrained to meet total reserve demand in the short run (failure to do so would lead to wild swings in the federal funds rate). However, it can effectively tighten policy by reducing nonborrowed reserves and forcing banks to borrow more from the discount window. An important advantage of Strongin's approach is that, because it allows the projection coefficient of nonborrowed reserves on total reserves to vary over time, it is able to nest alternative operating procedures. For example, a policy in which the Federal Reserve fully accommodates shocks to the demand for reserves (the projection coefficient of nonborrowed reserves on total reserves is unity) is essentially equivalent to a strategy targeting the federal funds rate as in Bernanke and Blinder. Alternatively, a strategy of targeting nonborrowed reserves, as suggested by Christiano and Eichenbaum, can be represented by a zero response of nonborrowed reserves to total reserves growth.

Strongin's key assumptions are that the level of total reserves is largely determined by the Federal Reserve's short run accommodation of the demand for reserves, and that policy innovations are reflected in the mix of borrowed and nonborrowed reserves used to meet short-run demand for reserves. Specifically, policy innovations are measured by using the innovation in total reserves to extract changes in the reserve mix between borrowed and nonborrowed reserves that are due to the accommodation of reserve demand shocks, leaving only those changes in the mix which are truly policy innovations. This identification implies that the demand for total reserves is perfectly inelastic with respect to the funds rate, so that an open market purchase that increases nonborrowed reserves is exactly matched by a decrease in discount loans. However, when excess reserves are positive, the demand for reserves is not completely interest inelastic. The opportunity cost of total reserves is a function of the supply of total reserves and is independent of the composition of total reserves between borrowed and nonborrowed reserves (Goodfriend, 1982). His

specification also ignores the possibility that the Federal Reserve responds to borrowing shocks.

Bernanke and Mihov (1995) adopt a strategy similar to Strongin's where they employ a specification of the bank reserves market that can accommodate a variety of alternative operating procedures, institutional features, and identifying restrictions. They estimated models of the Federal Reserve operating procedure for different periods. They found that the federal funds rate is an excellent measure of monetary policy for the 1965-79 period, but more recently, the best indicator is one that combines information from both the federal funds rate and a measure of reserves.

On the whole, the Federal Reserve operating procedures have changed over time and, hence, no single policy measure may be best for an extended time period. Thus, I followed Christiano, Eichenbaum, and Evans (1996) in using the federal funds rate and nonborrowed reserves as the monetary policy measures. Innovations to those policy measures are the policy shocks. The effects of monetary policy shocks are then identified by the dynamic responses of variables in a VAR model to the innovations.

CHAPTER 6. THE EFFECTS OF MONETARY POLICY SHOCKS ON FARM PRICES

The above strategy will be followed to identify monetary policy shocks and assess the effects of these shocks on relative farm prices using a monthly VAR. The procedure requires the inclusion of both policy variables and nonpolicy variables in the VARs.¹⁷ The policy variables are: the monthly average of the daily federal funds rate (FF); minus the log of nonborrowed reserves (NBRD); and the log of total reserves (TOTRES). Data for NBRD and TOTRES are seasonally adjusted and adjusted for changes in reserve requirements. The nonpolicy variables are: the output level (Y) - measured by the index of industrial production; the price level (P) - measured by log of the all-item consumer price index for urban consumers, CPI-U; and the commodity price index (PCOM) - measured by the smoothed change in sensitive materials prices.¹⁸

The commodity price index (PCOM) was included in the VAR system in order to capture additional information available to the Federal Reserve about the future course of inflation. The exclusion of the commodity price index tends to lead to the “price puzzle,” the finding that monetary contraction leads to a rising rather than falling price level. Sims (1992) showed that this problem can be eliminated by including a variable in the VAR that proxies for the Federal Reserve information about future inflation. For example, the Federal Reserve responds to a commodity price index or the exchange rate in setting monetary policy. Christiano, Eichenbaum

¹⁷ The issue of whether the variables in a VAR need to be stationary exists. Sims (1980) and Doan (1996) recommend against differencing even if the variables contain a unit root. They argue that the goal of the VAR analysis is to determine the interrelationships among variables, not the parameter estimates. The main argument against differencing is that it “throws away” information concerning the comovements in the data (such as cointegrating relationships). Similarly it is argued that the data need not be detrended. In a VAR, a trending variable will be well approximated by a unit root plus drift. However, the majority view is that the form of the variables in the VAR should mimic the true data-generating process. This is particularly true if the aim is to estimate a structural model.

and Evans (1996) found that including the commodity price index and measuring the general price level by an index that treats housing costs correctly, such as the GDP deflator or personal consumption expenditure (PCE), largely eliminates the price puzzle. Experimentation with these variables suggests that the results are quite robust.

As was also noted in the previous chapter, there are two possible identifying assumptions: That policymakers have contemporaneous information about nonpolicy variables (implying that the policy variables should be ordered last in the VAR), and that policymakers know only lagged values of the nonpolicy variables (implying that the policy variables should be ordered first). My results turned out to be not terribly sensitive to the ordering chosen. Thus, only results based on the assumption that policymakers have contemporaneous information about the nonpolicy variables are reported.

Assessing the Monthly Monetary Policy Measures

To assess the monthly monetary policy measures, I consider the benchmark FF and NBRD policy shocks that emerge from six-variable VARs that include Y, P, PCOM, FF, NBRD, and TOTRES in the vector X_t in (5.2). When FF is specified as the policy shock, the VAR ordering is Y, P, PCOM, FF, NBRD, and TOTRES. When NBRD is specified as the policy shock, the VAR ordering is Y, P, PCOM, NBRD, FF, and TOTRES. In both cases, the VAR was estimated using monthly data over the period 1960:01-1995:10, using 12 lags of the variables in the system.¹⁹

¹⁸ All data was obtained from the Federal Reserve Economic Data (FRED) except for PCOM, which was obtained from the Survey of Current Business, October 1995, Volume 75, Number 10, Page C-47, Series 99.

¹⁹ The VAR lag length is often selected by statistical criteria such as the modified likelihood ratio test of Sims (1980) which is based on sample size. Sims argued that conventional likelihood ratio test is too conservative in favor of acceptance of the null hypothesis. He suggested a modified likelihood ratio statistic:

Using the modified likelihood ratio test of Sims (1980), a lag length of 12 months seems most appropriate. Reducing the lag length from 24 months to 12 months had a χ_2 value that was significant at the 0.05 level, and reducing the lag length to 6 months had a χ_2 value that was also significant at the 0.05 level. Thus, the test results suggested longer lags than 12, but given degrees-of-freedom considerations, i.e., exhausting the degrees of freedom with longer lags,²⁰ I decided to use 12 lags. Using monthly data makes a lag length of 12 months sufficiently long to capture the system dynamics.

To smooth the policy shock measures, their three-month, moving average is reported in Figures 6.1 and 6.2. The estimated standard deviation of the FF policy shock is 0.48%, at an annual rate, while the estimated standard deviation of the NBRD policy shock is 0.0154. As Figure 6.1 suggests, the estimated standard deviation of the FF policy shocks is influenced by the high variance of those shocks in the early 1980s.

In describing the results, monetary policy is characterized as “contractionary” when the policy shock is positive and “expansionary” when it is negative. According to the FF policy shock, monetary policy was relatively contractionary before each recession, and became expansionary around business cycle troughs. A similar pattern is observed for the NBRD policy shock, except in the 1981-82 period, monetary

$$L(k) = (T - C) (\ln |\Sigma_R| - \ln |\Sigma_u|), \quad (6.1)$$

where T is the number of usable observations, C is a correction factor to improve small sample properties (Sims recommended that C equals the number of parameters estimated in the unrestricted system), and Σ_R and Σ_u are determinants of variance/covariance matrix of the residuals in the restricted and unrestricted models. Under the null hypothesis that lag length = k , the statistic, $L(k)$, converges to $\chi_2(df)$ where the degree of freedom (df) is the number of linear restrictions.

²⁰ In a VAR, appropriate lag-length selection can be critical. If k is too small, the model is misspecified; and if k is too large, degrees of freedom are wasted. Long lag lengths quickly consume degrees of freedom. If the lag length is k , each of the n equations contains nk coefficients plus the intercept term.

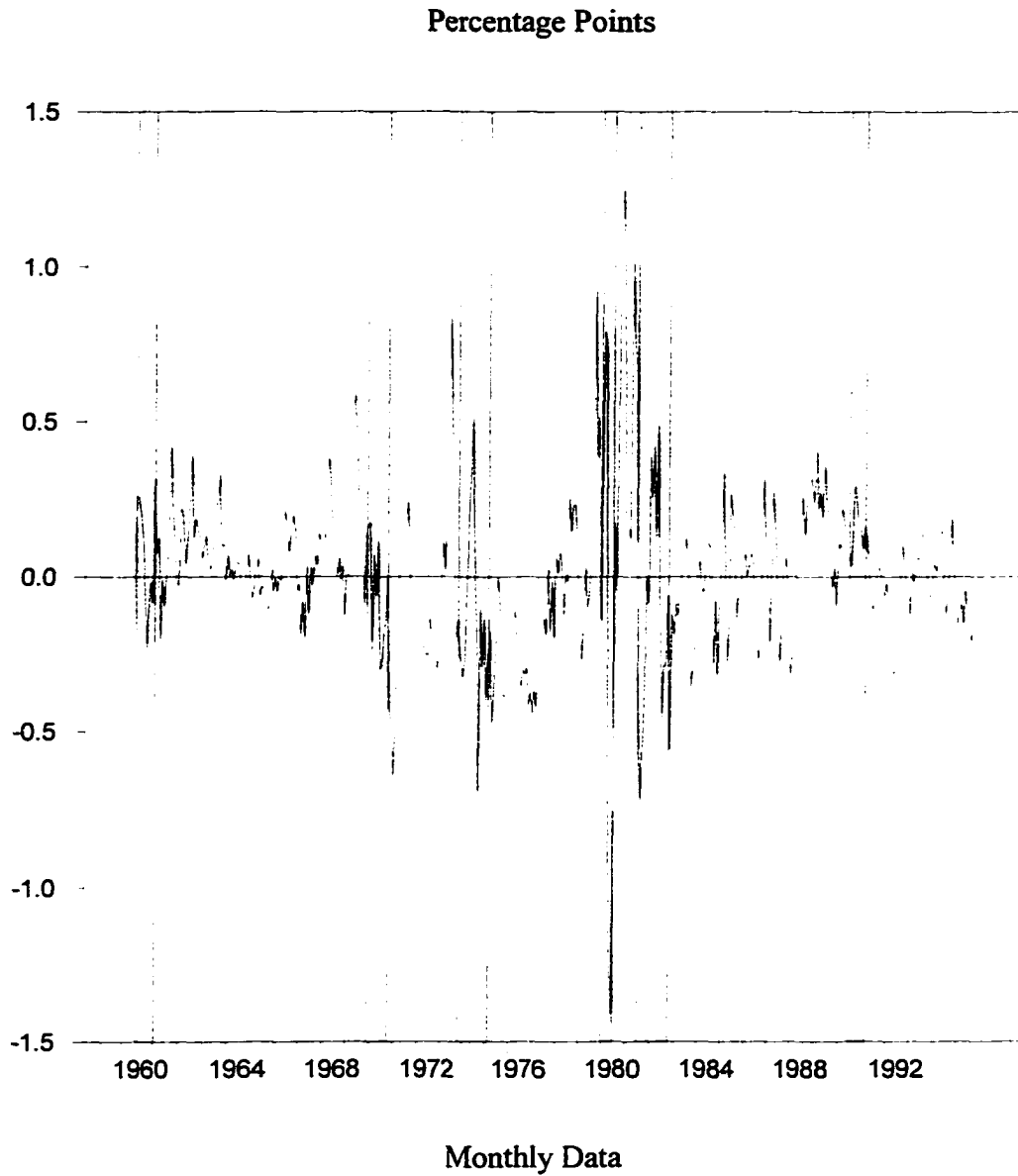


Figure 6.1 Three-Month, Moving Average of FF Policy Shock

The policy shock is as the orthogonalized innovations from a 6-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), and the log of total reserves (TOTRES). The shaded areas indicate recessions, as dated by the National Bureau of Economic Research.

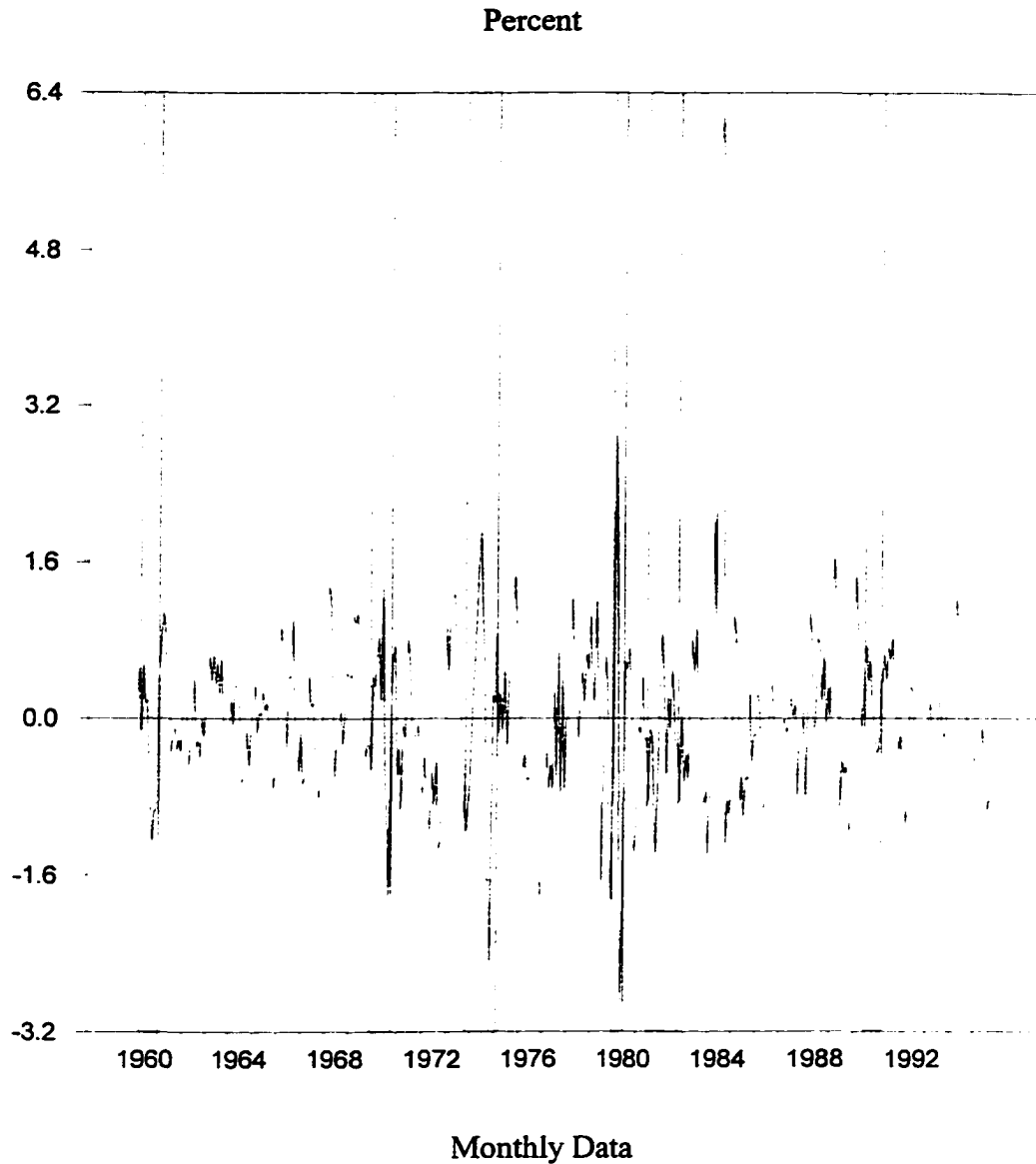


Figure 6.2 Three-Month, moving Average of NBRD Policy Shock

The policy shock is as the orthogonalized innovations from a 6-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), and the log of total reserves (TOTRES). The shaded areas indicate recessions, as dated by the National Bureau of Economic Research.

policy was expansionary at the start, very contractionary in the middle, and expansionary at the end of the recession.

Figures 6.3 to 6.14 display the impulse response functions of the variables in the VAR model to the policy shocks. Middle lines represent the point estimates, while upper and lower lines denote plus and minus one standard deviation bands.²¹ Considering the effects of a contractionary FF policy shock, several observations are worth emphasizing. First, after a delay of about 3 to 4 months, the FF policy shock leads to a sustained and statistically significant drop in output. This is consistent with the results in Bernanke and Blinder (1992) and Sims (1992). Second, the FF policy shock leads to sharp and persistent decline in PCOM. The inclusion of PCOM in the analysis is important for resolving the “price puzzle”. However, P increases for about one year after the shock, then begins to decline steadily.²² The initial rise is statistically significant indicating there is still remaining a small “price puzzle”. This is may be from the mortgage cost component of the CPI playing a large role in the rise in the price level. Third, the effect of the FF policy shock on the federal funds rate is persistent, with the funds rate staying up for approximately a year and a half after the shock. Fourth, the FF policy shock generates a statistically significant decline in nonborrowed reserves (NBRD goes up). This is consistent with the presence of a strong liquidity effect and with the view that Federal Reserve raises interest rates by selling U.S. government securities. Fifth, the fall in total reserves is negligible initially (actually, the point estimates show a small and statistically significant fall). Eventually total reserves fall by around 0.2%. So, according to the FF policy shock, the Federal Reserve insulates total reserves in the short run from the full impact of a

²¹ The standard errors were computed using the Monte Carlo method described in Doan (1996) using 500 draws from the estimated asymptotic distribution of the VAR coefficients and the covariance matrix of the innovations, U_t , in (5.2).

²² When the impulse responses are constructed over a longer horizon, the decline in P reaches a steady level.

Percent

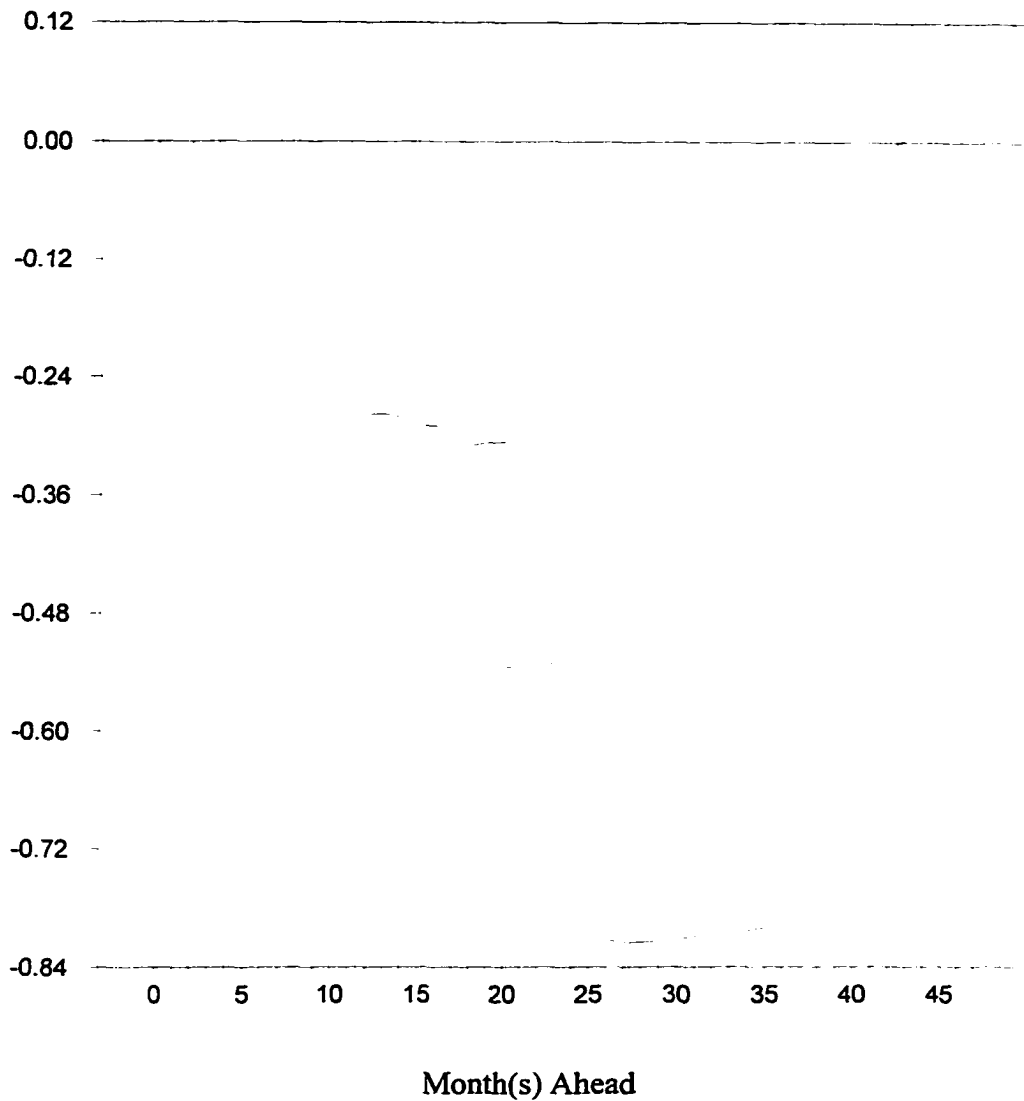


Figure 6.3 Response of Y to FF Policy Shock

The impulse responses come from estimates from a 6-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), and the log of total reserves (TOTRES). The impulse responses are constructed at 48 months horizon.

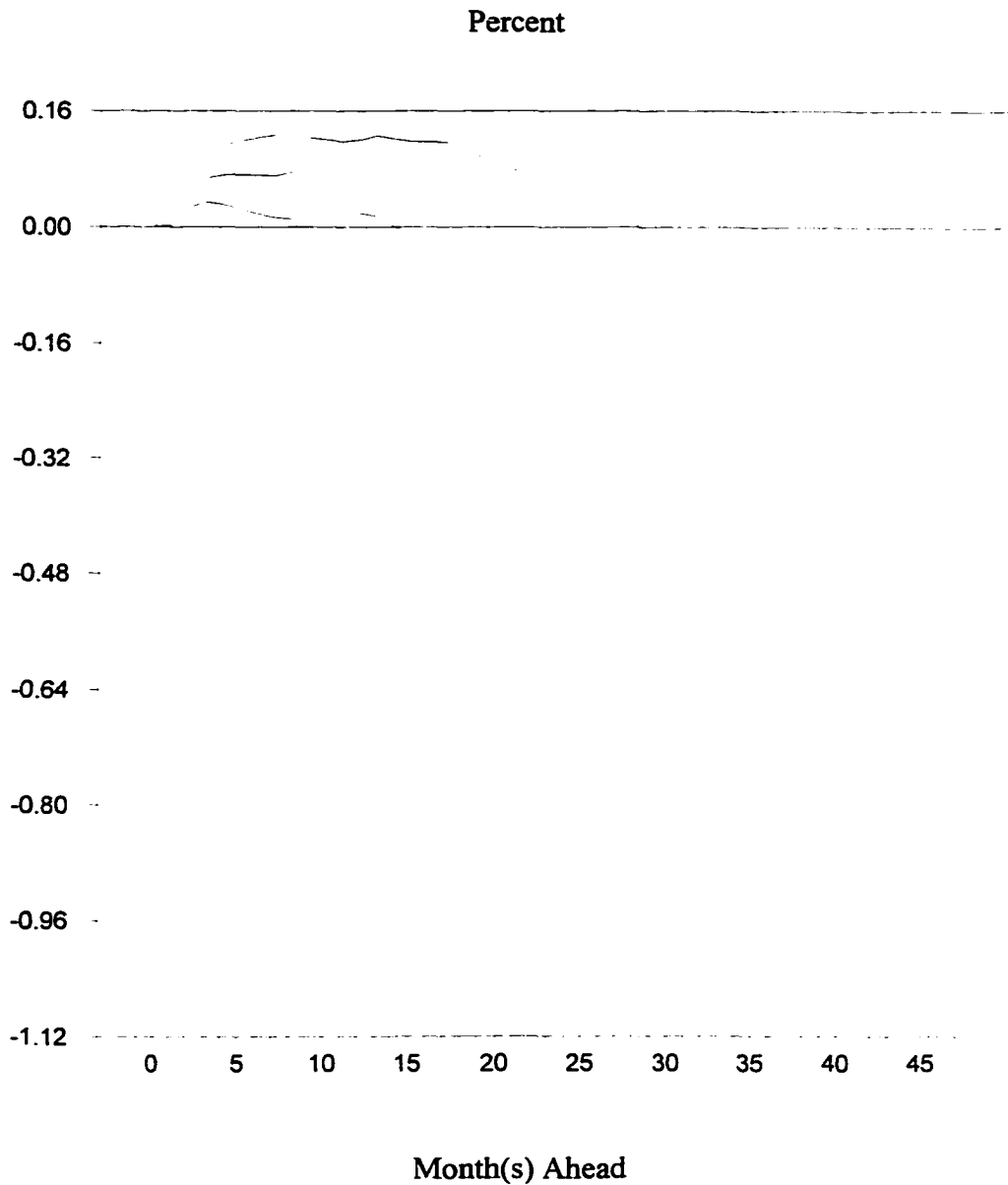


Figure 6.4 Response of P to FF Policy Shock

The impulse responses come from estimates from a 6-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), and the log of total reserves (TOTRES). The impulse responses are constructed at 48 months horizon.

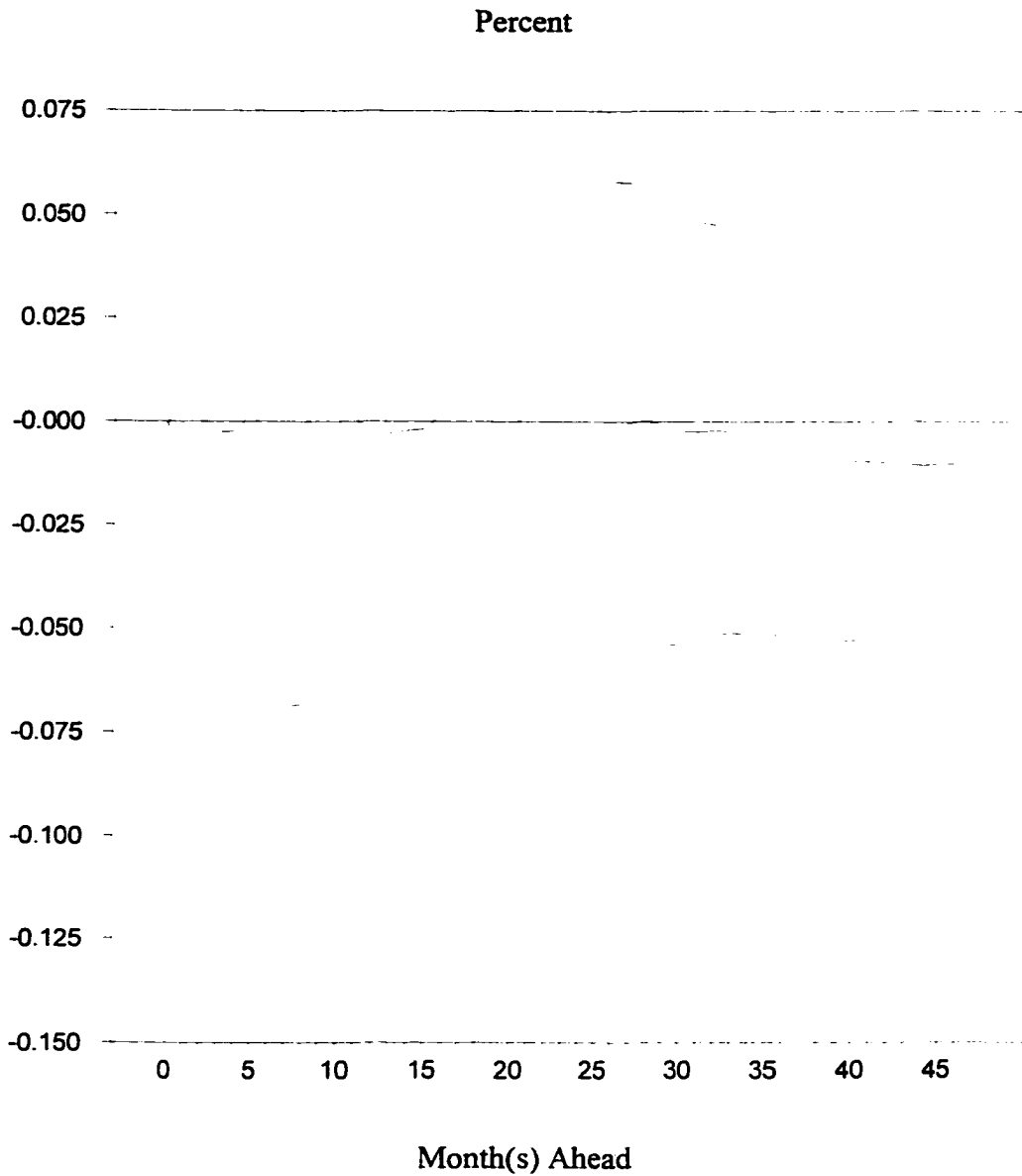


Figure 6.5 Response of PCOM to FF Policy Shock

The impulse responses come from estimates from a 6-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), and the log of total reserves (TOTRES). The impulse responses are constructed at 48 months horizon.

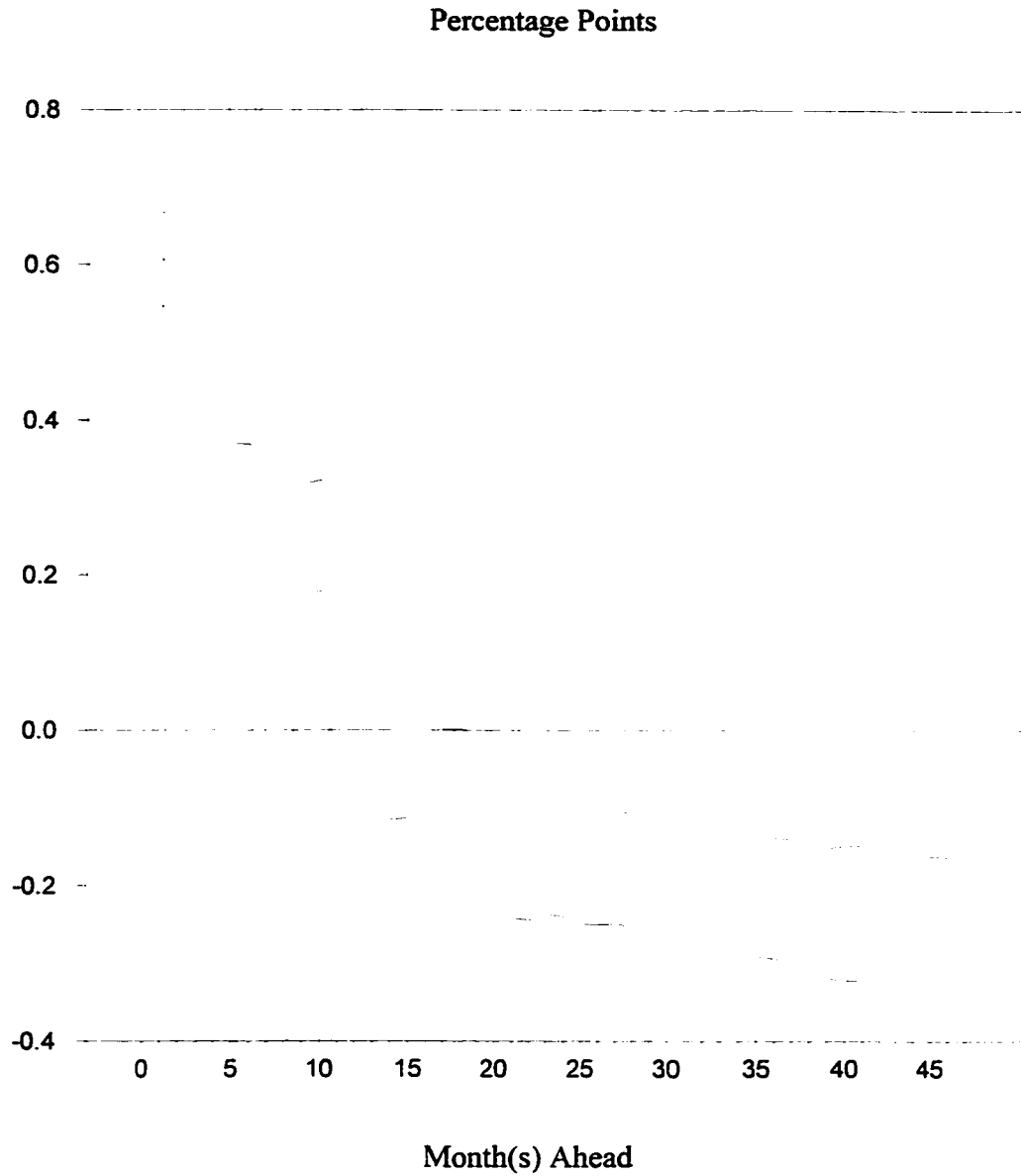


Figure 6.6 Response of FF to FF Policy Shock

The impulse responses come from estimates from a 6-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), and the log of total reserves (TOTRES). The impulse responses are constructed at 48 months horizon.

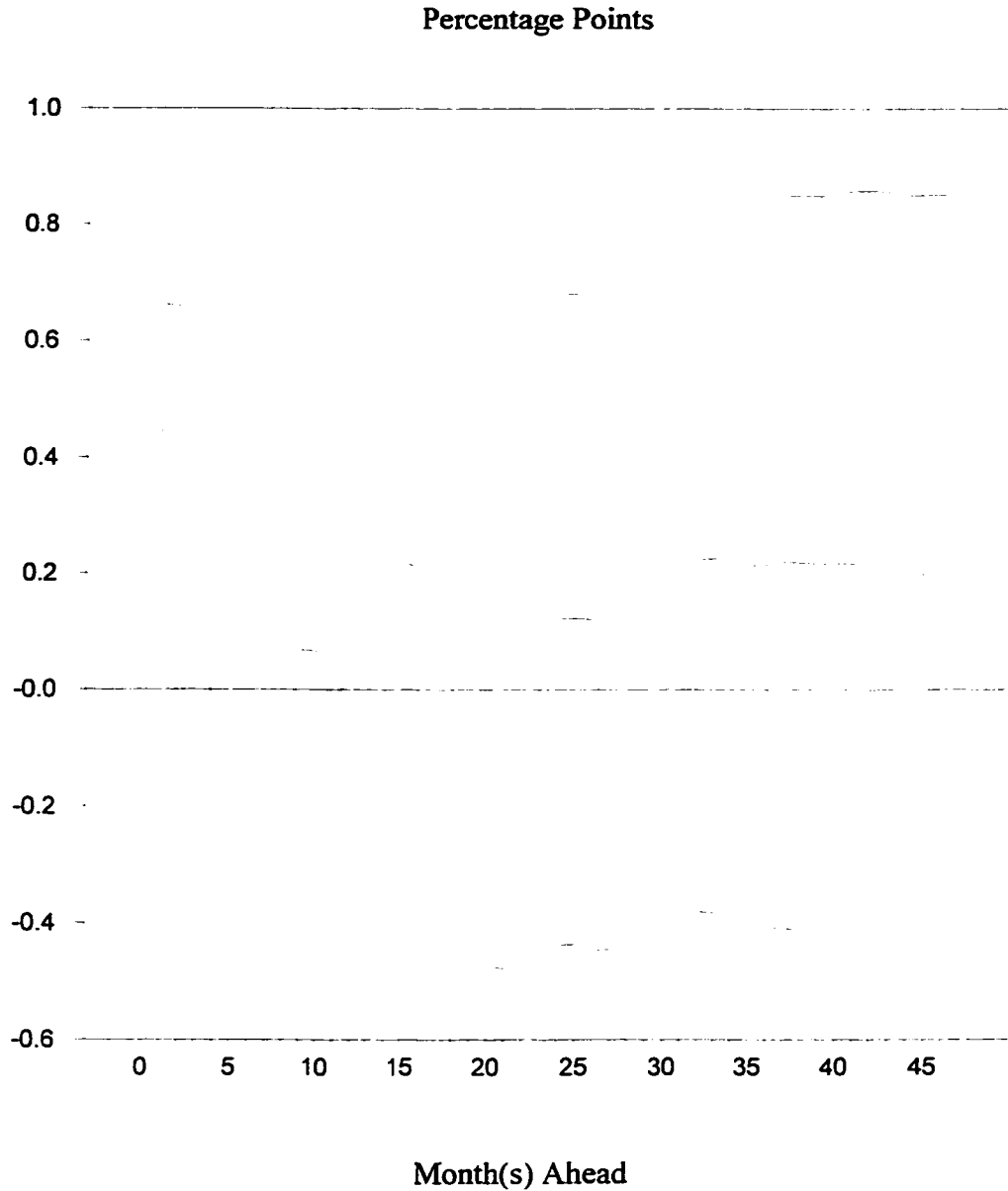


Figure 6.7 Response of NBRD to FF Policy Shock

The impulse responses come from estimates from a 6-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), and the log of total reserves (TOTRES). The impulse responses are constructed at 48 months horizon.

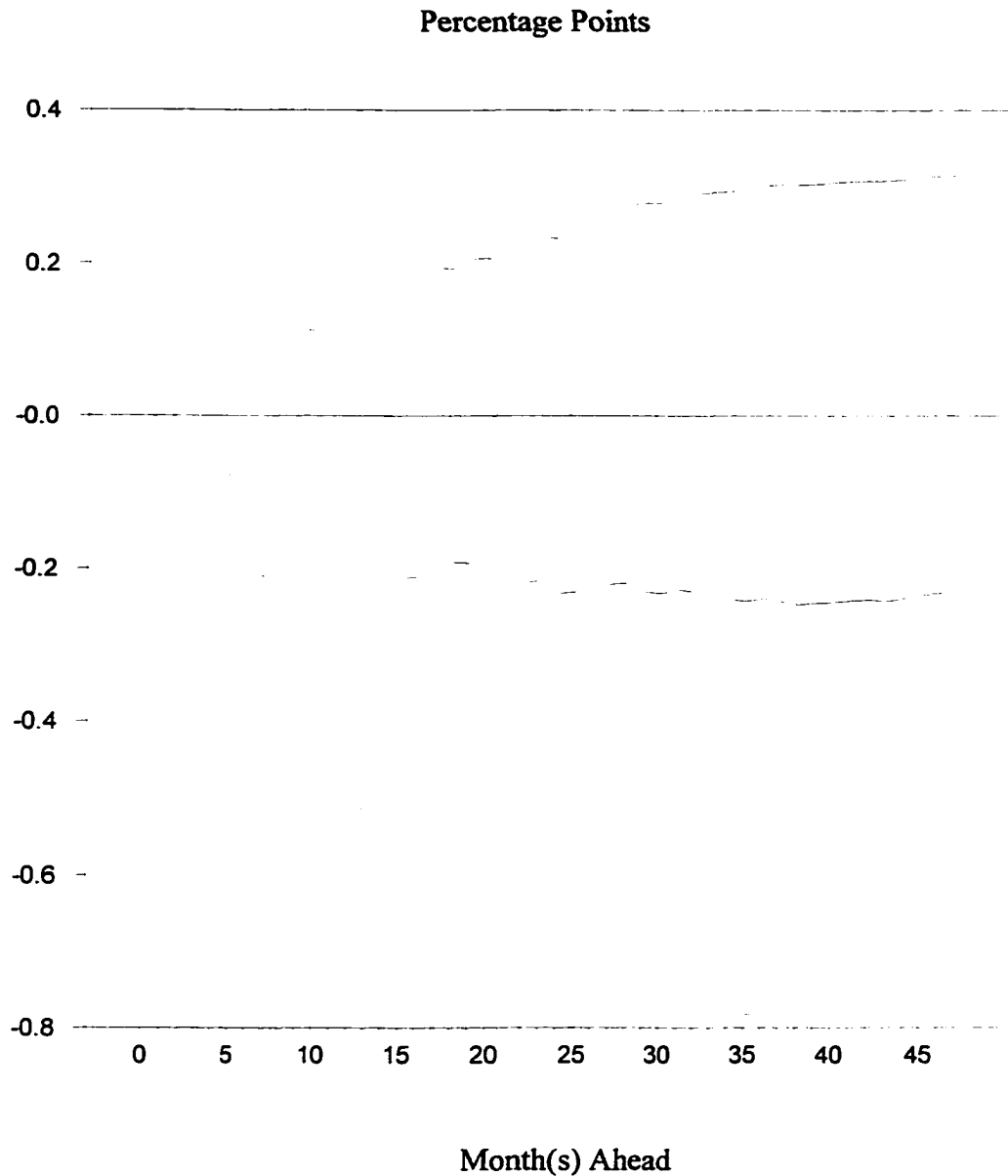


Figure 6.8 Response of TOTRES to FF Policy Shock

The impulse responses come from estimates from a 6-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), and the log of total reserves (TOTRES). The impulse responses are constructed at 48 months horizon.

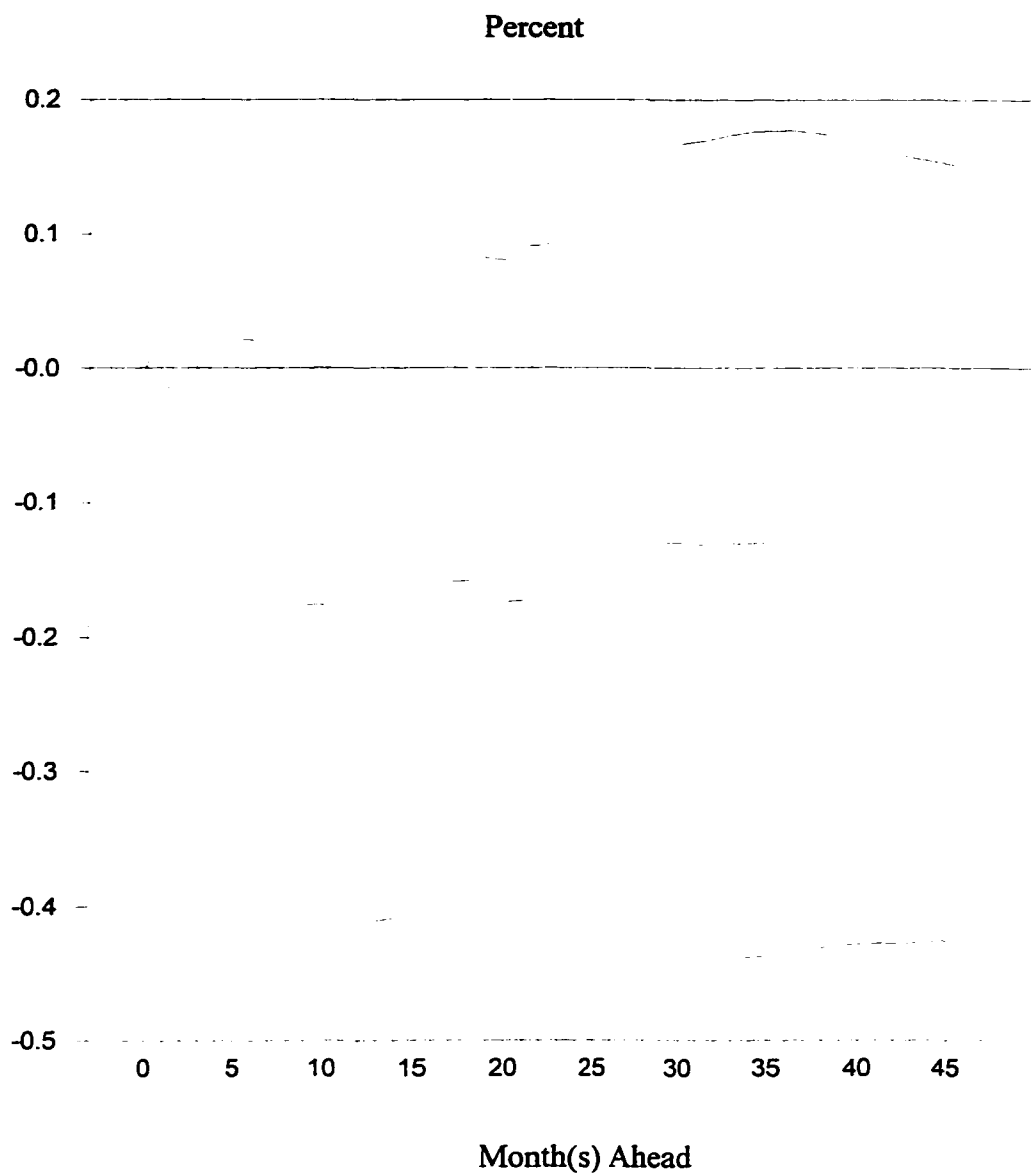


Figure 6.9 Response of Y to NBRD Policy Shock

The impulse responses come from estimates from a 6-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), and the log of total reserves (TOTRES). The impulse responses are constructed at 48 months horizon.

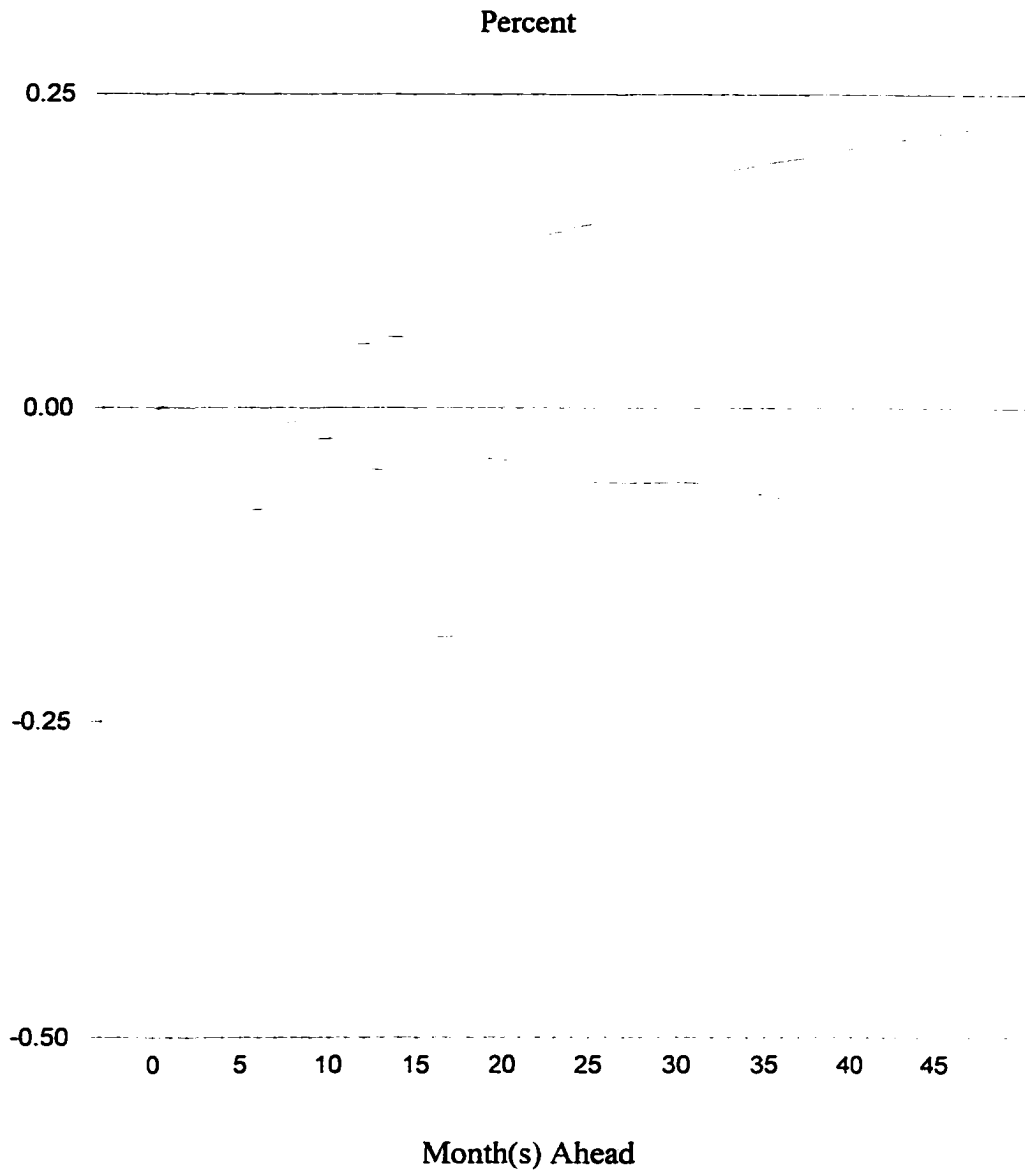


Figure 6.10 Response of P to NBRD Policy Shock.

The impulse responses come from estimates from a 6-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), and the log of total reserves (TOTRES). The impulse responses are constructed at 48 months horizon.

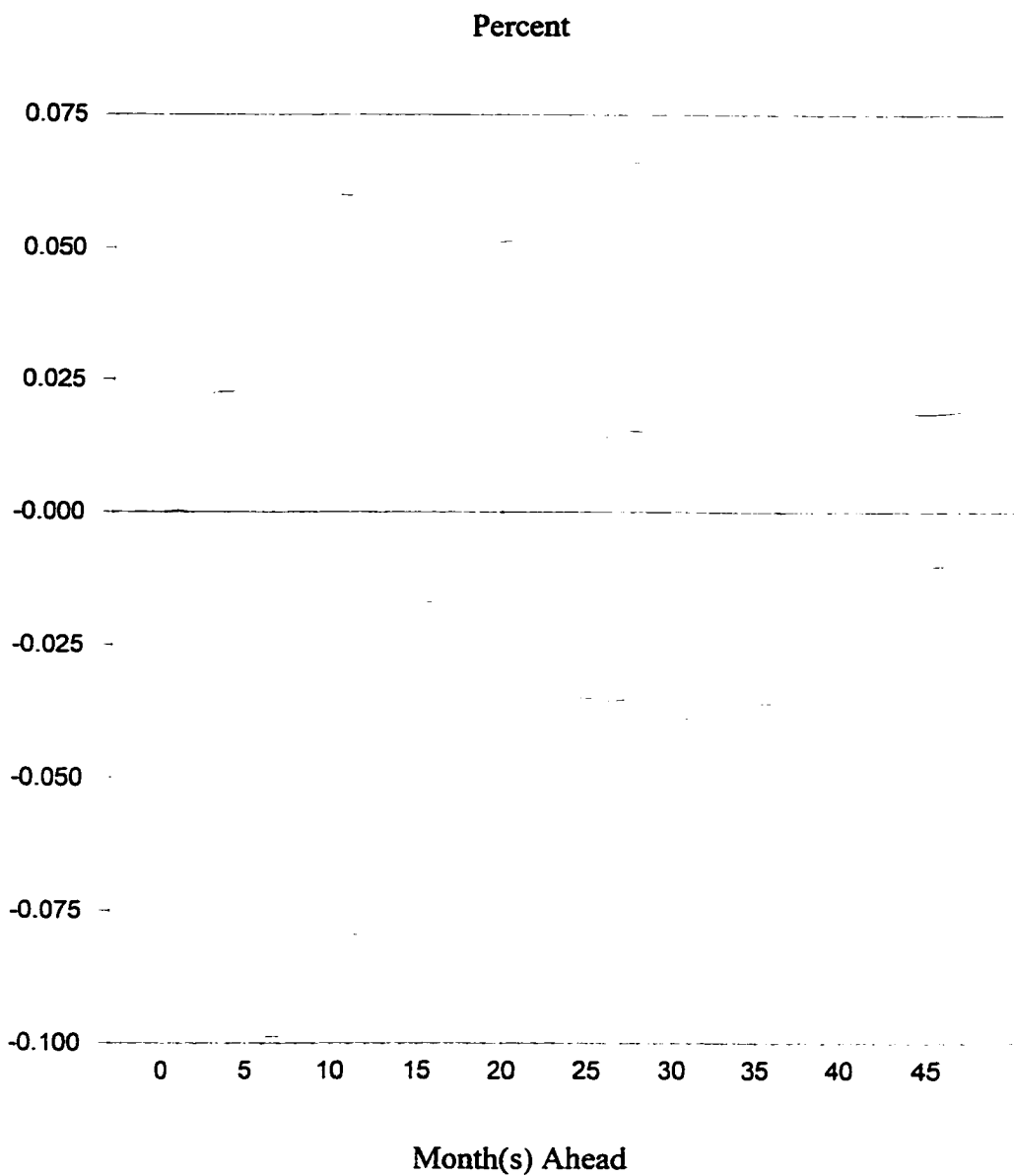


Figure 6.11 Response of PCOM to NBRD Policy Shock

The impulse responses come from estimates from a 6-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), and the log of total reserves (TOTRES). The impulse responses are constructed at 48 months horizon.

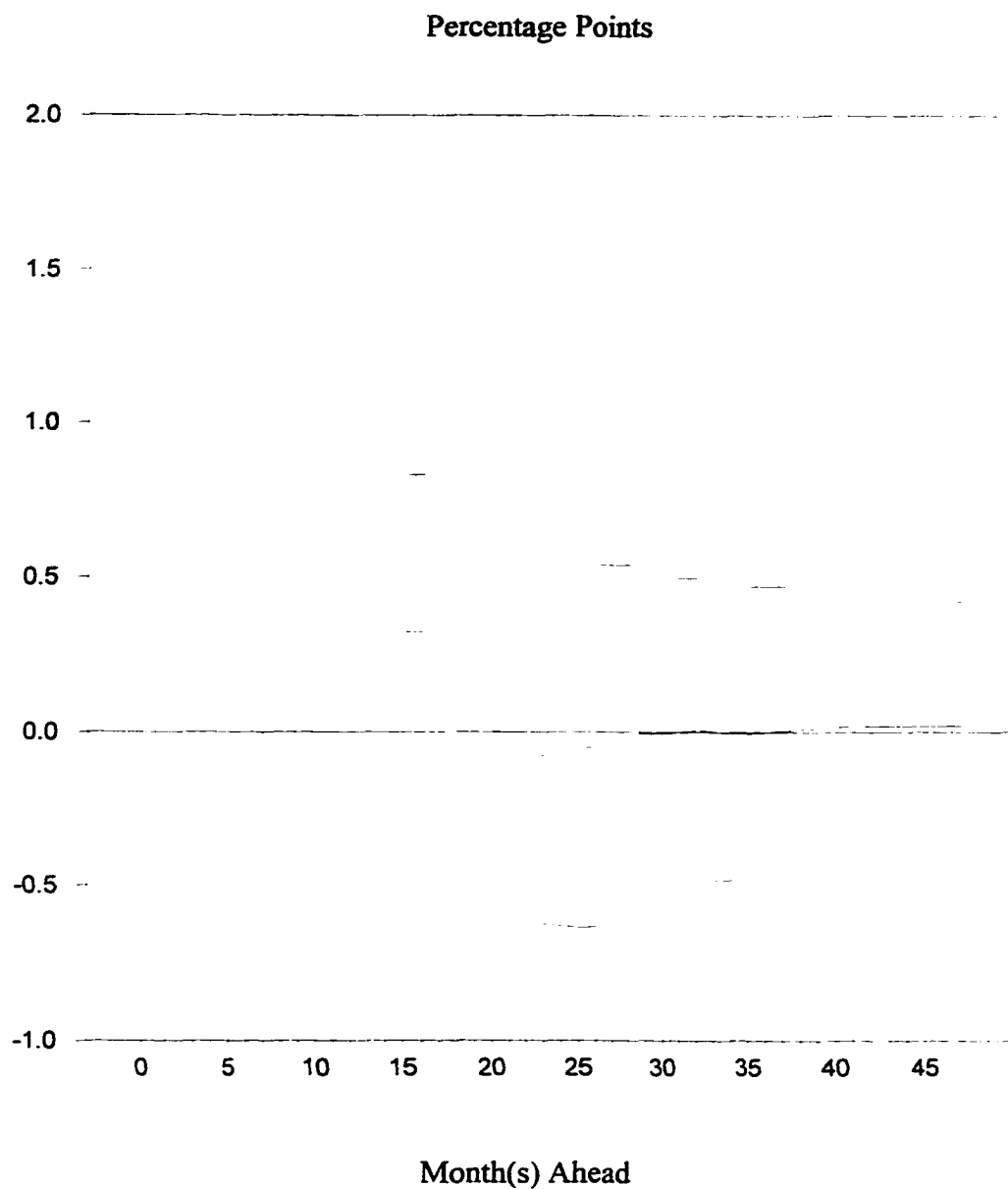


Figure 6.12 Response of NBRD to NBRD Policy Shock

The impulse responses come from estimates from a 6-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), and the log of total reserves (TOTRES). The impulse responses are constructed at 48 months horizon.

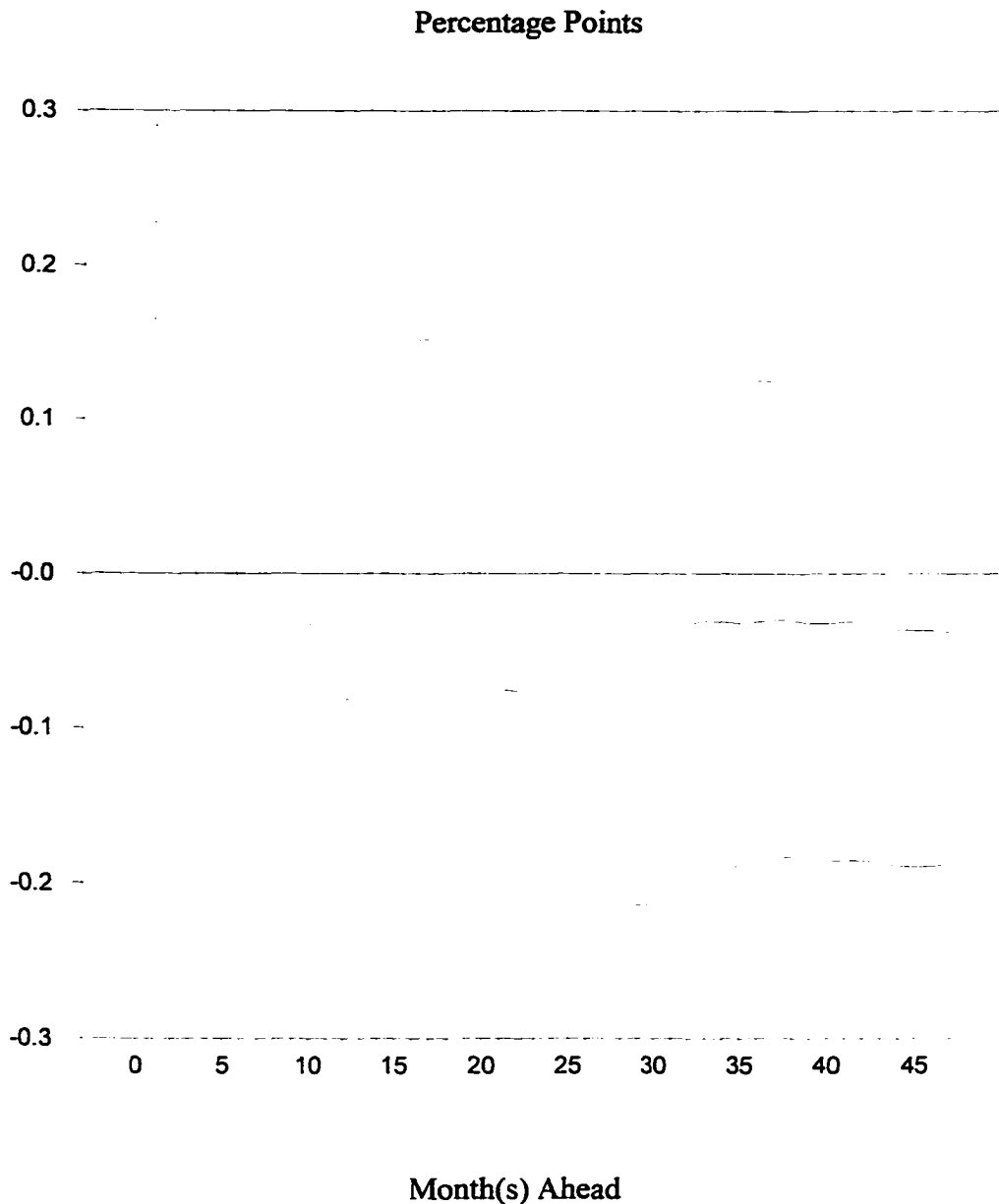


Figure 6.13 Response of FF to NBRD Policy Shock

The impulse responses come from estimates from a 6-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), and the log of total reserves (TOTRES). The impulse responses are constructed at 48 months horizon.

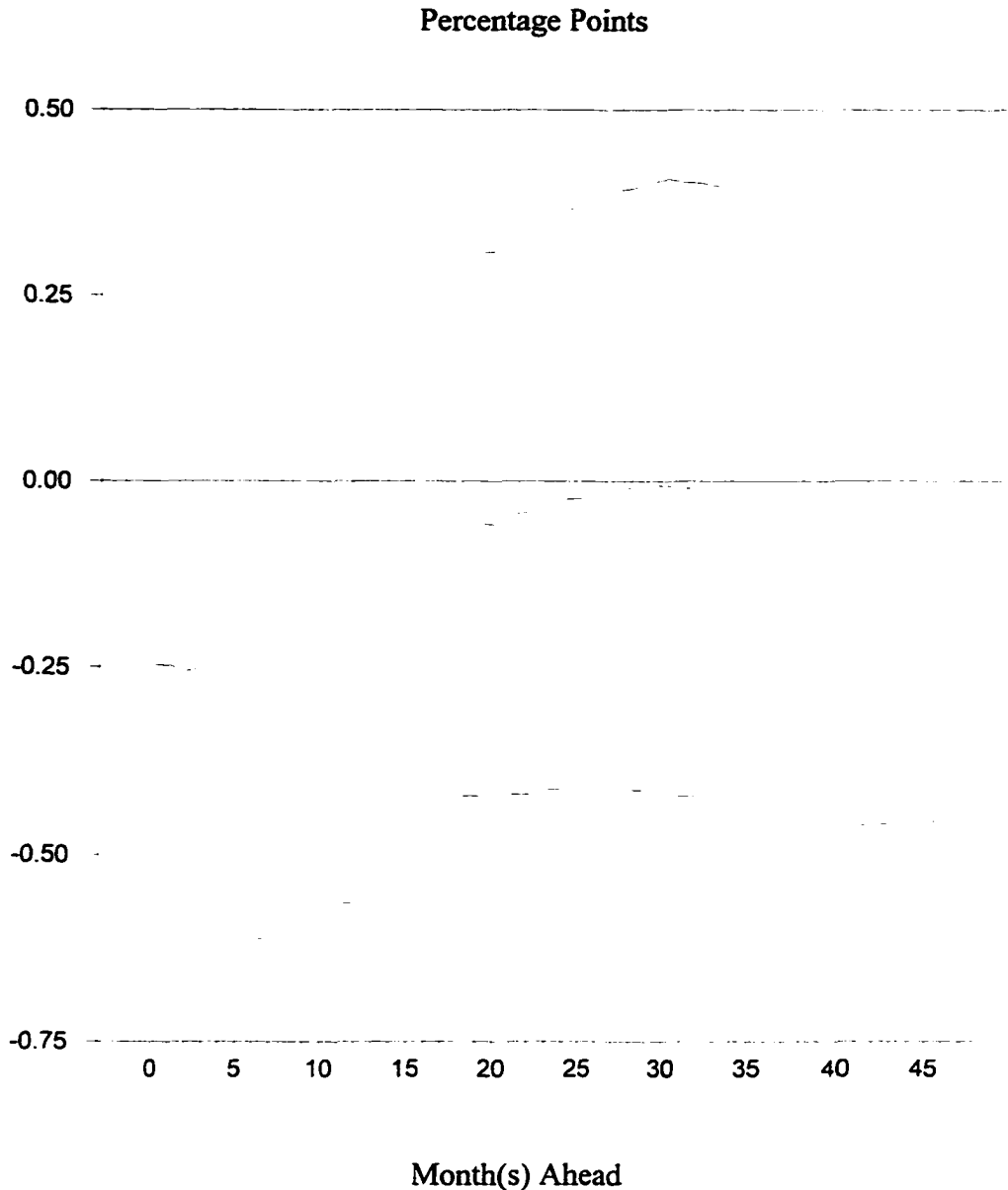


Figure 6.14 Response of TOTRES to NBRD Policy Shock

The impulse responses come from estimates from a 6-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), and the log of total reserves (TOTRES). The impulse responses are constructed at 48 months horizon.

decrease in nonborrowed reserves.²³ Strongin (1995) discusses this point in details.

As for the effects of the NBRD policy shock, with one exception, inference is quite robust to which of the two policy measures is used. The exception has to do with the degree to which total reserves are initially insulated from policy shocks. The FF measure implies that total reserves are insulated contemporaneously from monetary policy shocks, while the NBRD measure implies that roughly 30% of the policy shock is contemporaneously transmitted to total reserves.

The monthly monetary policy measures are used to identify the effects of monetary policy shocks on other macroeconomic variables. Variables such as M1 money supply (M1) - measured by the log of M1 money supply; the unemployment rate (UNRATE); and the level of employment (EMPL) - measured by the log of total nonfarm payroll employment, are closely related to monetary policy actions.²⁴ When FF is specified as the policy shock, the VAR ordering is Y, P, PCOM, FF, NBRD, TOTRES, and D, where D is either M1, UNRATE, or EMPL. When NBRD is specified as the policy shock, the VAR ordering is Y, P, PCOM, NBRD, FF, TOTRES, and D. Figures 6.15 to 6.20 display the impulse responses of M1, UNRATE, and EMPL to the policy shocks.

Consistent with the interpretation of a positive FF policy shock as reflecting a contractionary monetary policy, M1 declines in a statistically significant way. With an initial delay, similar to that of output, the FF policy shock leads to a significant increase in the unemployment rate and a significant decrease in employment. The dynamic response functions are qualitatively similar whether we work with FF or NBRD policy shocks.

²³ A given percentage change in total reserve and nonborrowed reserves correspond roughly to an equal dollar change in these variables. Historically nonborrowed reserves are roughly 95% of total reserves. Since 1986, the ratio has moved up, being above 98% most of the time.

²⁴ All data was obtained from the Federal Reserve Economic Data (FRED).

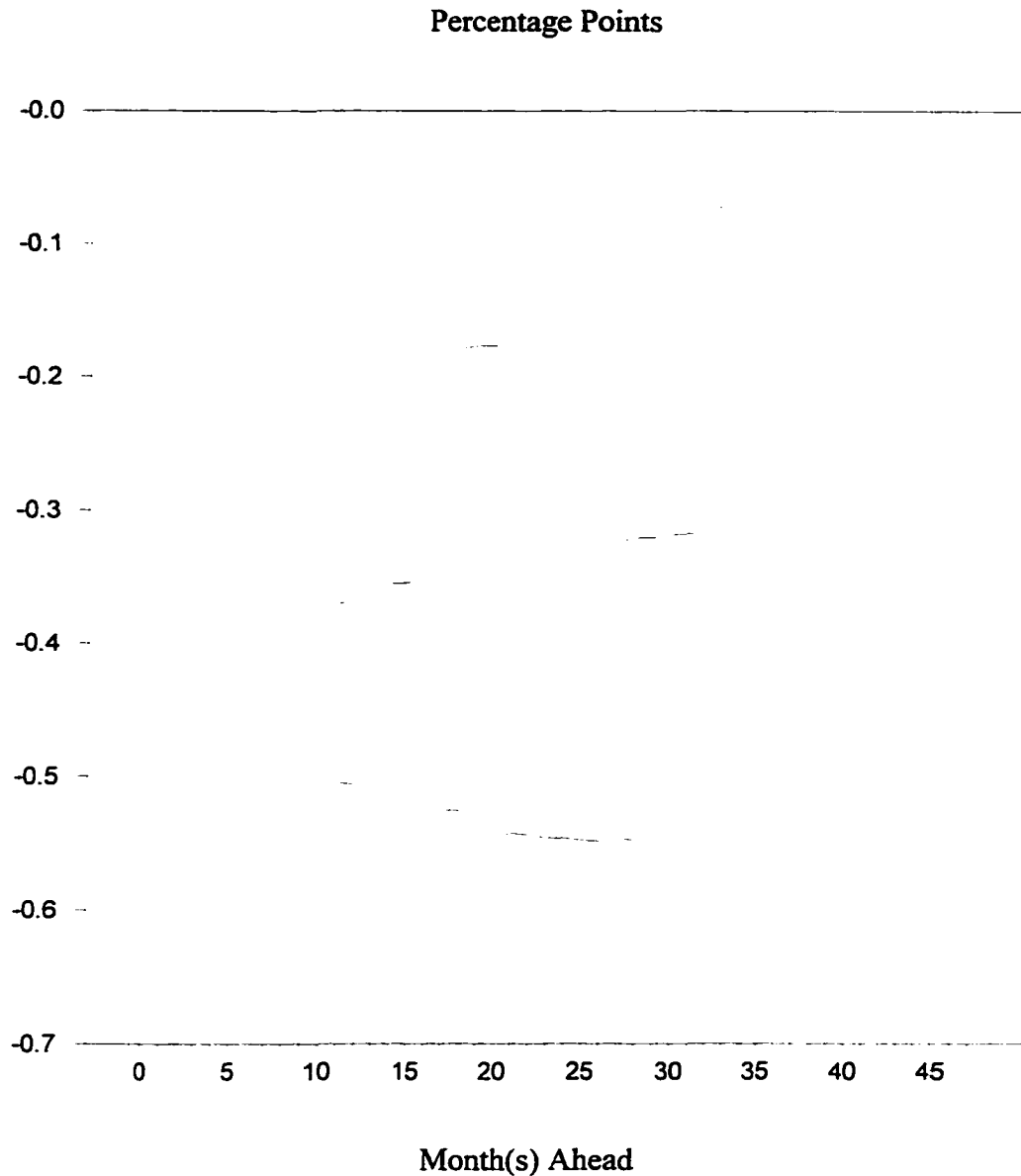


Figure 6.15 Response of M1 to FF Policy Shock

The impulse responses come from estimates from a 7-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), the log of total reserves (TOTRES), and the log of M1 money supply (M1). The impulse responses are constructed at 48 months horizon.

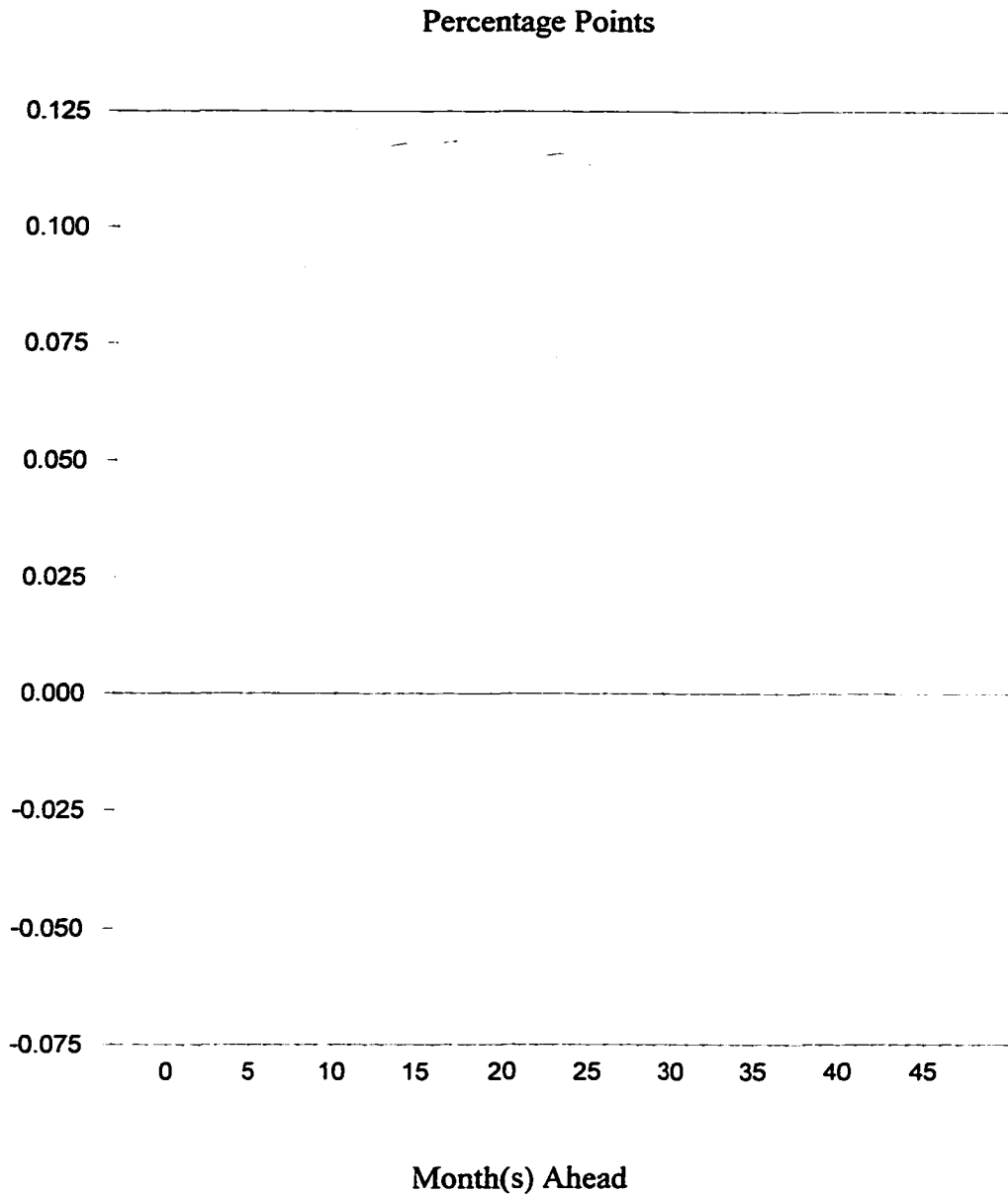


Figure 6.16 Response of UNRATE to FF Policy Shock

The impulse responses come from estimates from a 7-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), the log of total reserves (TOTRES), and the unemployment rate (UNRATE). The impulse responses are constructed at 48 months horizon.

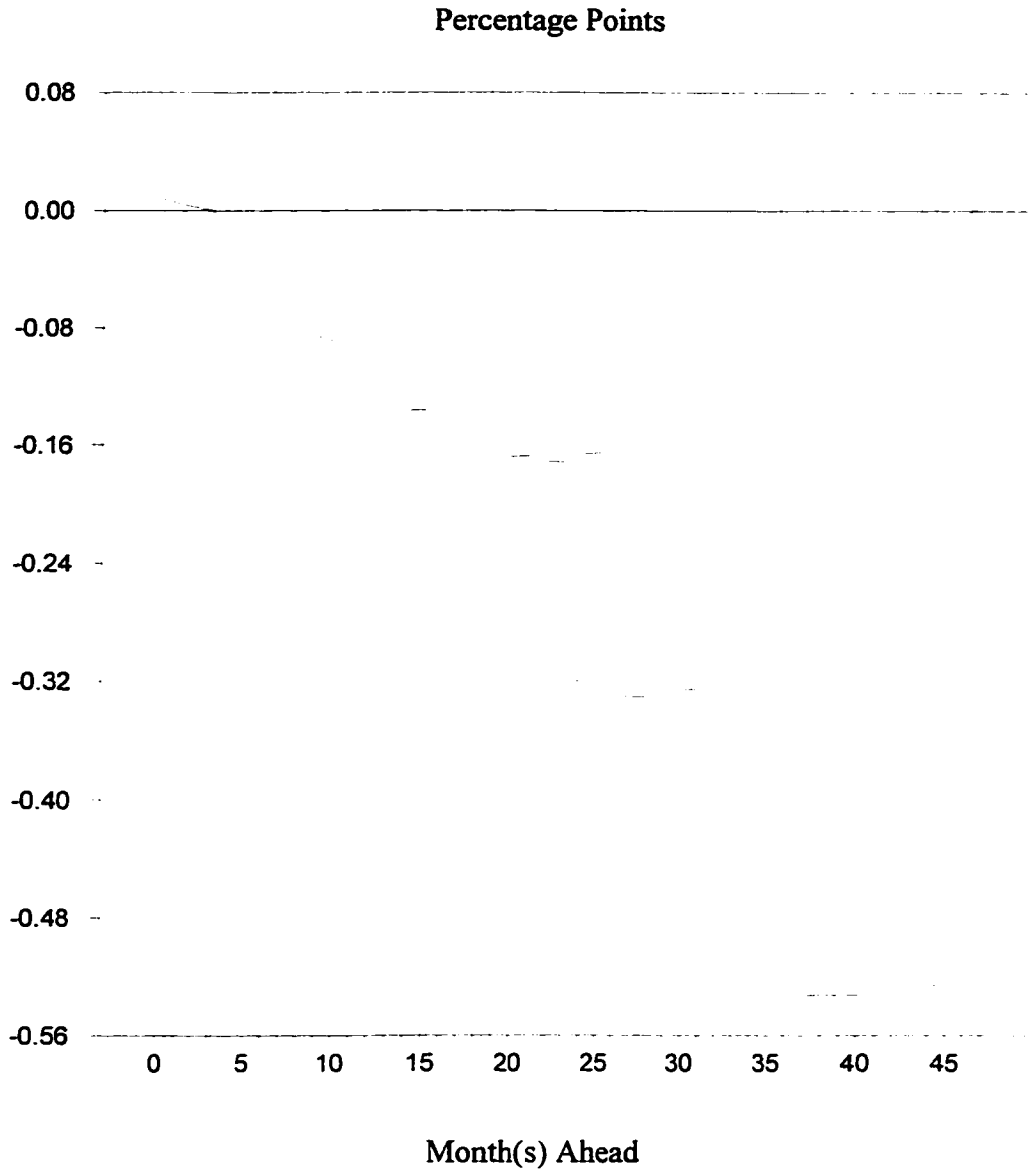


Figure 6.17 Response of EMPL to FF Policy Shock

The impulse responses come from estimates from a 7-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), the log of total reserves (TOTRES), and the log of total nonfarm payroll employment (EMPL). The impulse responses are constructed at 48 months horizon.

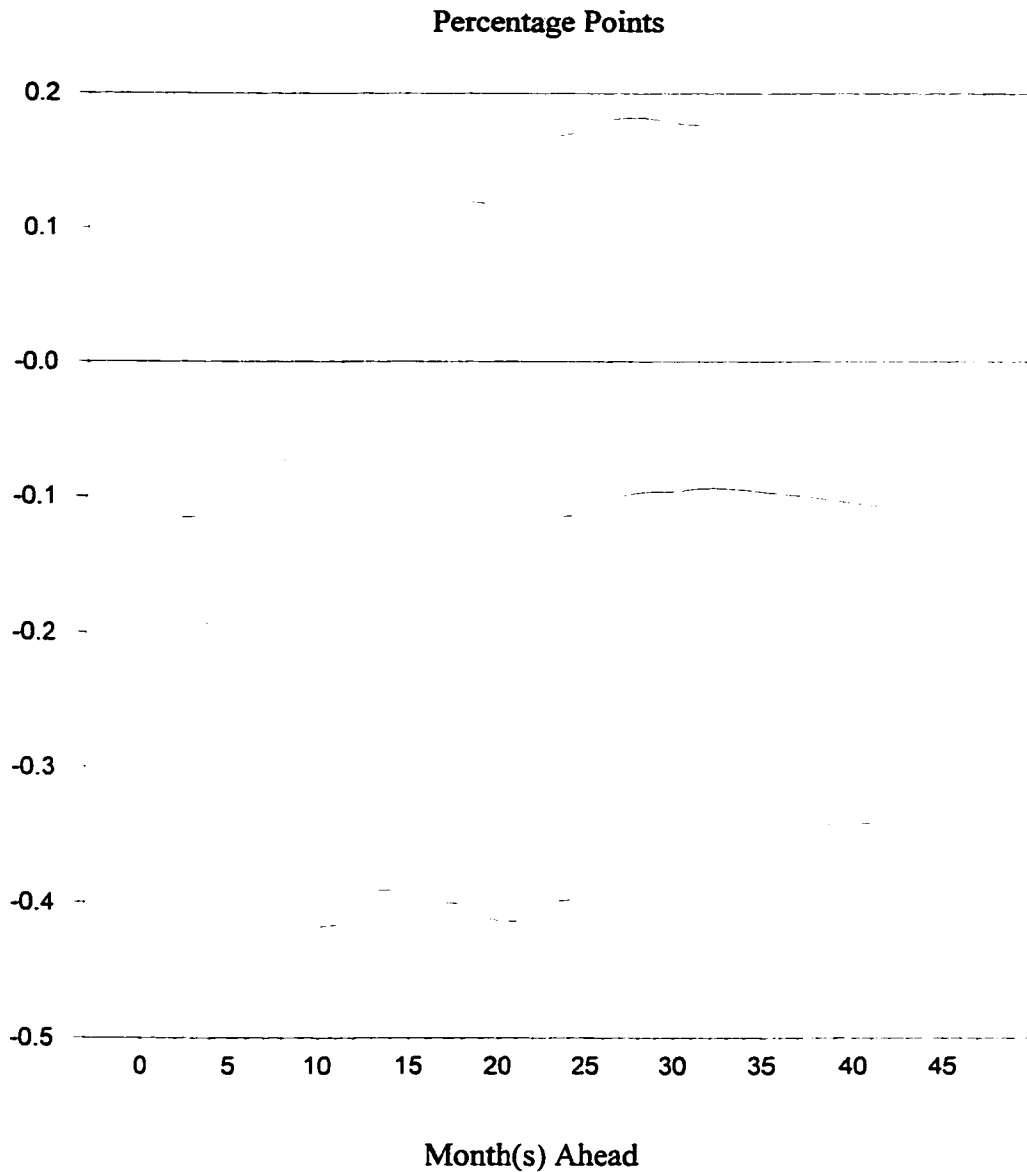


Figure 6.18 Response of M1 to NBRD Policy Shock

The impulse responses come from estimates from a 7-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), the log of total reserves (TOTRES), and the log of M1 money supply (M1). The impulse responses are constructed at 48 months horizon.

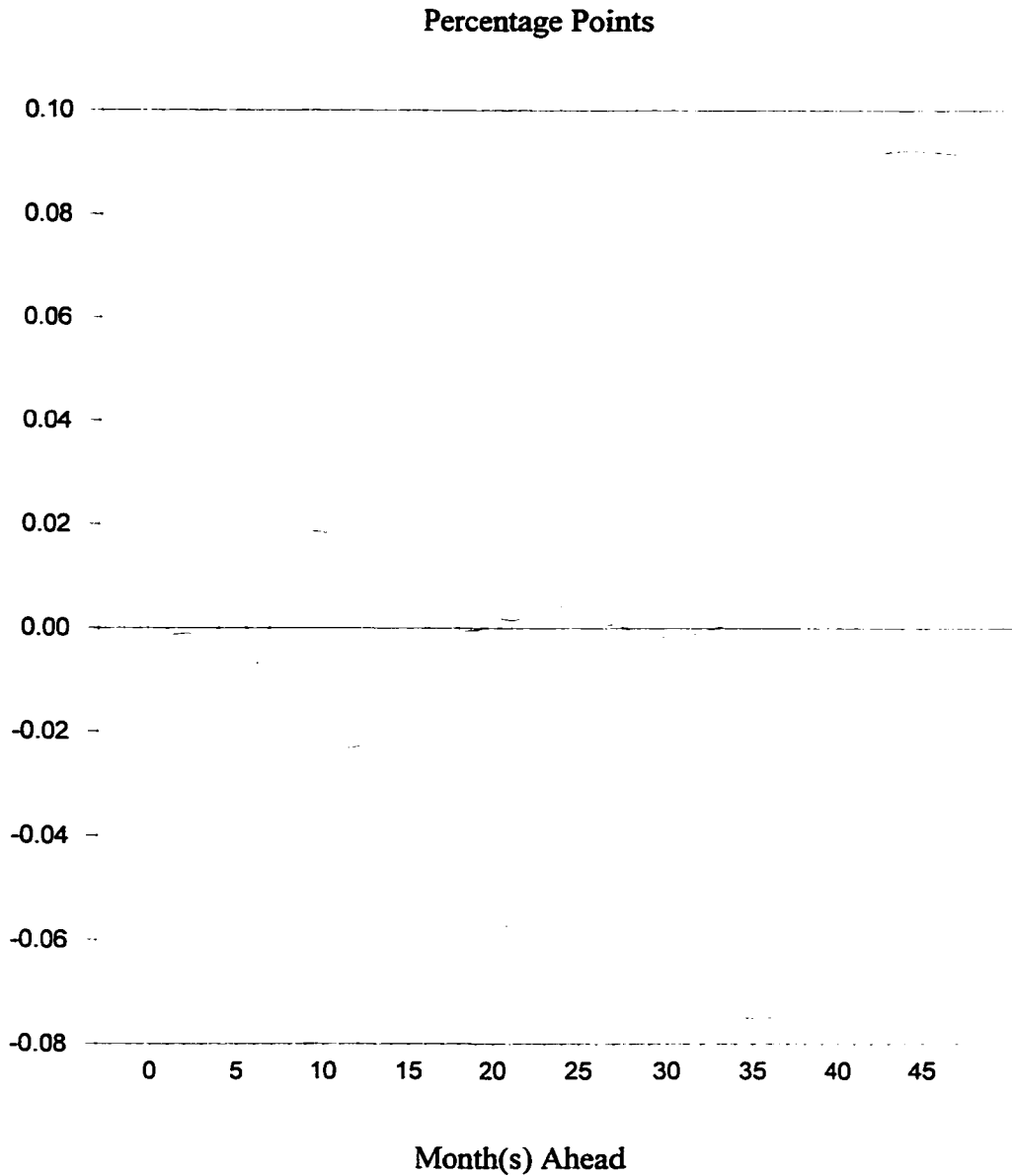


Figure 6.19 Response of UNRATE to NBRD Policy Shock

The impulse responses come from estimates from a 7-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), the log of total reserves (TOTRES), and the unemployment rate (UNRATE). The impulse responses are constructed at 48 months horizon.

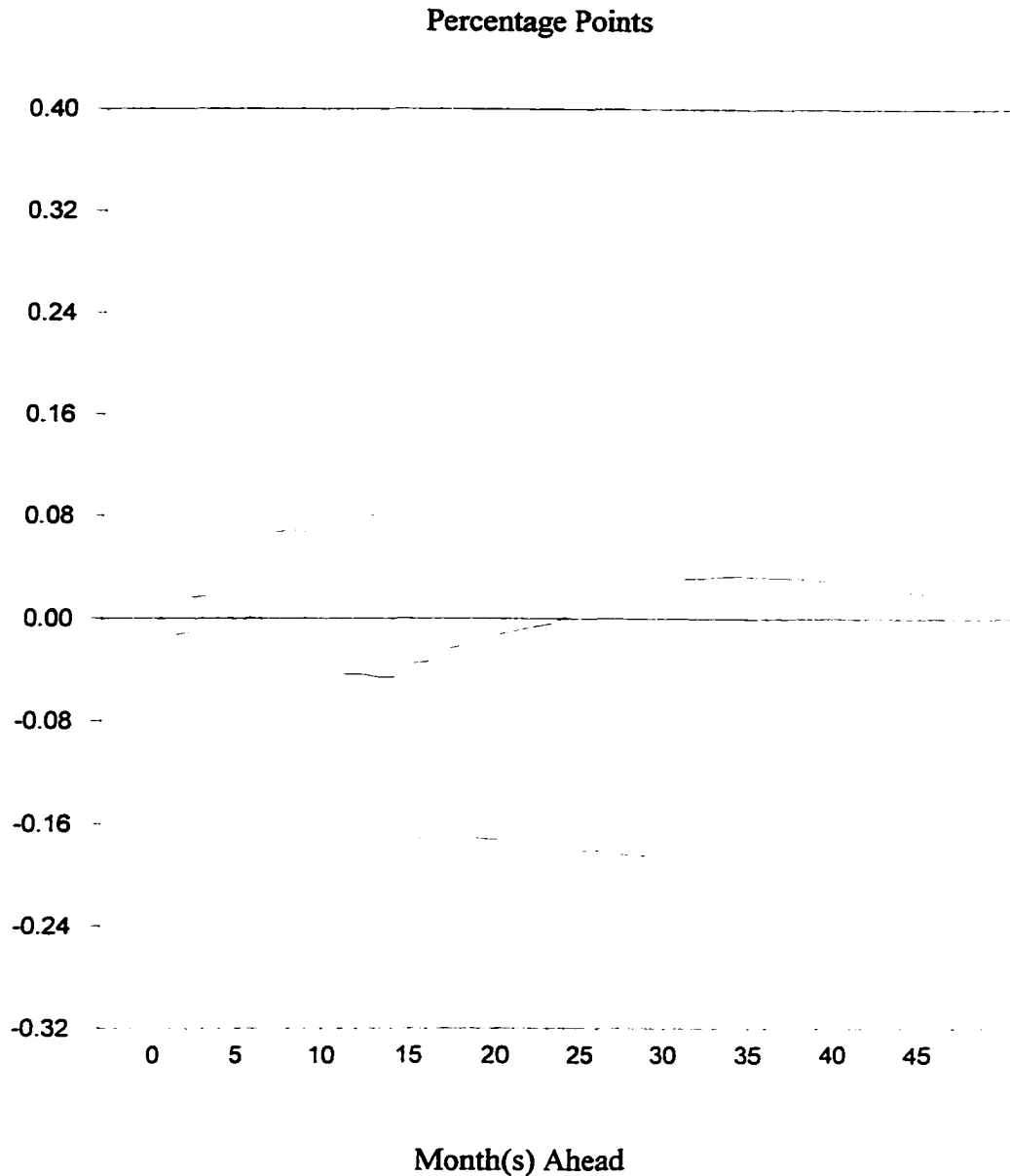


Figure 6.20 Response of EMPL to NBRD Policy Shock

The impulse responses come from estimates from a 7-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), the log of total reserves (TOTRES), and the log of total nonfarm payroll employment (EMPL). The impulse responses are constructed at 48 months horizon.

Tables 6.1 and 6.2 show the variance decompositions for each variable - the percentage of the forecast error variance attributable to the policy shock. The FF policy shock accounts for 41%, 8.2% and 30.9% of the 48-month ahead forecast error variance of output, the unemployment rate, and employment, while the NBRD policy shock accounts for 5.5%, 0.3%, and 0.5%. So, monetary policy shocks seem to be an important contributor to aggregate fluctuations. The effects associated with FF policy shock are much larger than those associated with NBRD policy shock. The forecast standard errors increase towards an upper bound for each variable indicating that the VAR system is stationary.

In summary, the results in this section support the view that FF and NBRD policy shocks are reasonable measures of monetary policy shocks. Other alternative interpretations seem implausible. For example, the view that a contractionary FF policy shock really reflects a contractionary shock to money demand (rather than supply) seems hard to square with the finding that total reserves and M1 fall after an FF policy shock. The view that a contractionary NBRD policy shock reflects a contractionary money demand shock is difficult to reconcile with the fact that it is followed by a rise in the interest rate and the unemployment rate, as well as a fall in output. The view that contractionary FF policy shock reflects an increase in household and/or business optimism seems hard to reconcile with the fall in aggregate economic activity that follows the FF policy shock. Finally, a rise in interest rates due to a shock generating a sectoral reallocation of resources, such as an oil price shock, could lead to an initial fall in aggregate economic activity. However, this seems implausible given the persistence of the fall in aggregate economic activity that occurs after contractionary FF and NBRD policy shocks.

Table 6.1 Variance Decompositions for the Variables in the VAR Model

Variable	Month(s) Ahead	FF Policy Shock	NBRD Policy Shock
Y	1	0.0% (0.464)	0.0% (0.462)
	6	3.1% (1.396)	0.8% (1.396)
	12	19.9% (2.071)	4.3% (2.071)
	24	42.0% (3.000)	6.8% (3.000)
	48	41.0% (4.394)	5.5% (4.3947)
P	1	0.0% (0.002)	0.0% (0.002)
	6	4.8% (0.006)	0.5% (0.006)
	12	2.9% (0.011)	0.5% (0.011)
	24	1.7% (0.025)	0.8% (0.025)
	48	15.6% (0.051)	1.1% (0.051)
PCOM	1	0.0% (0.111)	0.0% (0.111)
	6	1.7% (0.614)	0.4% (0.614)
	12	5.4% (0.758)	0.9% (0.758)
	24	7.5% (0.869)	1.0% (0.869)
	48	6.8% (0.928)	1.1% (0.928)
FF	1	94.8% (0.484)	7.1% (0.484)
	6	63.5% (1.414)	6.4% (1.414)
	12	43.9% (1.798)	4.4% (1.798)
	24	28.0% (2.271)	3.4% (2.271)
	48	25.5% (2.688)	2.8% (2.688)
NBRD	1	7.2% (0.016)	96.7% (0.015)
	6	10.5% (0.037)	89.3% (0.037)
	12	6.7% (0.048)	55.3% (0.048)
	24	3.3% (0.072)	26.1% (0.072)
	48	3.1% (0.086)	18.5% (0.086)
TOTRES	1	2.6% (0.008)	16.7% (0.008)
	6	1.1% (0.020)	19.7% (0.020)
	12	2.2% (0.033)	14.4% (0.033)
	24	2.7% (0.052)	6.5% (0.052)
	48	4.4% (0.066)	4.0% (0.066)

Note: Standard errors of forecast are in parentheses.

Table 6.2 Variance Decompositions for Other Macroeconomic Variables

Variable	Month(s) Ahead	FF Policy Shock	NBRD Policy Shock
M1	1	1.3% (0.003)	4.0% (0.003)
	6	22.8% (0.011)	13.0% (0.011)
	12	26.8% (0.019)	12.0% (0.019)
	24	26.8% (0.031)	7.4% (0.031)
	48	34.8% (0.039)	6.8% (0.039)
UNRATE	1	0.7% (0.148)	0.2% (0.148)
	6	0.6% (0.401)	0.0% (0.401)
	12	3.7% (0.593)	0.4% (0.593)
	24	10.9% (0.790)	0.5% (0.790)
	48	8.2% (1.119)	0.3% (1.119)
EMPL	1	0.1% (0.002)	0.0% (0.002)
	6	3.3% (0.006)	0.1% (0.006)
	12	12.6% (0.011)	0.5% (0.011)
	24	29.8% (0.019)	0.4% (0.019)
	48	30.9% (0.032)	0.5% (0.032)

Note: Standard errors of forecast are in parentheses.

The Effects of Monetary Policy Shocks on Farm Prices

The monetary policy measures are used to identify the effects of monetary policy shocks on relative farm prices (FP) - measured by the index of prices received by farmers deflated by the CPI-U.²⁵ When FF is specified as the policy shock, the VAR ordering is Y, P, PCOM, FF, NBRD, TOTRES, and FP. When NBRD is specified as the policy shock, the VAR ordering is Y, P, PCOM, NBRD, FF, TOTRES, and FP.

²⁵ Farm prices measured by the index of prices received by farmers were obtained from the National Agricultural Statistics Service of the U.S. Department of Agriculture.

Figures 6.21 to 6.22 display the impulse response functions of FP to monetary policy shocks. A contractionary FF policy shock leads to an immediate and sustained, statistically significant drop in relative farm prices. The impulse response function of FP to NBRD policy shock is qualitatively similar though statistically not as significant. Actually, the point estimates show a small, statistically significant fall. These findings are consistent with the Cairnes-Bordo theory that agricultural prices respond more rapidly than industrial prices to monetary policy shocks.

Table 6.3 shows that a relatively small proportion of the forecast error variance of FP can be attributed to monetary policy shocks. Given the size and number of real agricultural shocks, these shocks obviously account for much of FP volatility. Thus, it appears that the linkage between monetary policy and the agricultural sector, while statistically significant, is weaker than effects arising directly within the agricultural sector. However, as time wears on, monetary policy shocks explain successively more and more of the forecast error variance in FP.

As a check on the robustness of the results, the monthly VAR model is reestimated using a different ordering with total nonfarm payroll employment (EMPL) included. Employment is an important measure of the performance of the economy that policy makers watch and utilize in the formulation of policy. Total nonfarm payroll employment (EMPL) is used instead of the unemployment rate (UNRATE) because it is based on much more solid statistical information (establishment survey data) than is the unemployment rate (household survey data). Figures 6.23 and 6.24 display the effects of FF and NBRD policy shocks on FP. As can be seen, the basic results are quite robust to specification.

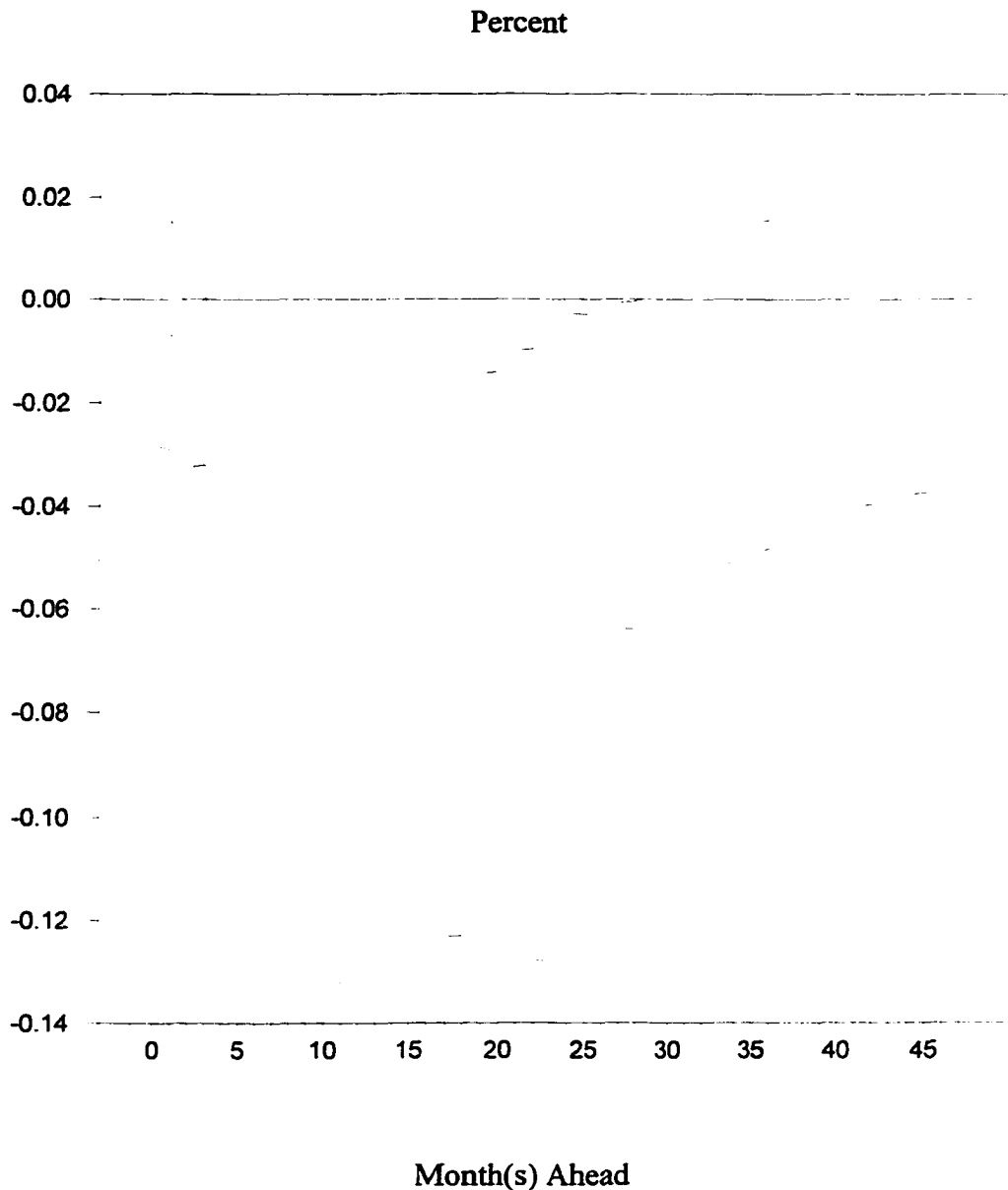


Figure 6.21 Response of FP to FF Policy Shock

The impulse responses come from estimates from a 7-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), the log of total reserves (TOTRES), and the farm price index (FP). The impulse responses are constructed at 48 months horizon.

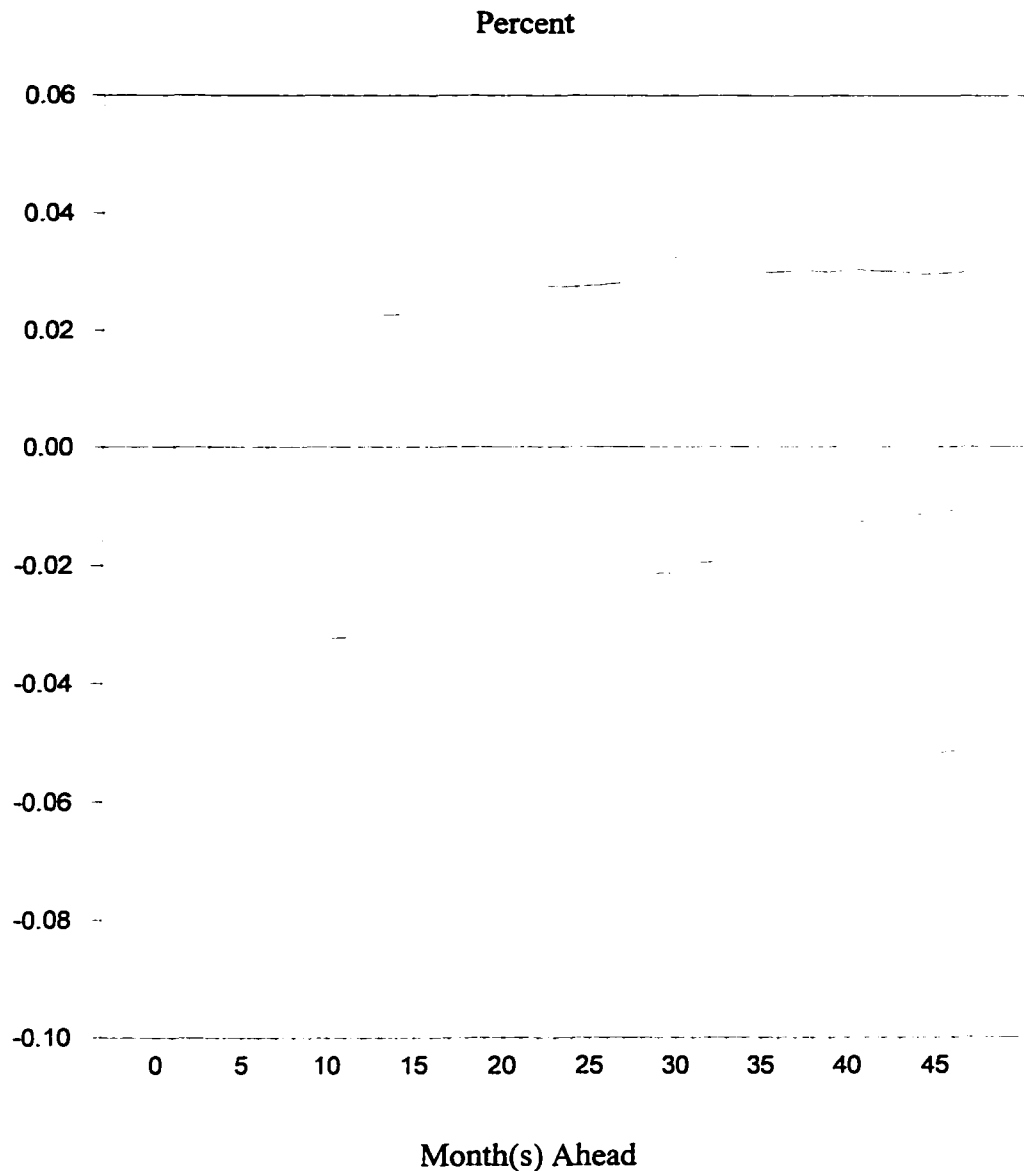


Figure 6.22 Response of FP to NBRD Policy Shock

The impulse responses come from estimates from a 7-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), the log of total reserves (TOTRES), and the farm price index (FP). The impulse responses are constructed at 48 months horizon.

Table 6.3 Variance Decompositions for Farm Prices

Variable	Month(s) Ahead	FF Policy Shock*	NBRD Policy Shock**
FP	1	0.5% (0.180)	0.2% (0.180)
	6	5.2% (0.425)	0.2% (0.425)
	12	10.3% (0.597)	0.7% (0.597)
	24	16.3% (0.743)	2.0% (0.743)
	48	22.2% (0.823)	2.5% (0.823)

Note: Standard errors of forecast are in parentheses.

* The estimates come from a 7-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), the log of total reserves (TOTRES), and the farm price index (FP).

** The estimates come from a 7-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), the log of total reserves (TOTRES), and the farm price index (FP).

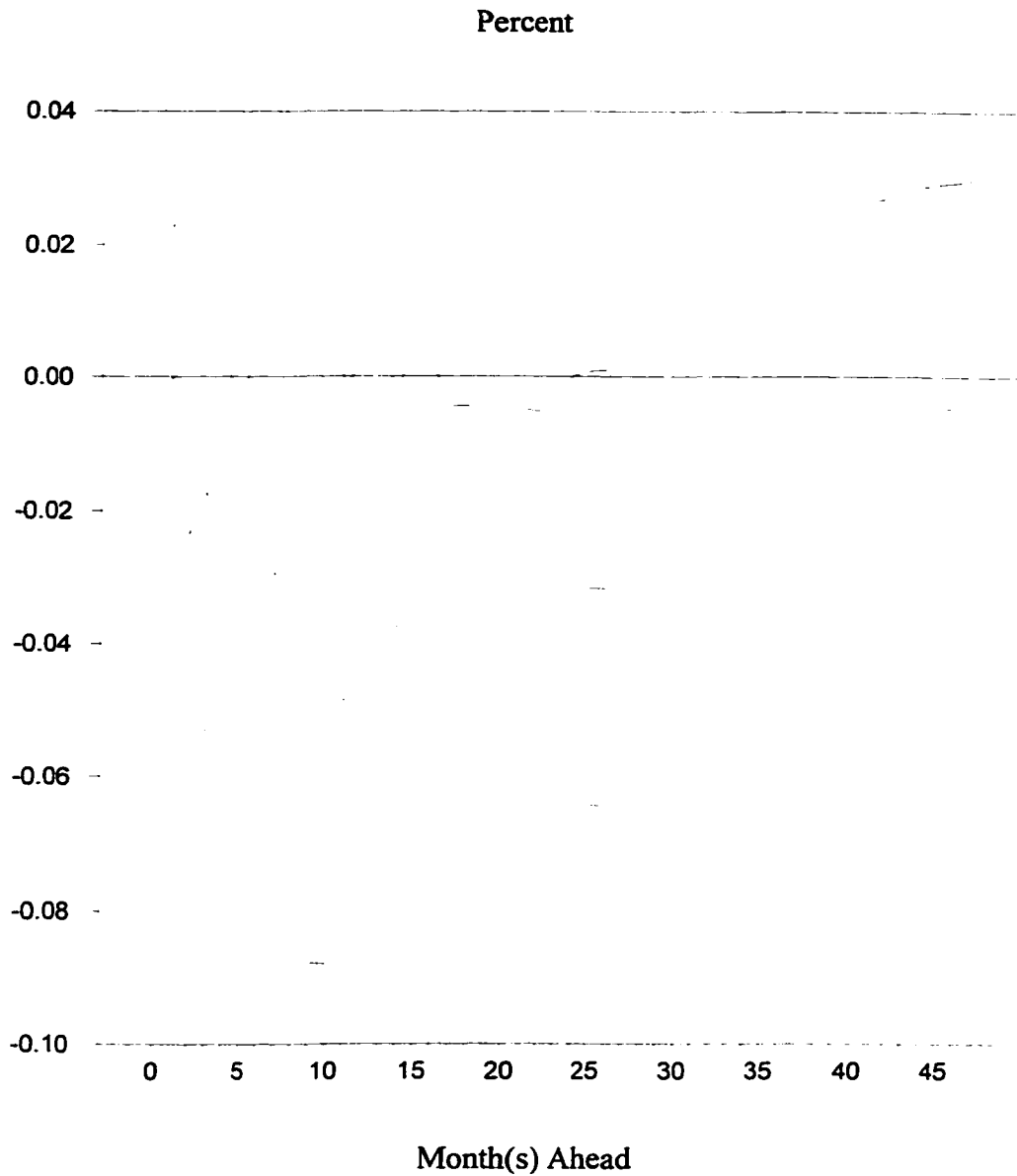


Figure 6.23 Response of FP to FF Policy Shock

The impulse responses come from estimates from a 6-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), the log of total nonfarm payroll employment (EMPL), the federal funds rate (FF), and the farm price index (FP). The impulse responses are constructed at 48 months horizon.

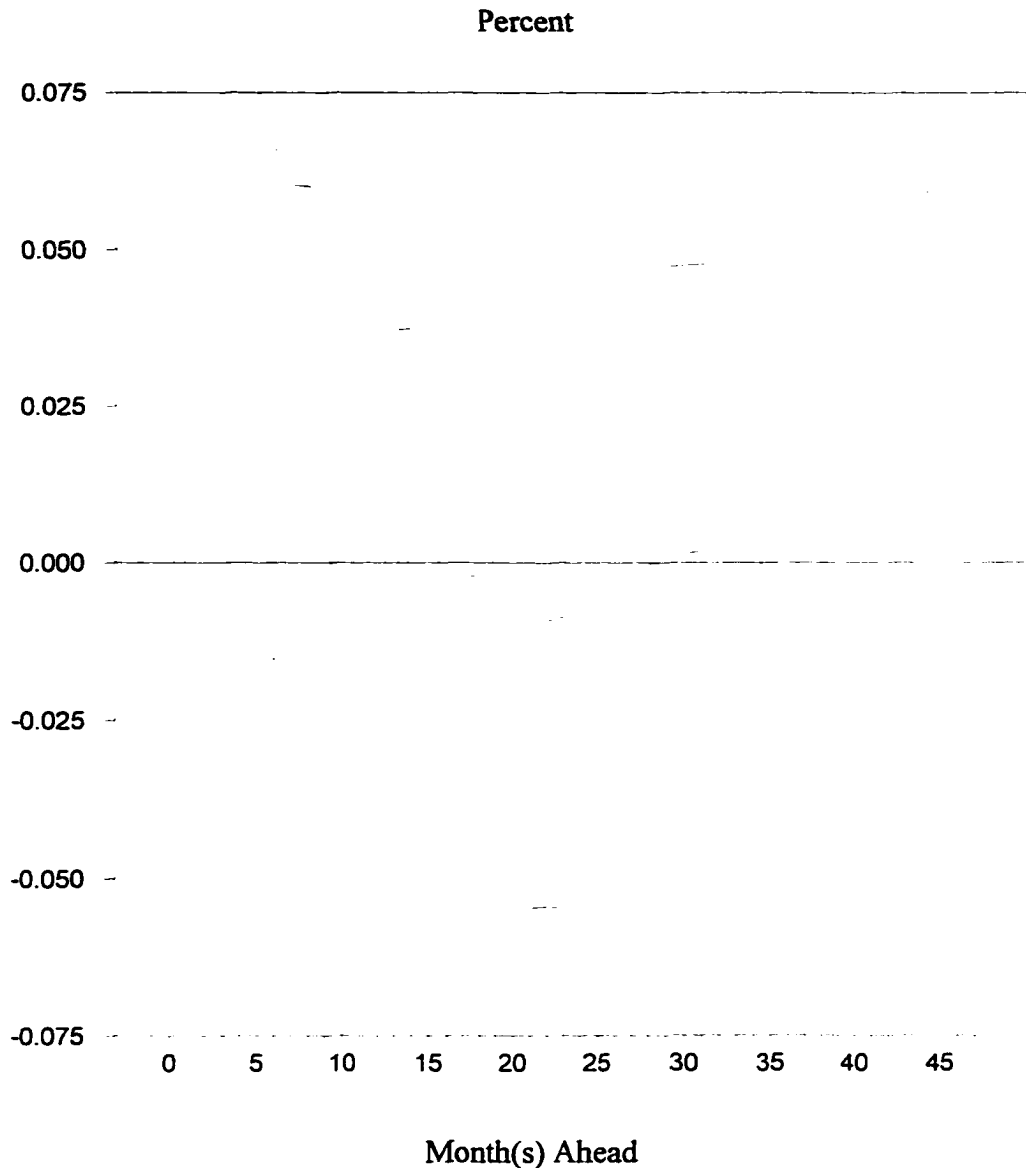


Figure 6.24 Response of FP to NBRD Policy Shock

The impulse responses come from estimates from a 6-variable monthly VAR which includes the index of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), the log of total nonfarm payroll employment (EMPL), minus the log of nonborrowed reserves (NBRD), and the farm price index (FP). The impulse responses are constructed at 48 months horizon.

CHAPTER 7. THE EFFECTS OF MONETARY POLICY SHOCKS ON NET FUNDS RAISED IN THE FARM SECTOR

The procedure of the previous chapter will be followed to assess monetary policy shocks and identify their effects on net funds raised in the farm sector using a quarterly VAR. The policy variables are: the quarterly average of the daily federal funds rate (FF); minus the log of nonborrowed reserves (NBRD); and the log of total reserves (TOTRES). Data for NBRD and TOTRES are seasonally adjusted and adjusted for changes in reserve requirements. The nonpolicy variables are: the output level (Y) - measured by the log of GDP in constant 1992 dollars; the price level (P) - measured by the log of 1992 GDP deflator (P); and the commodity price index (PCOM) - measured by the quarterly average of the smoothed change in sensitive materials prices.²⁶

Assessing the Quarterly Monetary Policy Measures

To assess the monetary policy measures, again I consider the benchmark FF and NBRD policy shocks that emerge from six-variable quarterly VARs that include Y, P, PCOM, FF, NBRD, and TOTRES in the vector X_t in (5.2). Again, when FF is specified as the policy shock, the VAR ordering is Y, P, PCOM, FF, NBRD, and TOTRES. When NBRD is specified as the policy shock, the VAR ordering is Y, P, PCOM, NBRD, FF, and TOTRES. In both cases, the VAR was estimated using quarterly data over the period 1960:1-1995:2, using 4 lags of the variables in the system.

The quarterly VAR lag length is selected by the same lag test used for the monthly VAR. Again, under the null hypothesis that lag length = k, the statistic, $L(k)$

²⁶ All data was obtained from the Federal Reserve Economic Data (FRED) except for PCOM, which was obtained from the Survey of Current Business, October 1995, Volume 75, Number 10, Page C-47, Series 99.

in (6.1), converges to $\chi_2(df)$ where the degree of freedom (df) is the number of linear restrictions. It seems that a lag length of 4 quarters was most appropriate. Reducing the lag length from 12 quarters to 8 quarters had a χ_2 value that was significant at the 0.05 level, and reducing the lag length to 4 quarters had a χ_2 value that was significant at the 0.05 level. Thus, the test results suggested longer lags than 4 quarters, but, given degrees-of-freedom considerations, I decided to use 4 lags. Using quarterly data makes a lag length of 4 quarters sufficiently long to capture the system dynamics.

The estimated standard deviation of the FF policy shock is 0.59%, at an annual rate, while the estimated standard deviation of the NBRD policy shock is 0.0172. As Figure 7.1 suggests, the estimated standard deviation of the FF policy shocks is influenced by the high variance of those shocks in the early 1980s.

According to the FF policy shock, monetary policy was relatively contractionary before each recession, and became expansionary around business cycle troughs. A similar pattern is observed for the NBRD policy shock, except in the 1981-82 period, monetary policy was expansionary at the start, very contractionary in the middle, and expansionary at the end of the recession.

Figures 7.3 to 7.14 display the impulse response functions of the variables in the VAR model to the policy shocks. Middle lines represent the point estimates, while upper and lower lines denote plus and minus one standard deviation bands.²⁷ The impulse response functions are very similar to the corresponding response functions obtained in the monthly VARs. After a delay of about 1 to 2 quarters, a contractionary FF policy shock leads to a sustained and statistically significant drop in output. The impact of the FF policy shock on the federal funds rate is consistent and induces a drop in nonborrowed reserves that last about two quarters, as well as longer

²⁷ The standard errors were computed as in the monthly VAR.

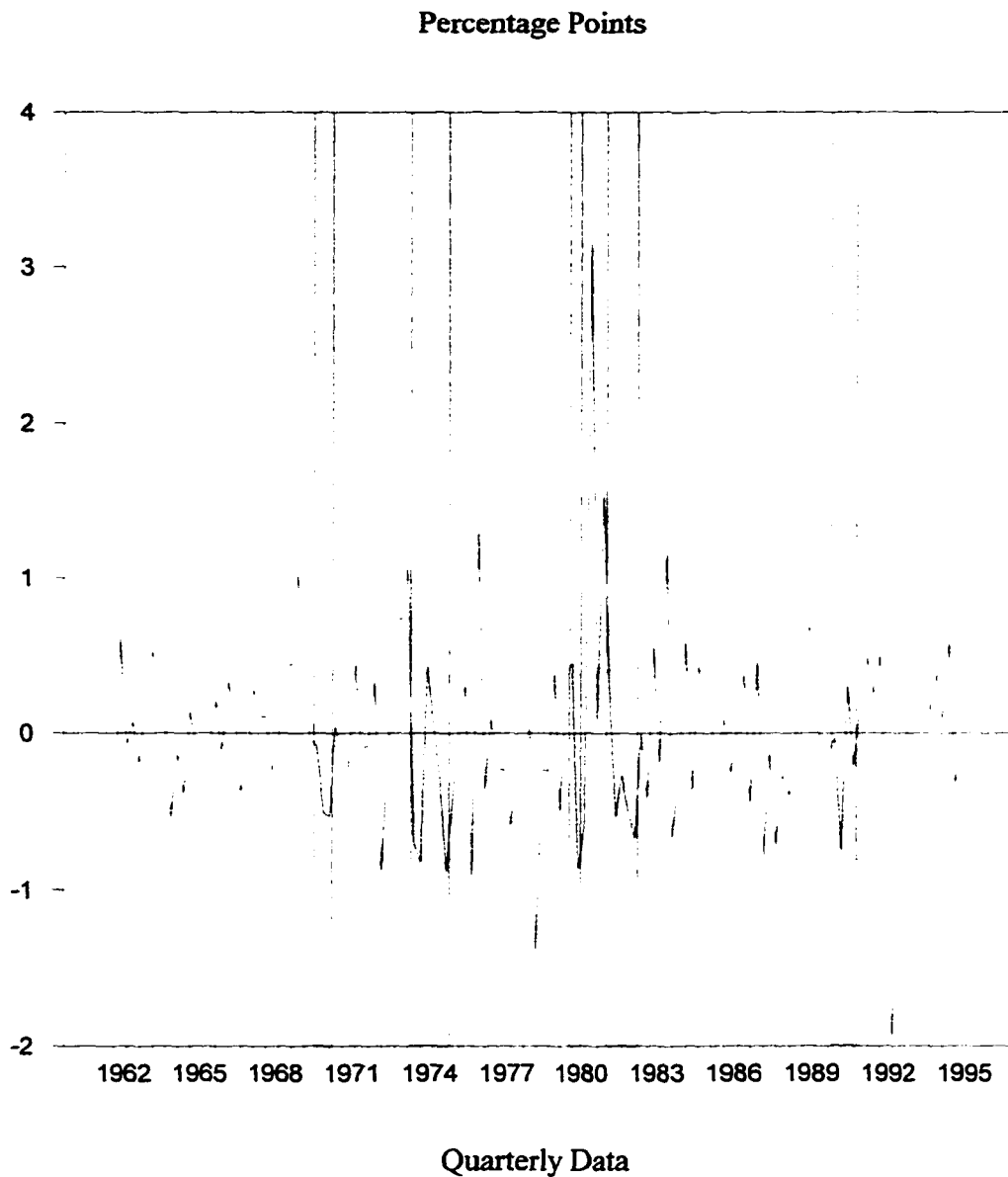
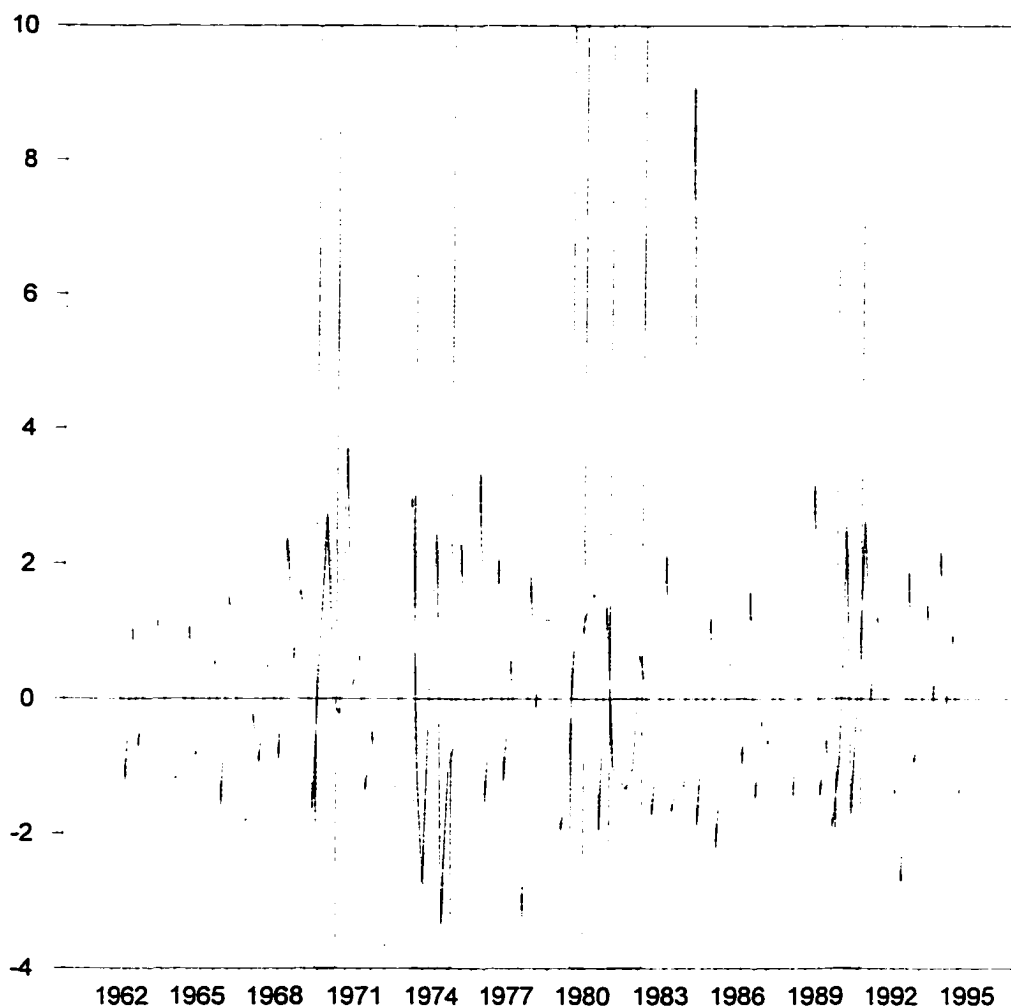


Figure 7.1 FF Policy Shock

The policy shock is as the orthogonalized innovations from a 6-variable quarterly VAR which includes the log of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), and the log of total reserves (TOTRES). The shaded areas indicate recessions, as dated by the National Bureau of Economic Research.

Percent



Quarterly Data

Figure 7.2 NBRD Policy Shock

The policy shock is as the orthogonalized innovations from a 6-variable quarterly VAR which includes the log of industrial production (Y), the log of consumer price index (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), and the log of total reserves (TOTRES). The shaded areas indicate recessions, as dated by the National Bureau of Economic Research.

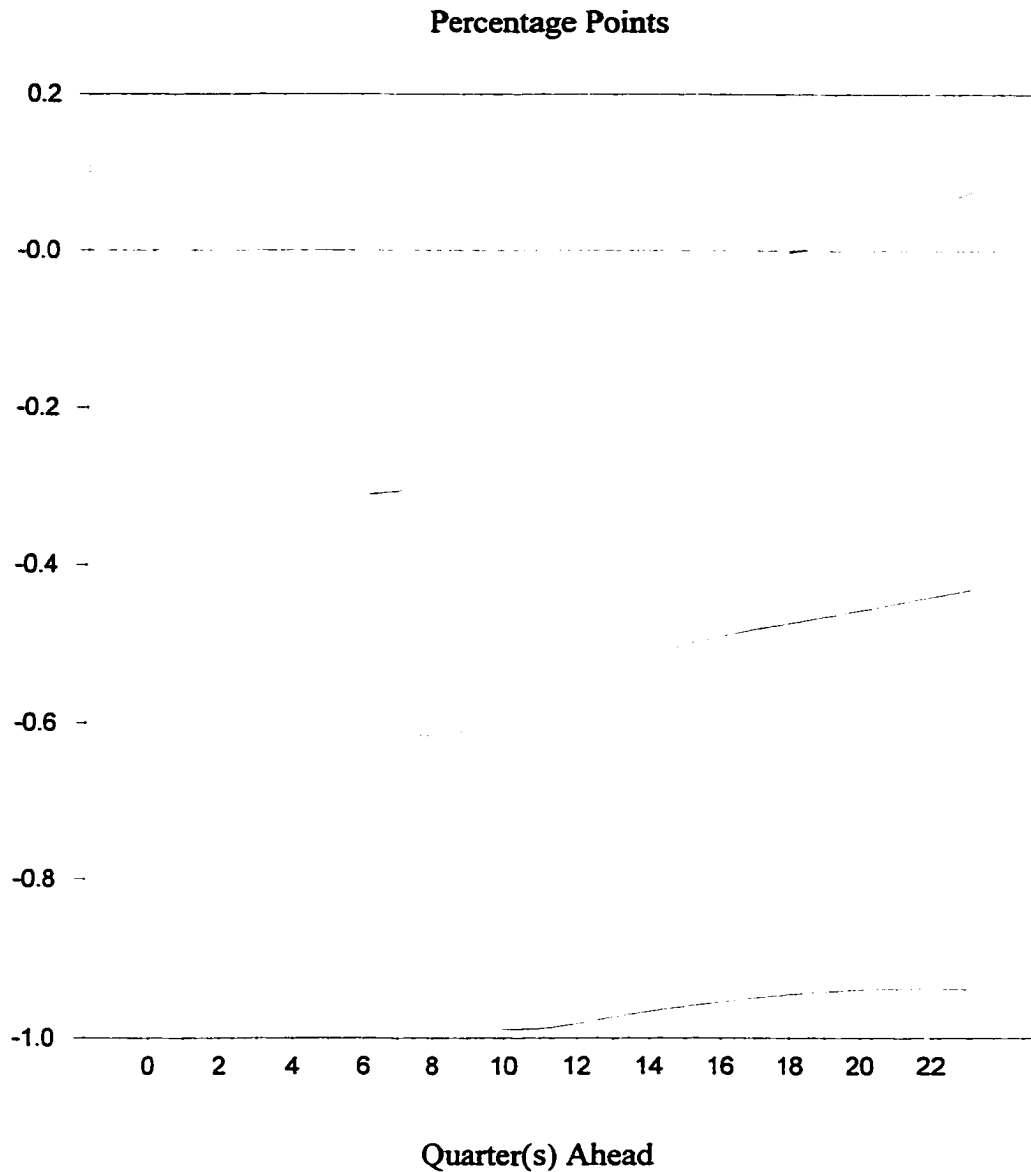


Figure 7.3 Response of Y to FF Policy Shock

The impulse responses comes from estimates from a 6-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), and the log of total reserves (TOTRES). The impulse responses are constructed at 24 quarters horizon.

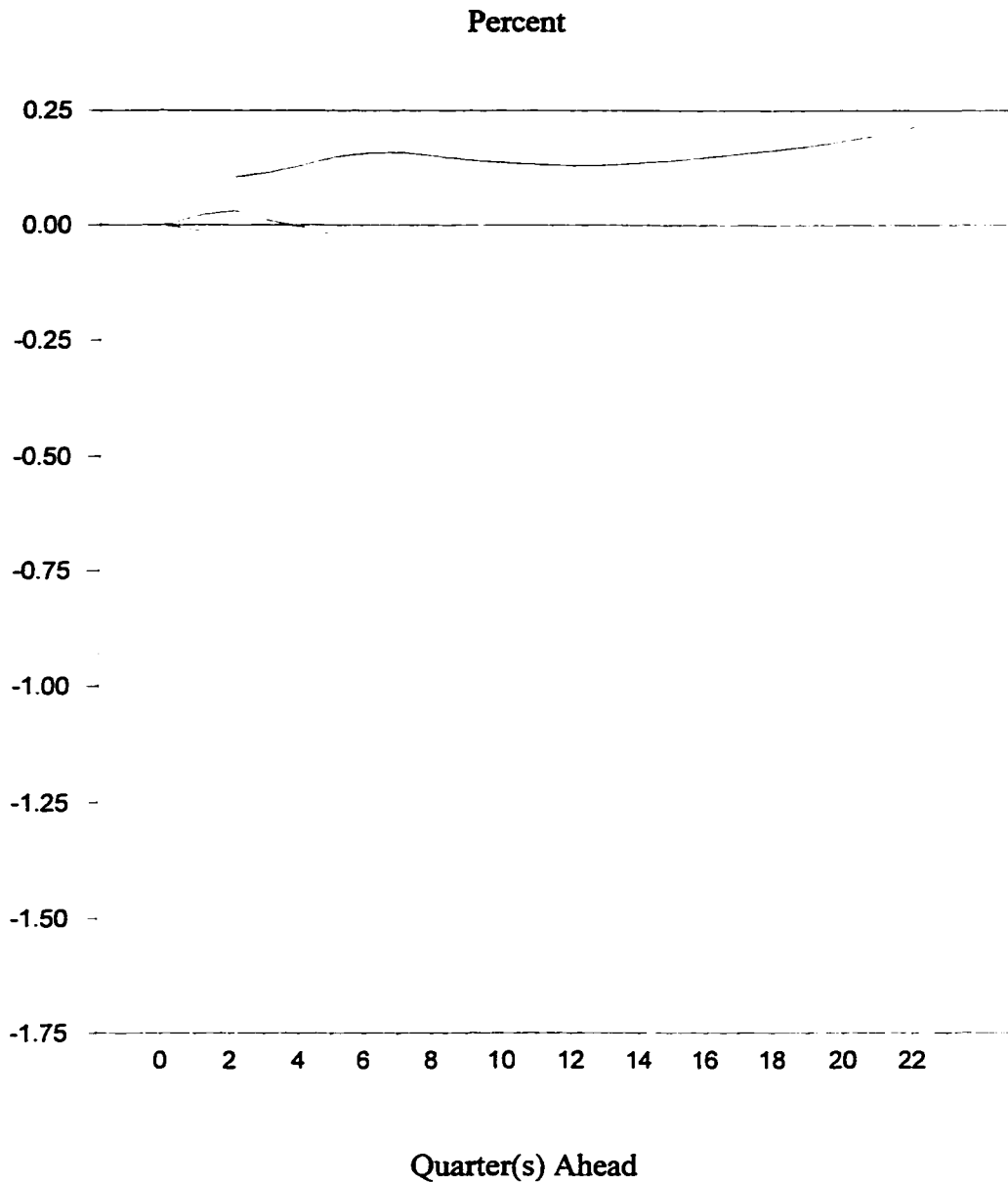
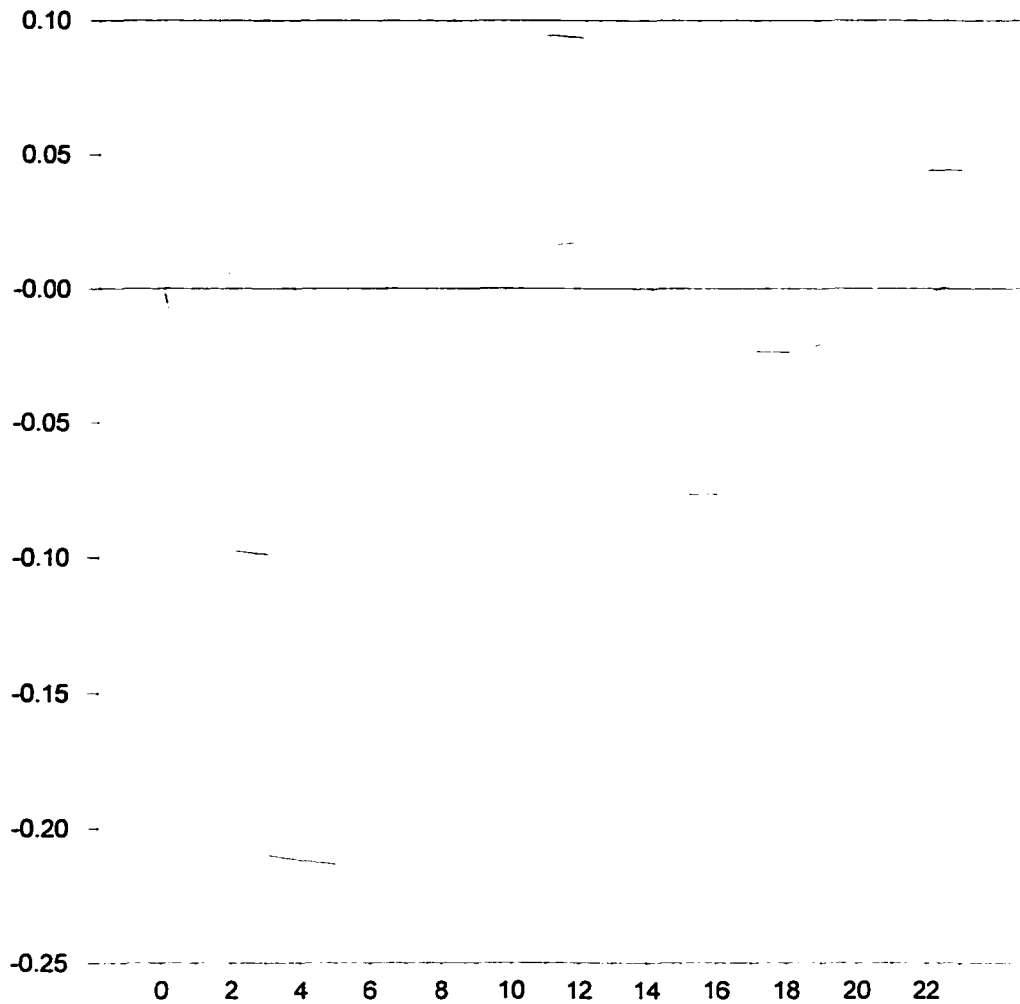


Figure 7.4 Response of P to FF Policy Shock

The impulse responses comes from estimates from a 6-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), and the log of total reserves (TOTRES). The impulse responses are constructed at 24 quarters horizon.

Percent



Quarter(s) Ahead

Figure 7.5 Response of PCOM to FF Policy Shock

The impulse responses comes from estimates from a 6-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), and the log of total reserves (TOTRES). The impulse responses are constructed at 24 quarters horizon.

Percentage Points

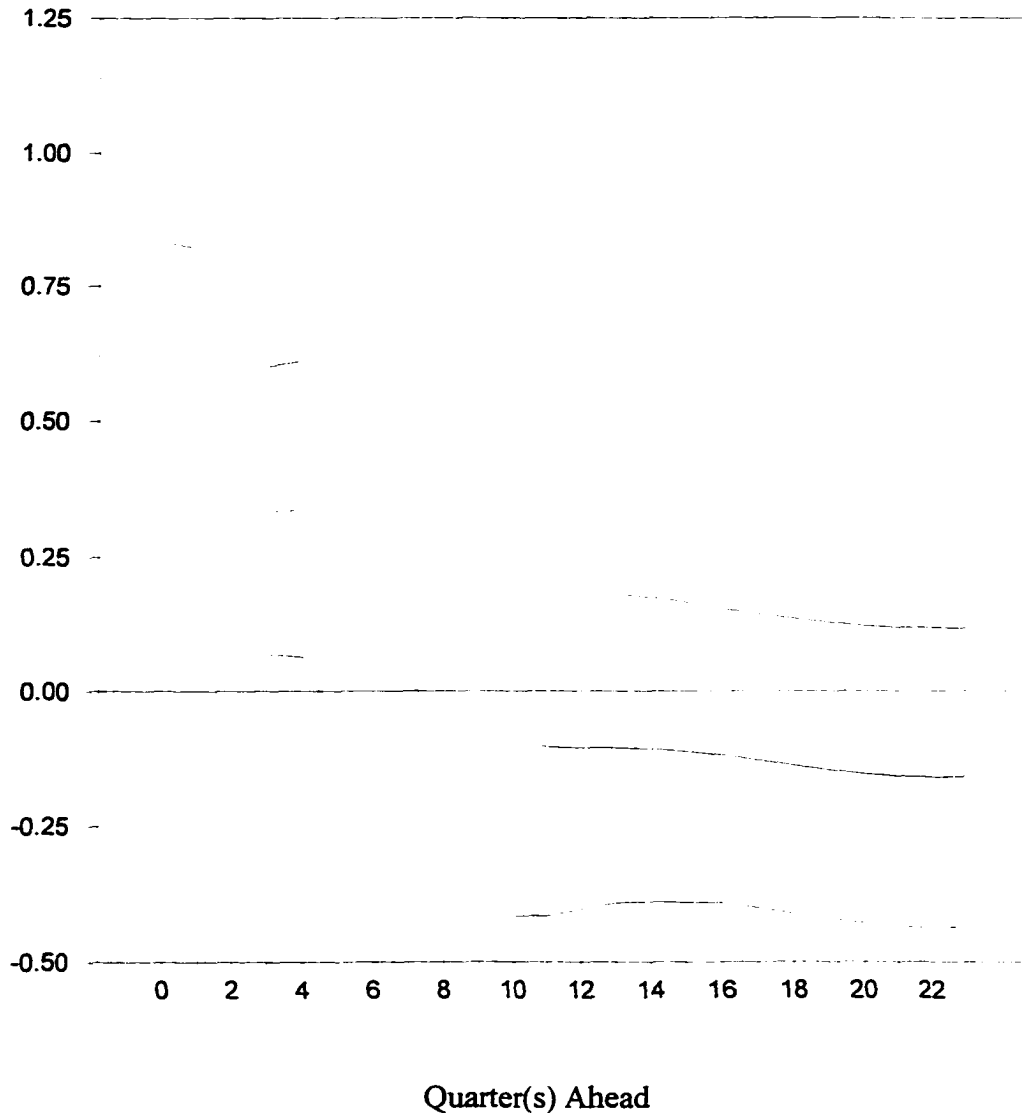


Figure 7.6 Response of FF to FF Policy Shock

The impulse responses comes from estimates from a 6-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), and the log of total reserves (TOTRES). The impulse responses are constructed at 24 quarters horizon.

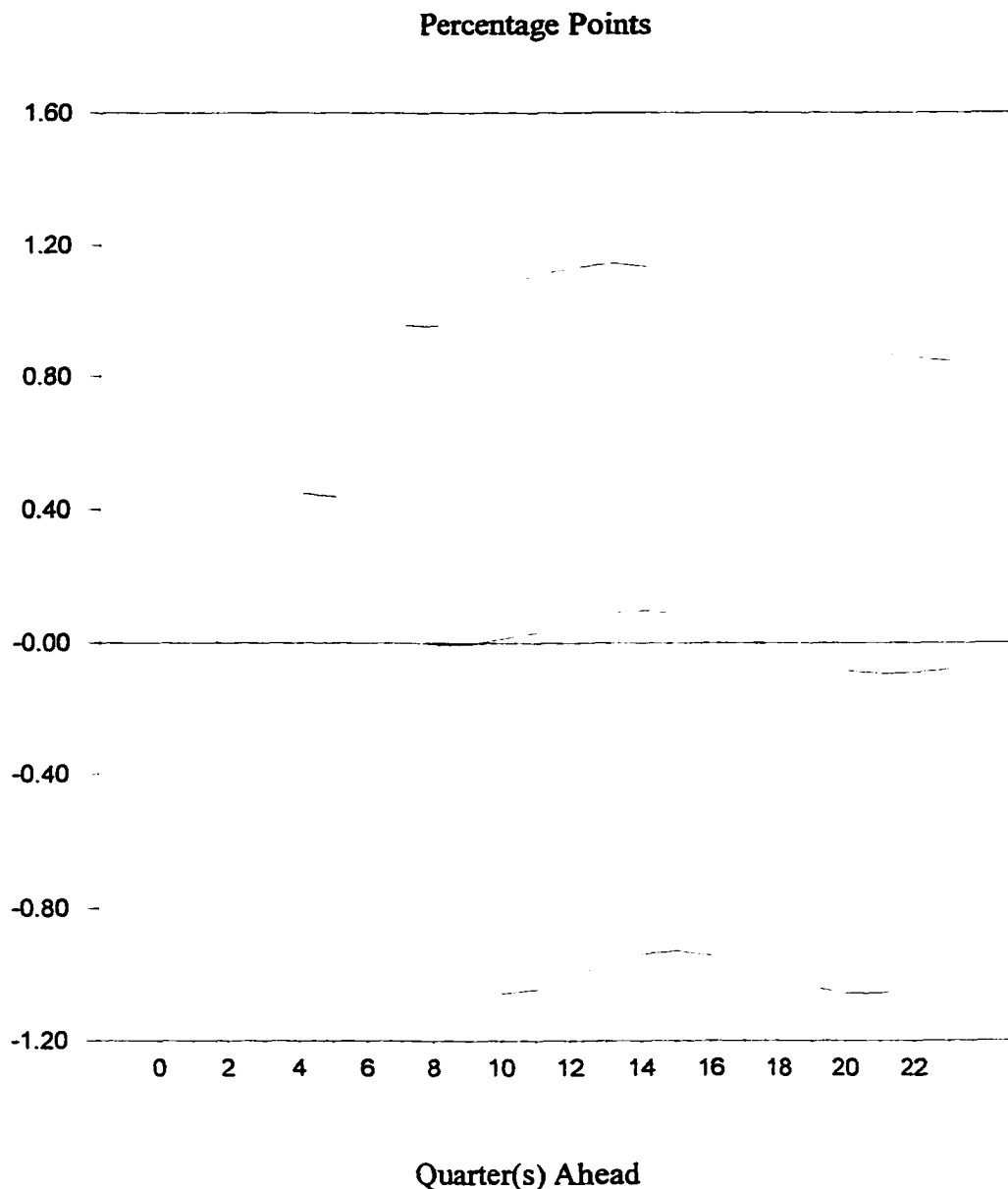


Figure 7.7 Response of NBRD to FF Policy Shock

The impulse responses comes from estimates from a 6-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), and the log of total reserves (TOTRES). The impulse responses are constructed at 24 quarters horizon.

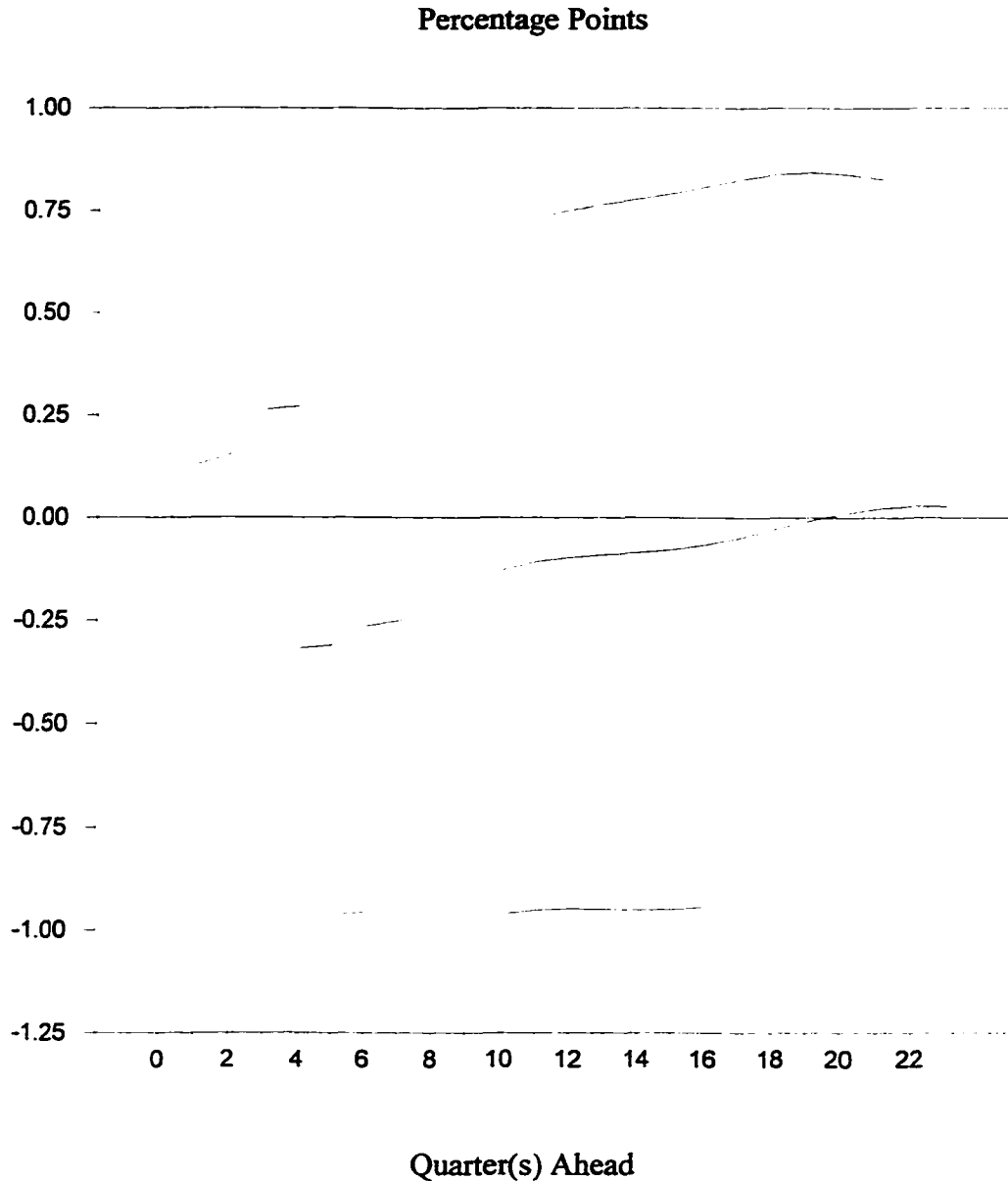


Figure 7.8 Response of TOTRES to FF Policy Shock

The impulse responses comes from estimates from a 6-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), and the log of total reserves (TOTRES). The impulse responses are constructed at 24 quarters horizon.

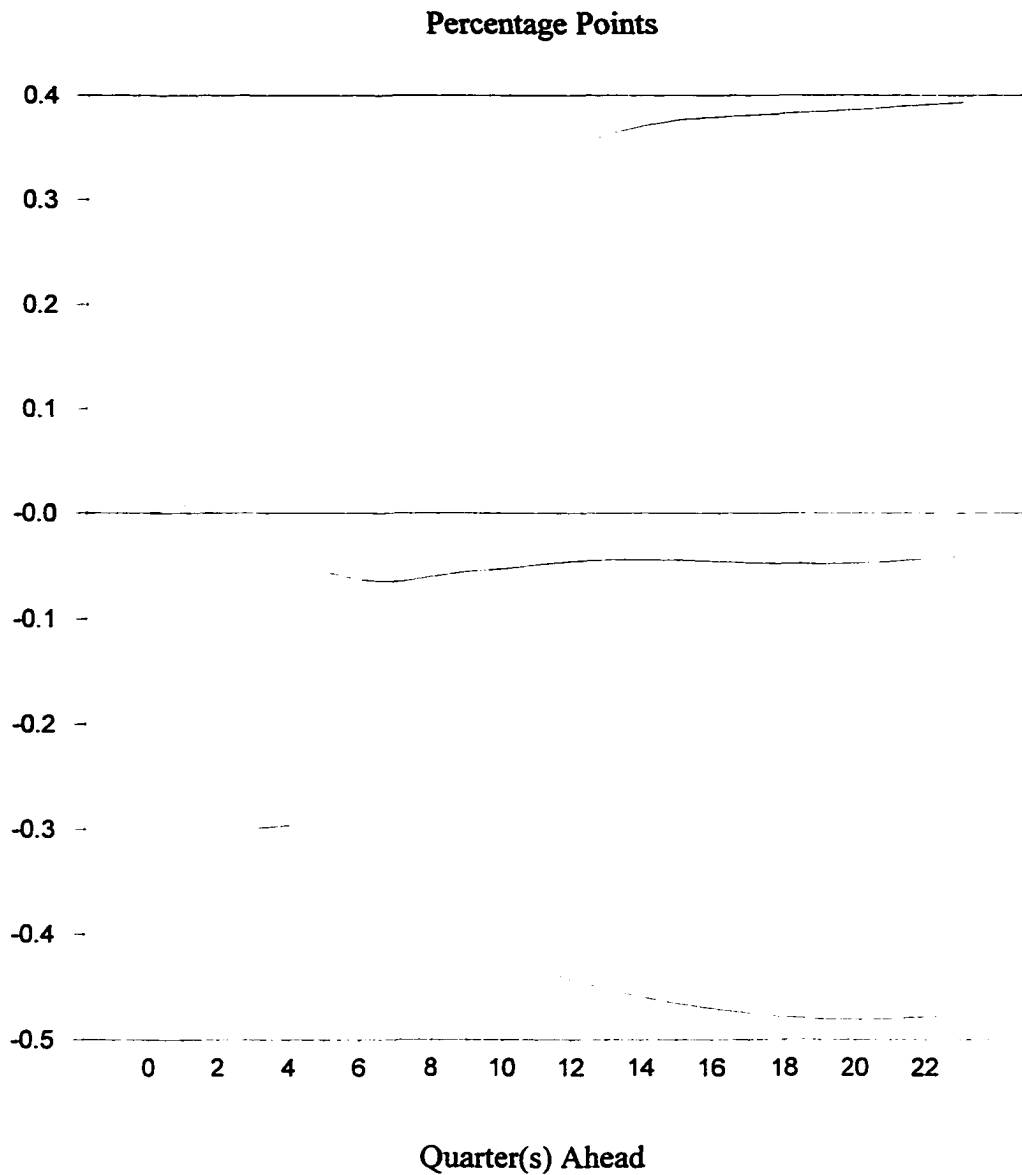


Figure 7.9 Response of Y to NBRD Policy Shock

The impulse responses come from estimates from a 6-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), and the log of total reserves (TOTRES). The impulse responses are constructed at 24 quarters horizon.

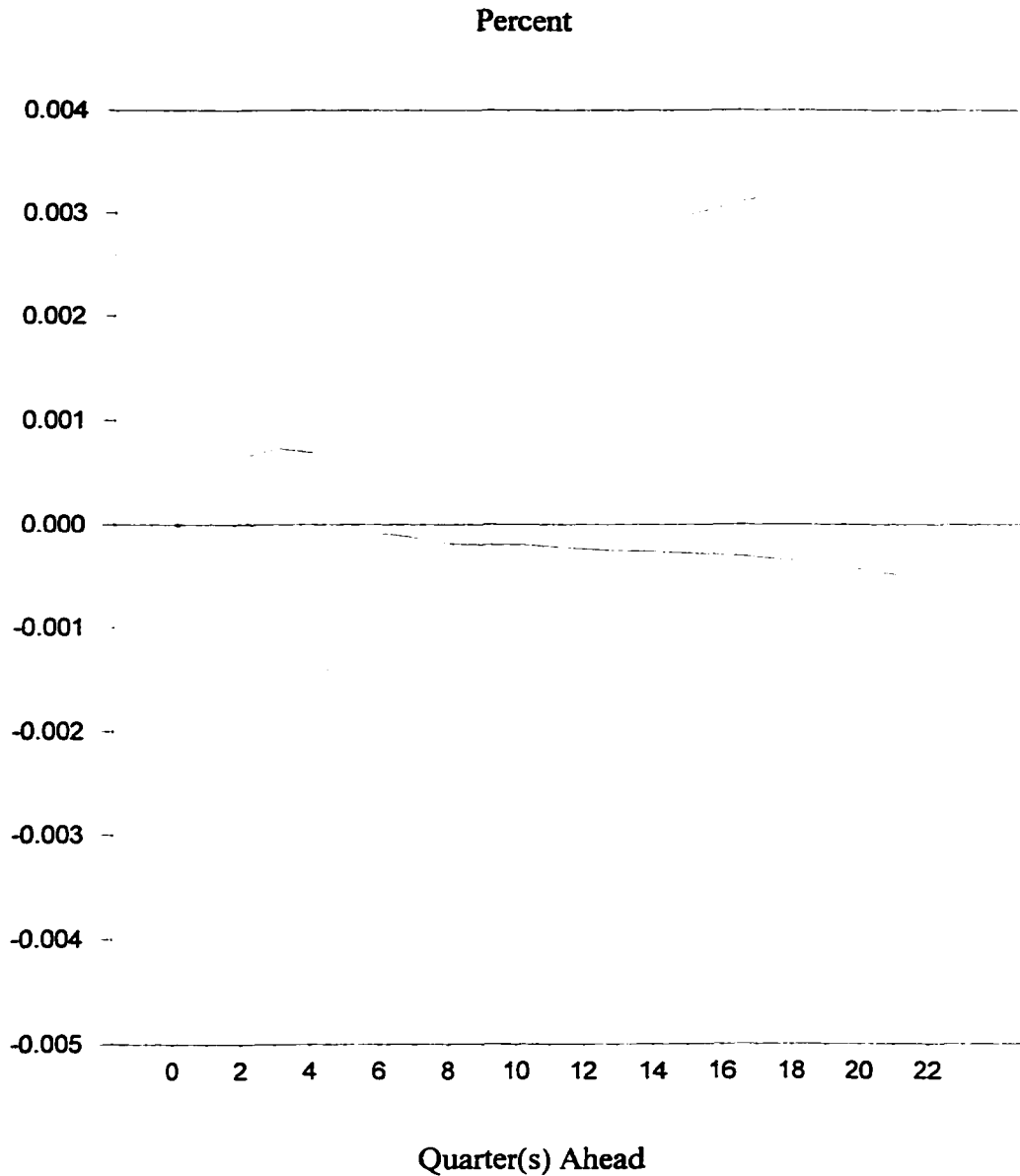


Figure 7.10 Response of P to NBRD Policy Shock.

The impulse responses come from estimates from a 6-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), and the log of total reserves (TOTRES). The impulse responses are constructed at 24 quarters horizon.

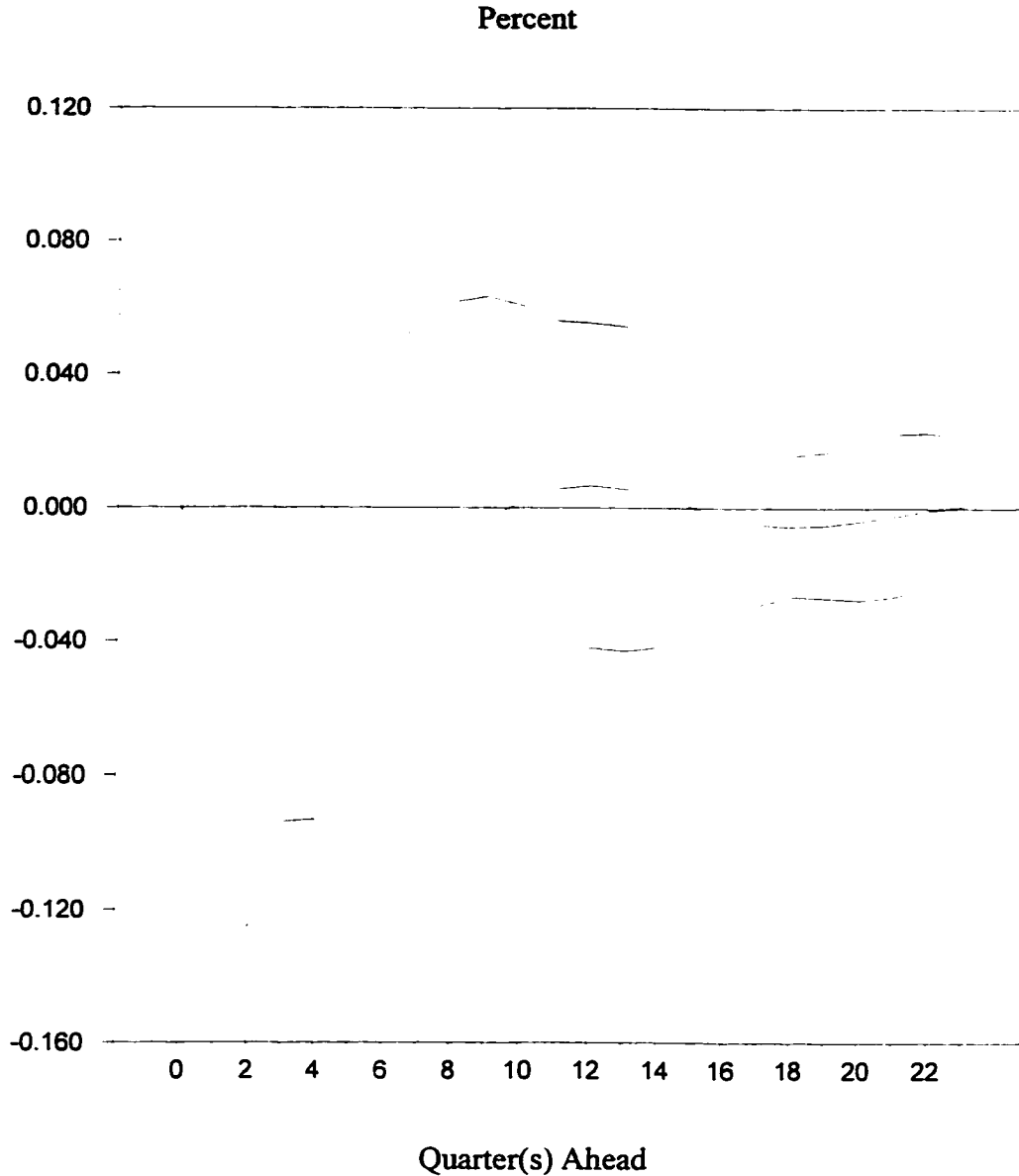


Figure 7.11 Response of PCOM to NBRD Policy Shock

The impulse responses come from estimates from a 6-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), and the log of total reserves (TOTRES). The impulse responses are constructed at 24 quarters horizon.

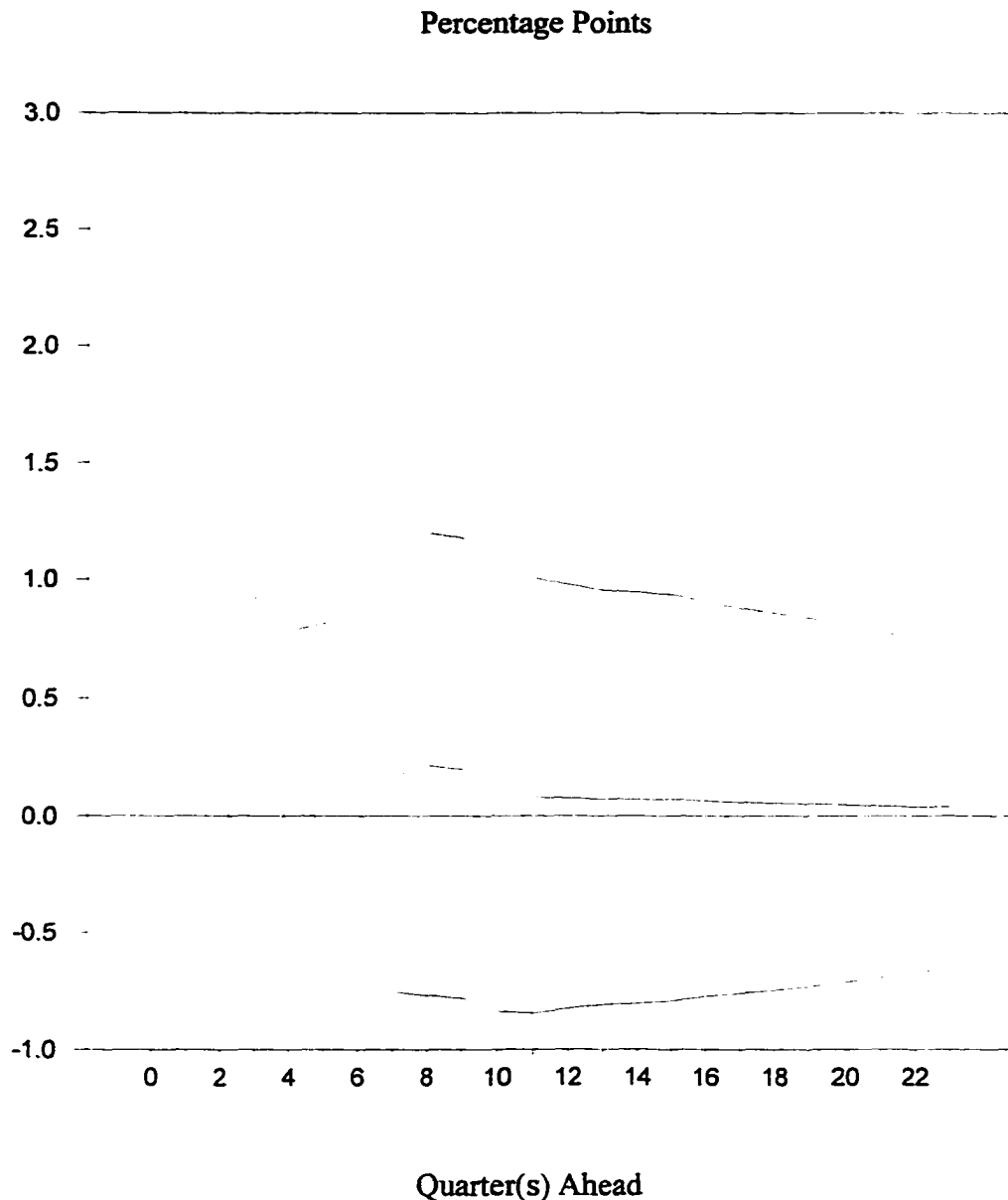


Figure 7.12 Response of NBRD to NBRD Policy Shock

The impulse responses come from estimates from a 6-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), and the log of total reserves (TOTRES). The impulse responses are constructed at 24 quarters horizon.

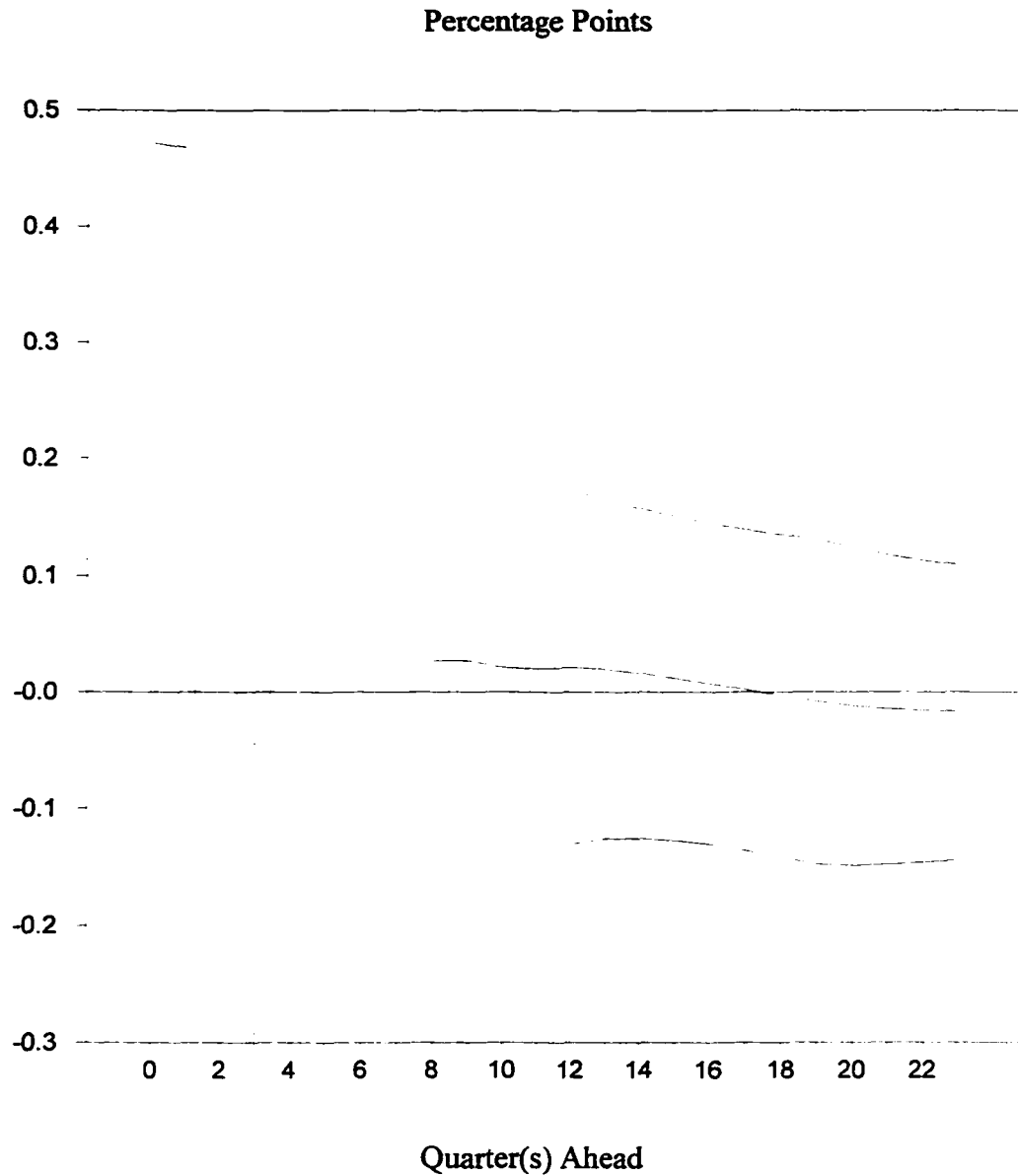


Figure 7.13 Response of FF to NBRD Policy Shock

The impulse responses come from estimates from a 6-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), and the log of total reserves (TOTRES). The impulse responses are constructed at 24 quarters horizon.

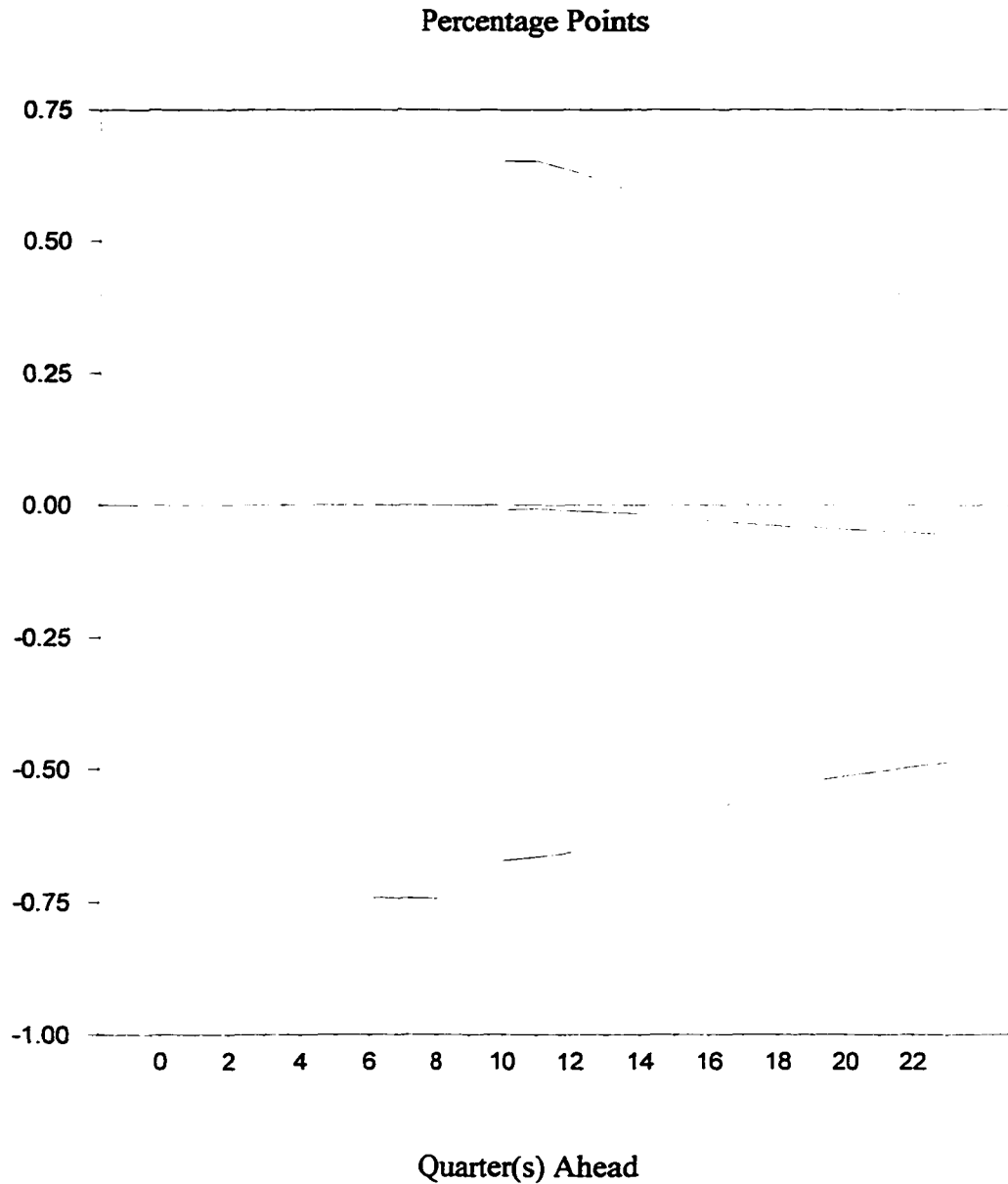


Figure 7.14 Response of TOTRES to NBRD Policy Shock

The impulse responses come from estimates from a 6-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), and the log of total reserves (TOTRES). The impulse responses are constructed at 24 quarters horizon.

lasting decline in PCOM. P, measured by the GDP deflator, does not respond for about a year, after which it begins a steady decline. This is qualitatively similar to the response of P, measured by the CPI, in the monthly VARs. Still a small “price puzzle” remains. The fall in total reserves is negligible initially. Eventually they fall by around 0.4%. So, according to the FF policy shock measure, the Federal Reserve insulates total reserves in the short run from the full impact of a decrease in nonborrowed reserves.

As for the effects of the NBRD policy shock, with one exception, inference is quite robust to which of the two policy measures is used. The exception has to do with the degree to which total reserves are initially insulated from policy shocks. The FF measure implies that total reserves are insulated contemporaneously from monetary policy shocks, while the NBRD measure implies that roughly 40% of the policy shock is contemporaneously transmitted to total reserves.

The quarterly monetary policy measures are used to identify the effects of monetary policy shocks on M1, UNRATE, and EMPL. Again, when FF is specified as the policy shock, the VAR ordering is Y, P, PCOM, FF, NBRD, TOTRES, and D, where D is either M1, UNRATE, or EMPL. When NBRD is specified as the policy shock, the VAR ordering is Y, P, PCOM, NBRD, FF, TOTRES, and D. Figures 7.15 to 7.20 display the impulse responses of M1, UNRATE, and EMPL to the policy shocks.

Consistent with the interpretation of a positive FF policy shock as reflecting a contractionary monetary policy, M1 declines in a statistically significant way. With an initial delay, similar to that of output, the FF policy shock leads to a significant increase in the unemployment rate and a significant decrease in employment. The dynamic response functions are qualitatively similar whether we work with FF or NBRD policy shocks.

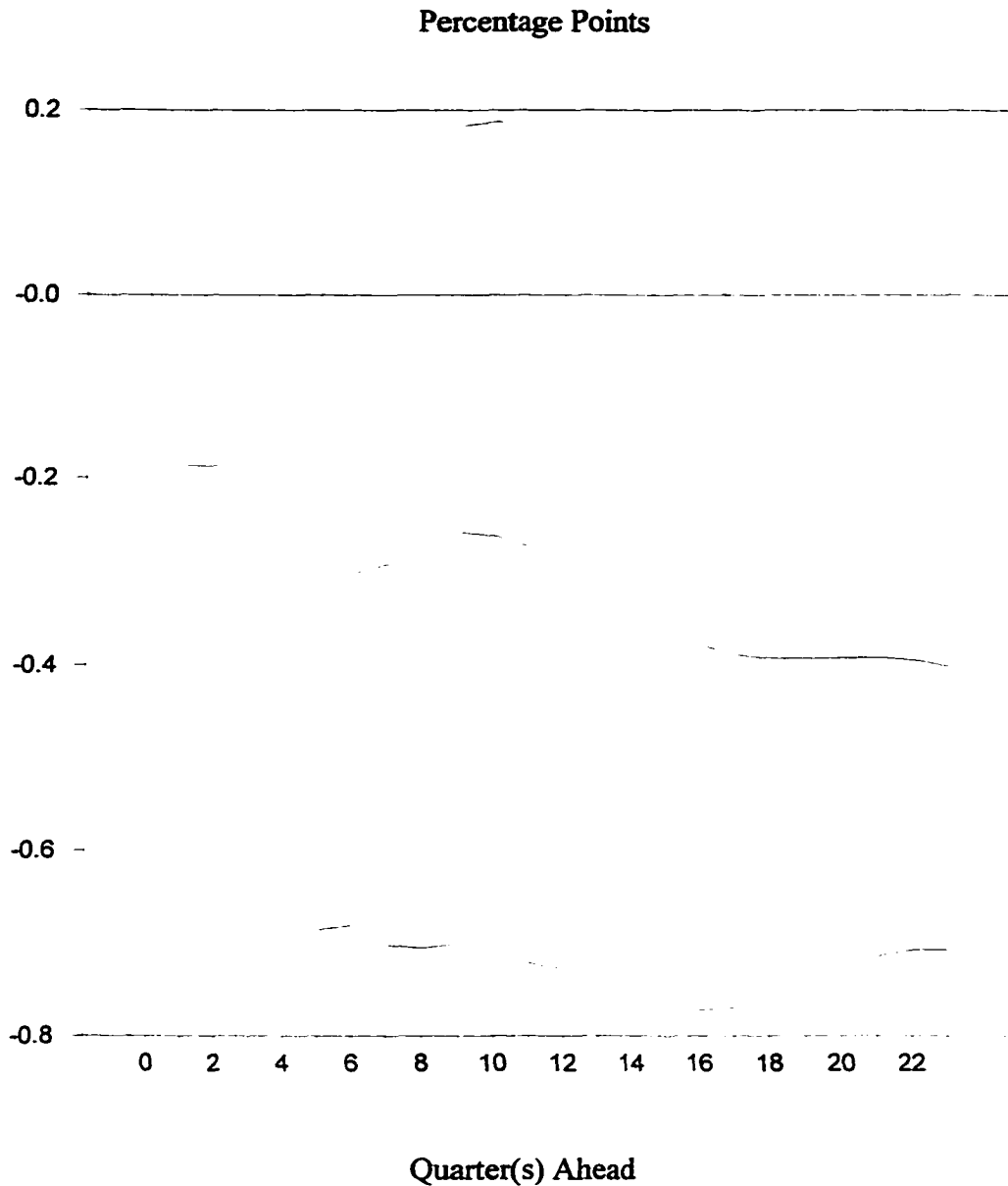


Figure 7.15 Response of M1 to FF Policy Shock

The impulse responses comes from estimates from a 7-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), the log of total reserves (TOTRES), and the log of M1 money supply (M1). The impulse responses are constructed at 24 quarters horizon.

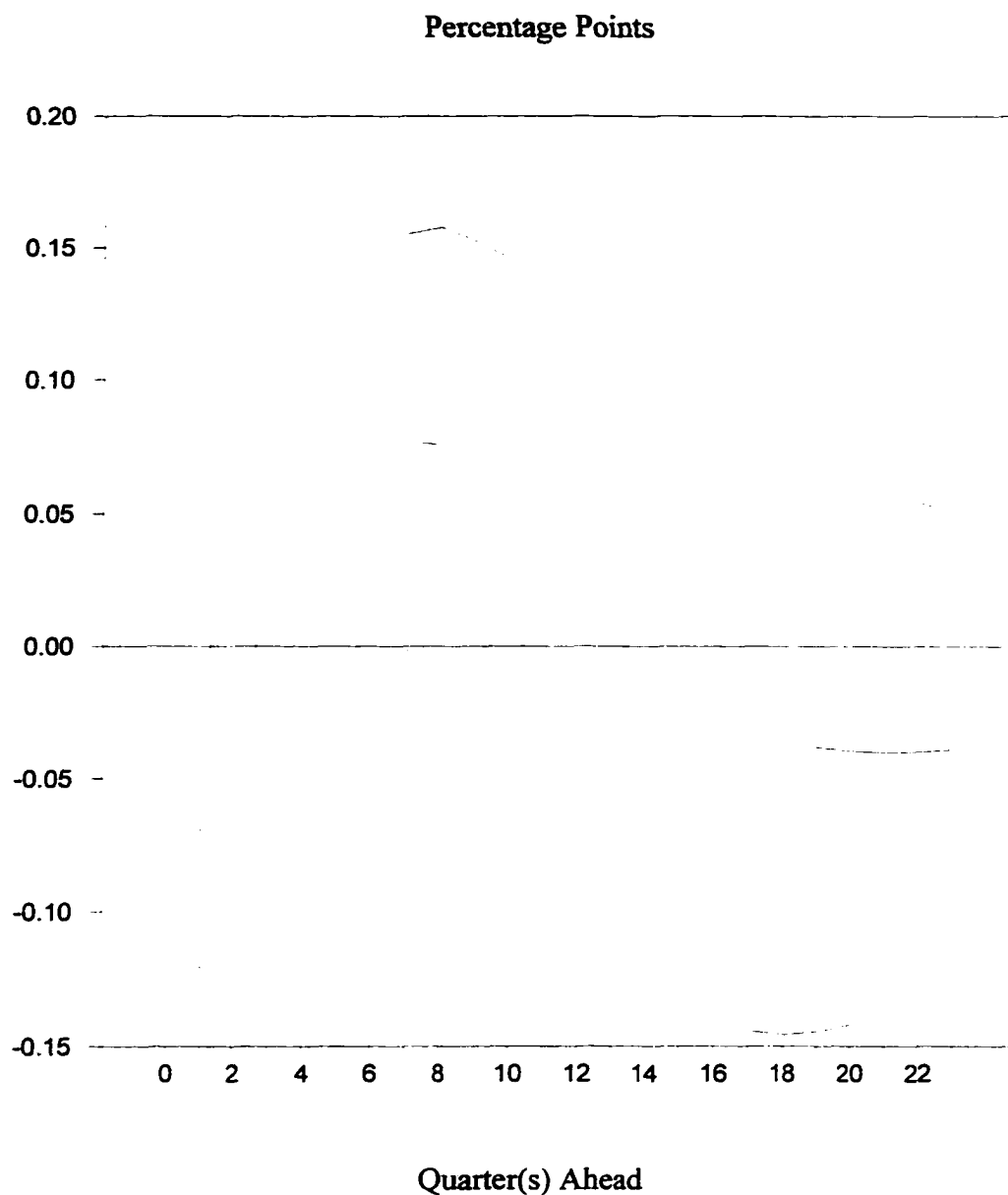


Figure 7.16 Response of UNRATE to FF Policy Shock

The impulse responses comes from estimates from a 7-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), the log of total reserves (TOTRES), and the unemployment rate (UNRATE). The impulse responses are constructed at 24 quarters horizon.

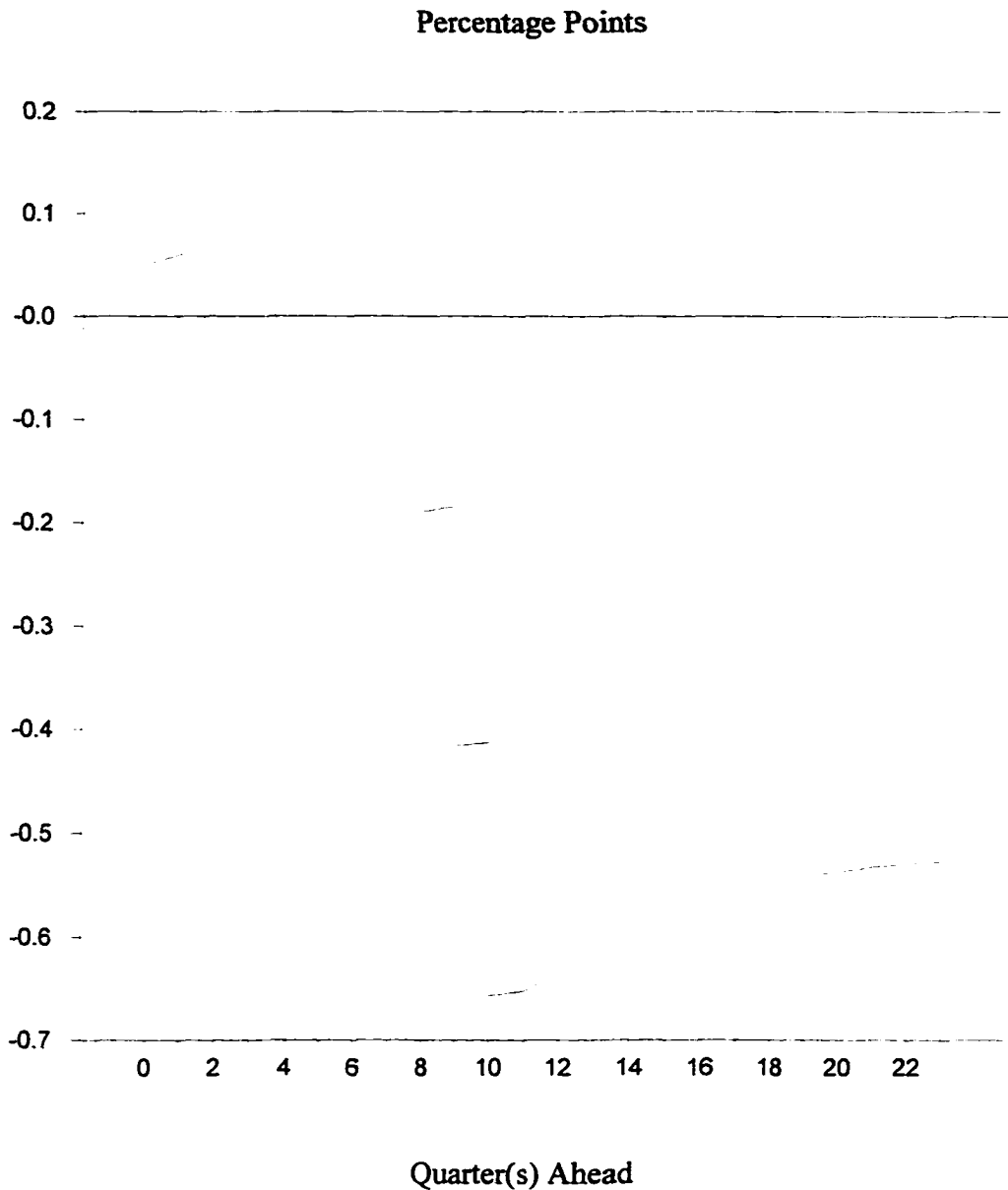


Figure 7.17 Response of EMPL to FF Policy Shock

The impulse responses comes from estimates from a 7-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), the log of total reserves (TOTRES), and the log of total nonfarm payrolls (EMPL). The impulse responses are constructed at 24 quarters horizon.

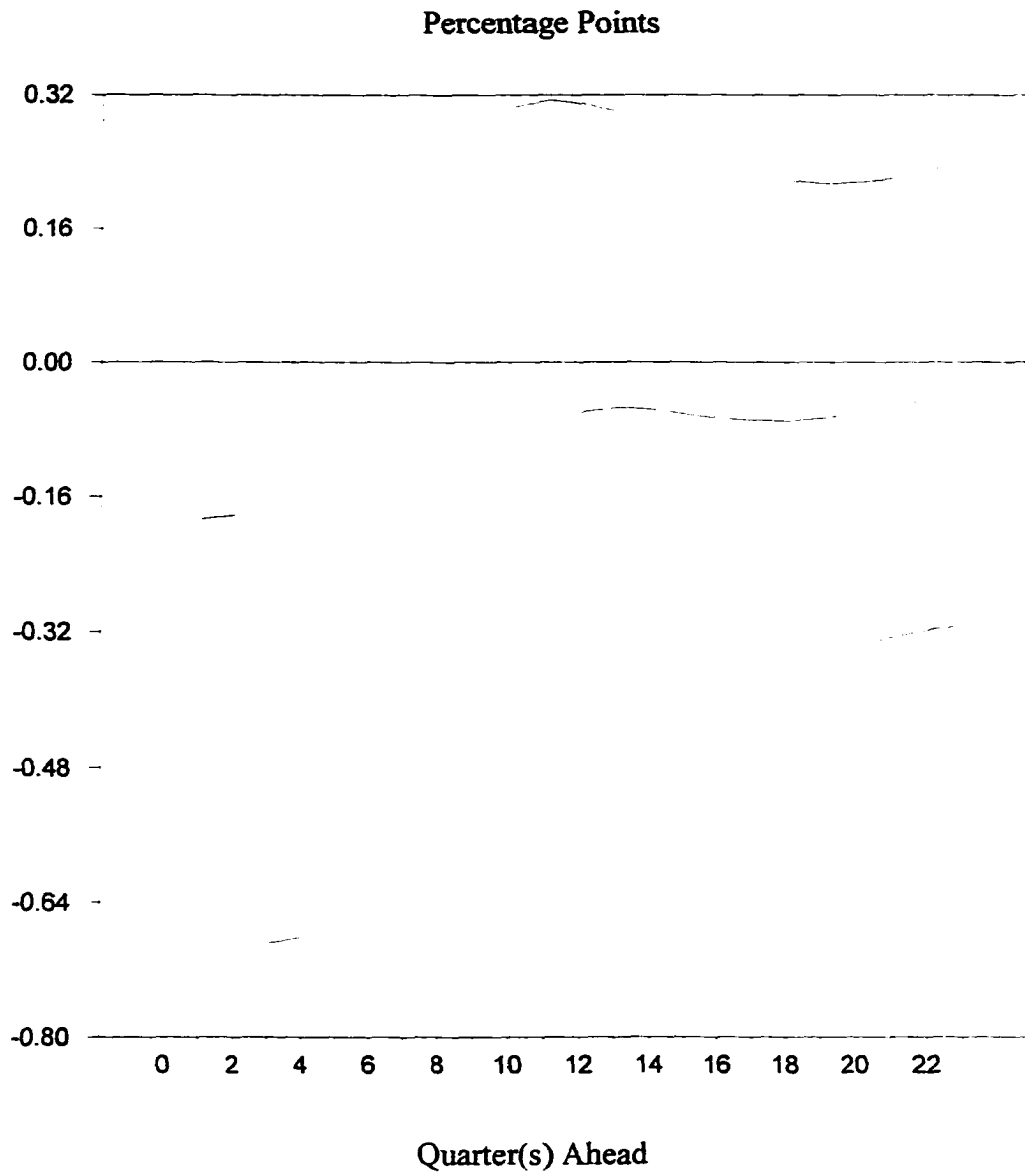


Figure 7.18 Response of M1 to NBRD Policy Shock

The impulse responses come from estimates from a 7-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), the log of total reserves (TOTRES), and the log of M1 money supply (M1). The impulse responses are constructed at 24 quarters horizon.

Percentage Points

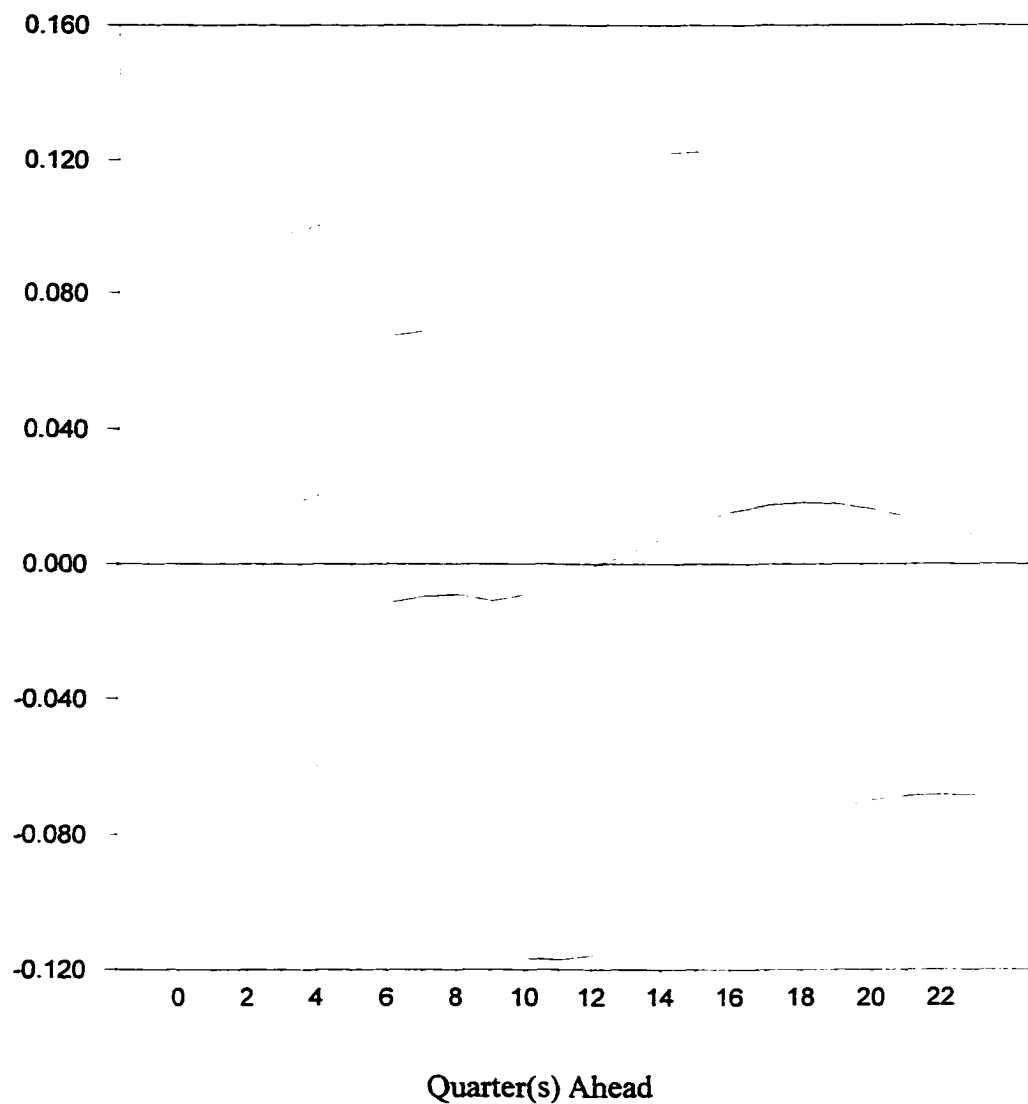


Figure 7.19 Response of UNRATE to NBRD Policy Shock

The impulse responses come from estimates from a 7-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), the log of total reserves (TOTRES), and the unemployment rate (UNRATE). The impulse responses are constructed at 24 quarters horizon.

Percentage Points

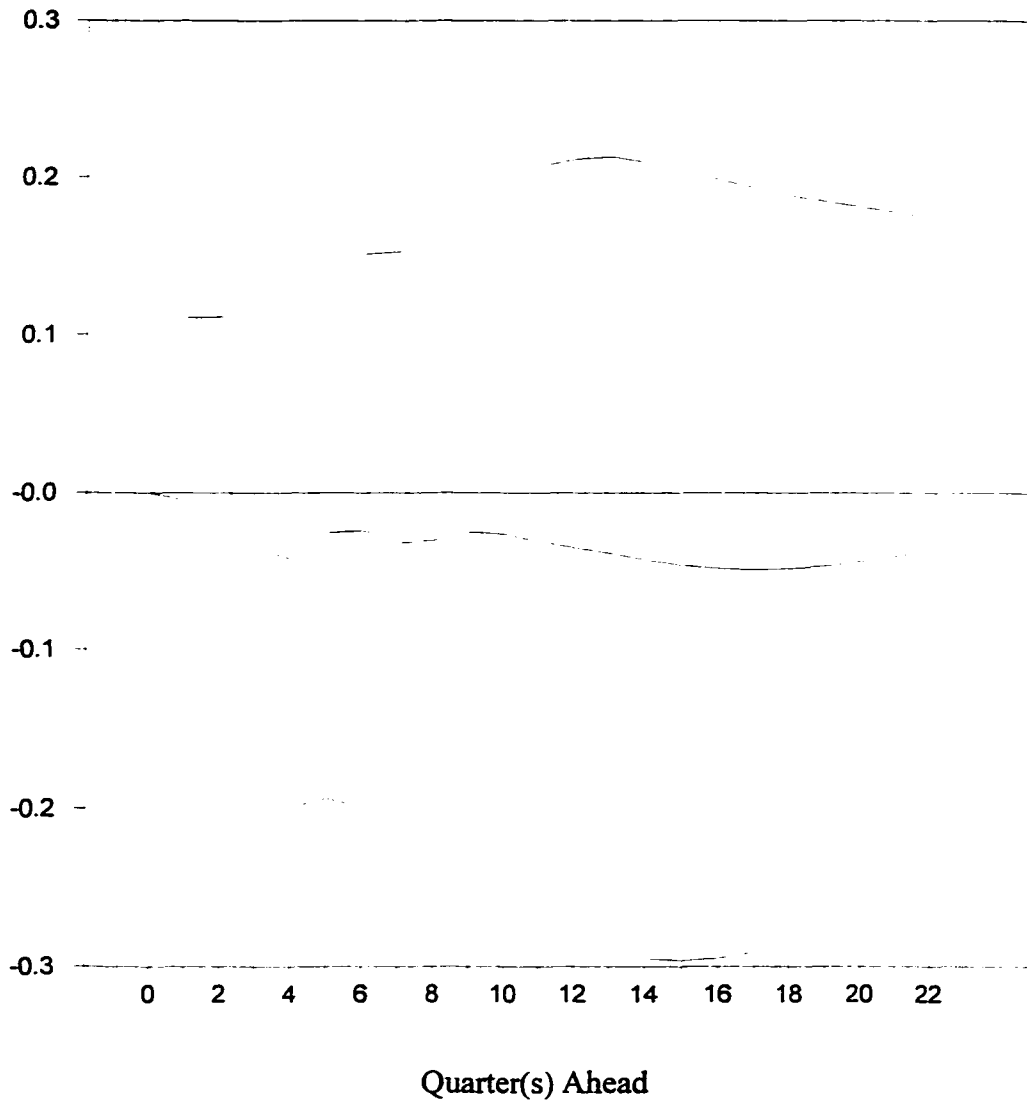


Figure 7.20 Response of EMPL to NBRD Policy Shock

The impulse responses come from estimates from a 7-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), the log of total reserves (TOTRES), and the log of total nonfarm payrolls (EMPL). The impulse responses are constructed at 24 quarters horizon.

Tables 7.1 and 7.2 show the variance decompositions for each variable - the percentage of the forecast error variance attributable to the policy shock. The FF policy shock accounts for 31.9%, 3.5% and 23% of the 24-quarter ahead forecast error variance of output, the unemployment rate, and employment, while the NBRD policy shock accounts for 0.6%, 0.2%, and 0.2%. Similar to the monthly VAR, monetary policy shocks seem to be an important contributor to aggregate fluctuations. The effects associated with FF policy shock are much larger than those associated with NBRD policy shock. The forecast standard errors increase towards an upper bound for each variable indicating that the VAR system is stationary.

In summary, the results in this section support the view that FF and NBRD policy shocks are reasonable measures of exogenous monetary policy shocks. Other alternative interpretations seem implausible. For example, the view that a positive FF policy shock really reflects a positive shock to money demand (rather than supply) seems hard to square with the finding that total reserves and M1 fall after an FF policy shock. The view that a positive NBRD policy shock reflects a negative money demand shock is difficult to reconcile with the fact that it is followed by a rise in the interest rate and the unemployment rate, as well as a fall in output. The view that positive FF policy shock reflects an increase in household and/or business optimism seems hard to reconcile with the fall in aggregate economic activity that follows the FF policy shock. Finally, a rise in interest rates due to a shock generating a sectoral reallocation of resources could, in principle, lead to an initial fall in aggregate economic activity. The obvious candidate is a shock to the price of oil. However, this scenario seems implausible given the persistence of the fall in aggregate economic activity that occurs after FF and NBRD policy shocks.

Table 7.1 Variance Decompositions for the Variables in the VAR Model

Variable	Quarter(s) Ahead	FF Policy Shock	NBRD Policy Shock
Y	1	0.0% (0.006)	0.0% (0.006)
	4	12.5% (0.014)	0.7% (0.014)
	8	28.6% (0.022)	0.7% (0.022)
	12	31.1% (0.030)	0.6% (0.030)
	24	31.9% (0.040)	0.6% (0.041)
P	1	0.0% (0.002)	0.0% (0.002)
	4	0.3% (0.008)	0.1% (0.008)
	8	0.5% (0.016)	0.1% (0.016)
	12	3.2% (0.026)	0.1% (0.026)
	24	16.2% (0.049)	0.1% (0.049)
PCOM	1	0.0% (0.341)	0.0% (0.341)
	4	4.7% (0.657)	0.3% (0.657)
	8	10.3% (0.759)	0.5% (0.759)
	12	9.6% (0.797)	0.5% (0.800)
	24	9.5% (0.811)	0.5% (0.811)
FF	1	84.9% (0.890)	14.0% (0.890)
	4	52.1% (0.757)	6.2% (1.757)
	8	35.6% (2.230)	4.0% (2.230)
	12	33.0% (2.332)	3.7% (2.332)
	24	30.4% (2.568)	3.1% (2.568)
NBRD	1	16.4% (0.025)	99.4% (0.025)
	4	9.3% (0.046)	52.6% (0.046)
	8	4.8% (0.070)	24.7% (0.070)
	12	3.8% (0.079)	19.5% (0.079)
	24	2.9% (0.092)	14.6% (0.092)
TOTRES	1	0.8% (0.010)	13.0% (0.010)
	4	1.7% (0.031)	13.6% (0.031)
	8	1.9% (0.050)	6.4% (0.050)
	12	1.5% (0.062)	4.3% (0.062)
	24	1.2% (0.073)	3.1% (0.073)

Note: Standard errors of forecast are in parentheses.

Table 7.2 Variance Decompositions for Other Macroeconomic Variables

Variable	Quarter(s) Ahead	FF Policy Shock	NBRD Policy Shock
M1	1	2.2% (0.006)	10.6% (0.006)
	4	12.8% (0.017)	16.2% (0.017)
	8	11.1% (0.029)	9.5% (0.029)
	12	11.2% (0.034)	7.1% (0.034)
	24	19.4% (0.040)	5.6% (0.040)
UNRATE	1	7.0% (0.215)	6.7% (0.215)
	4	2.6% (0.565)	2.3% (0.565)
	8	4.1% (0.746)	4.5% (0.746)
	12	3.9% (0.986)	4.5% (0.986)
	24	3.5% (1.189)	0.2% (1.189)
EMPL	1	3.1% (0.003)	0.9% (0.003)
	4	2.3% (0.010)	0.5% (0.010)
	8	15.7% (0.015)	0.3% (0.015)
	12	23.8% (0.020)	0.2% (0.020)
	24	23.0% (0.027)	0.2% (0.027)

Note: Standard errors of forecast are in parentheses.

The Effects of Monetary Policy Shocks on Net Funds Raised in the Farm Sector

The monetary policy measures are used to identify the effects of monetary policy shocks on the borrowing and lending activities of the farm sector. Specifically, the Flow of Funds Accounts (FOFA) data is used to identify the effects of a monetary policy shocks on net funds raised in the farm sector. Real net funds raised in the farm sector (FARMNET) as measured by the FOFA data, equals the amount of funds raised in the farm sector by issuing financial liabilities, net of funds spent acquiring

financial assets.²⁸ Again, when FF is specified as the policy shock, the VAR ordering is Y, P, PCOM, FF, NBRD, TOTRES, and FARMNET. When NBRD is specified as the policy shock, the VAR ordering is Y, P, PCOM, NBRD, FF, TOTRES, and FARMNET.

Figures 7.21 and 7.22 display the impulse response of FARMNET to monetary policy shocks. After a contractionary monetary policy shock, net funds raised in the farm sector increases for roughly two quarters. Then, as the recession induced by the policy shock takes hold, net farm borrowing declines. The decline is not significant for the NBRD policy shock. In this sense the inference about the response of net funds raised in the farm sector to monetary policy shocks is fragile.

There are important frictions that cause this response pattern of net funds raised to a contractionary monetary policy shock. The initial rise in the net fund raised may reflect deterioration in farmer's cash flow from a fall in sales. It is difficult for farmers to quickly alter their nominal expenditures. Eventually, they reduce their nominal expenditures and net funds raised in the farm sector decline as predicted by the credit view.

It is worth the effort to investigate this conjecture and identify the frictions that inhibit farmers from quickly adjusting their real expenditures. This points out to the importance of imperfect information and the special role of bank credit. Agricultural financial markets used to operate in considerable isolation. The markets were segmented in terms of both the demand and supply of credit. A fragmented banking system, limited geographic markets, and the predominance of small businesses with

²⁸ The Flow of Funds Accounts (FOFA) data is from the Federal Reserve's Z.1 Statistical Release of the second quarter of 1995. The data was seasonally adjusted by the reporting agency. Net funds raised in the farm sector (FARMNET) is given by the minus of line 12 in table F.102 converted to 1992 dollars using the seasonally adjusted GDP deflator. As more data is included in Z.1 Statistical Release, the line number of the tables will not correspond exactly to the line number referred to in *Guide to the Flow of Funds Accounts* (1993). Since the Guide also contains the original data source for the Flow of Funds Accounts, its line numbering convention is followed.

limited borrowing opportunities resulted in limited integration of rural areas into national financial markets.

Table 7.3 shows that a relatively small proportion of the forecast error variance of FARMNET can be attributed to monetary policy shocks. In the short run, monetary policy shocks do not account for much of FARMNET volatility, while in the long run, they have a modest effect on the variation in FARMNET. However, as time wears on, monetary policy shocks explain successively more and more of the forecast error variance in FARMNET.

As a check on the robustness of the results, the quarterly VAR model is reestimated using a different ordering with total nonfarm payroll employment (EMPL) included. Figures 7.23 and 7.24 display the effects of FF and NBRD policy shocks. As can be seen, the basic results are quite robust to specification.

Millions of 92\$

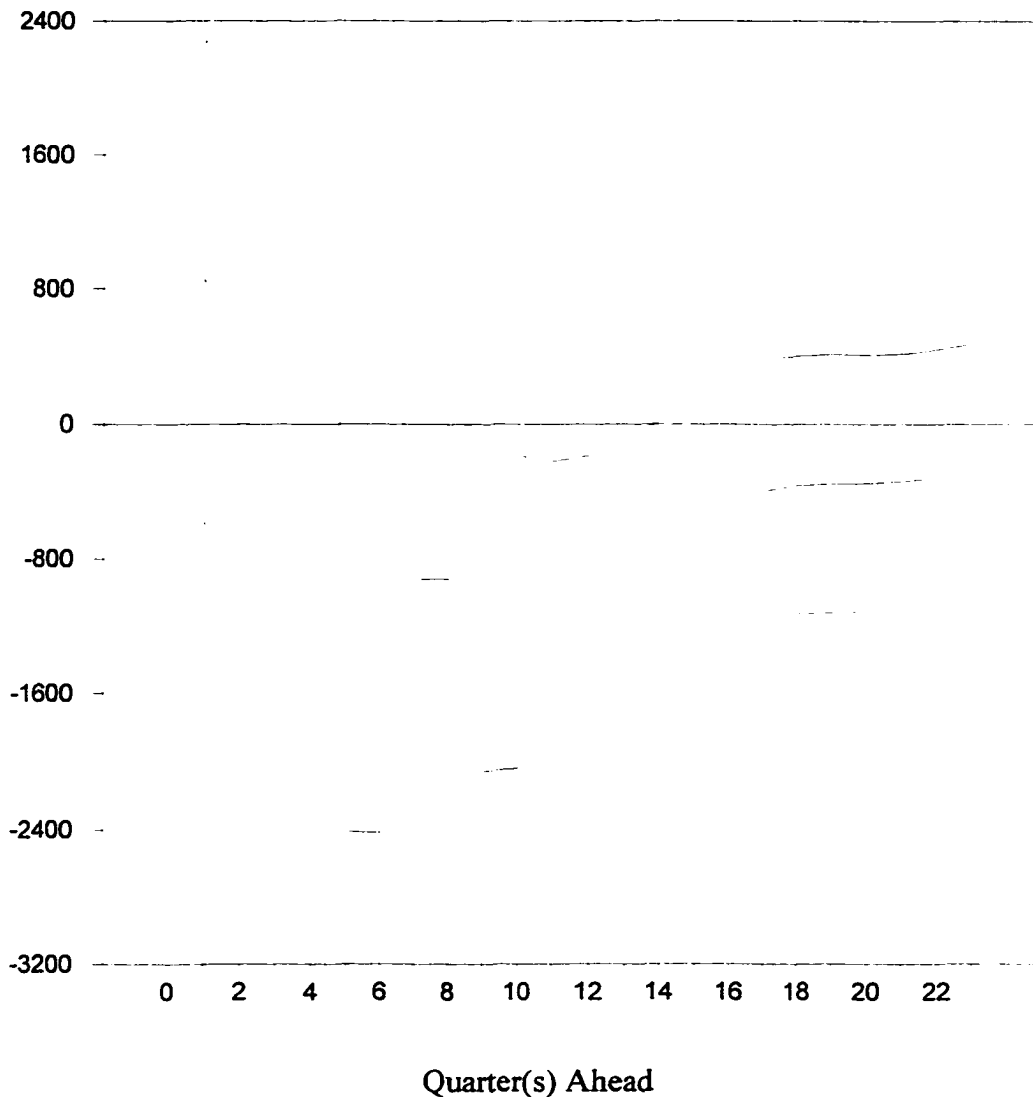


Figure 7.21 Response of FARMNET to FF Policy Shock

The impulse responses comes from estimates from a 7-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), the log of total reserves (TOTRES), and net funds raised in the farm sector (FARMNET). The impulse responses are constructed at 24 quarters horizon.

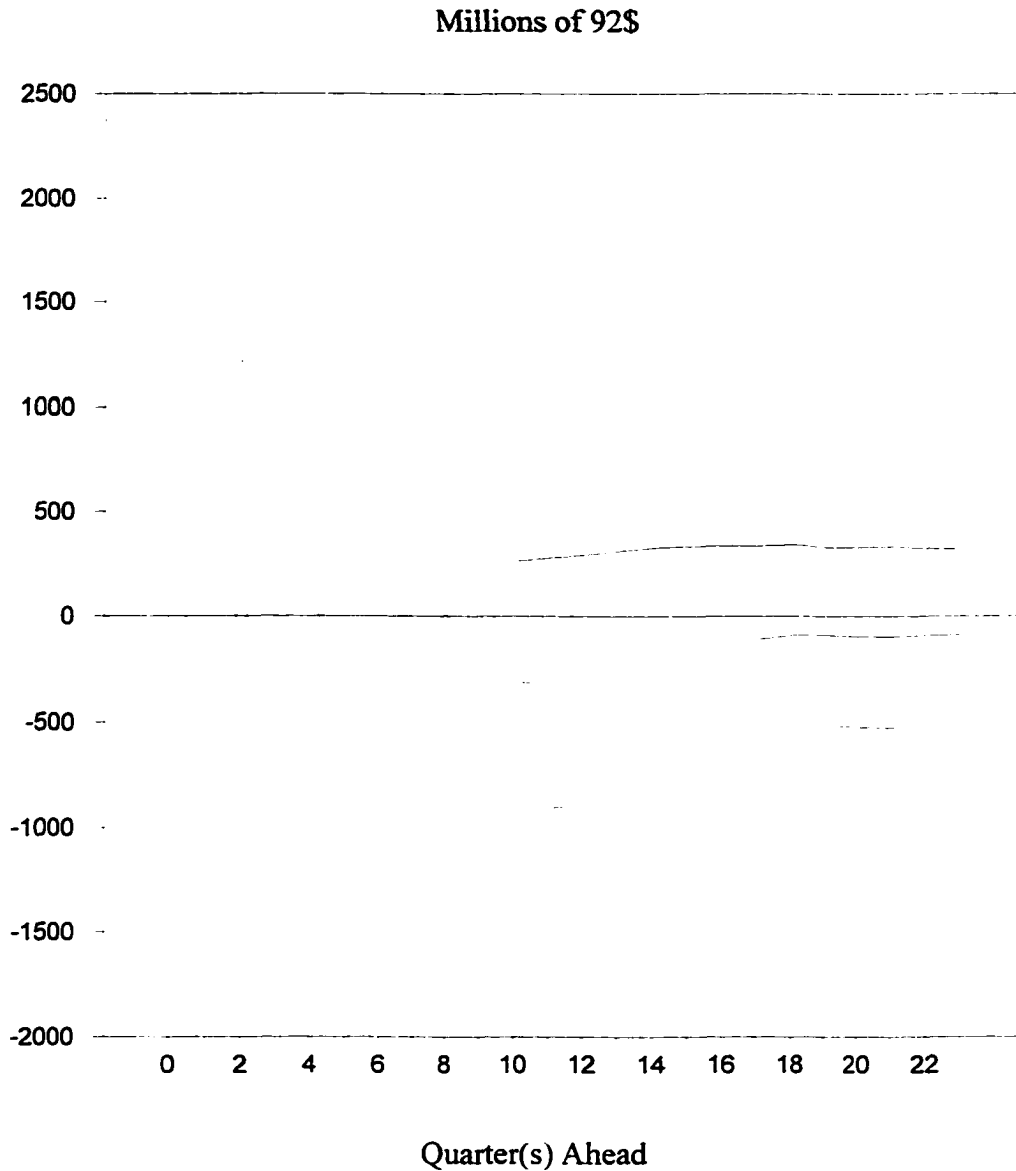


Figure 7.22 Response of FARMNET to NBRD Policy Shock

The impulse responses comes from estimates from a 7-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), the log of total reserves (TOTRES), and net funds raised in the farm sector (FARMNET). The impulse responses are constructed at 24 quarters horizon.

Table 7.3 Variance Decompositions for Net Funds Raised in the Farm Sector

Variable	Quarter(s) Ahead	FF Policy Shock*	NBRD Policy Shock**
FARMNET	1	0.1% (7075.5)	1.2% (7075.6)
	4	1.0% (8663.9)	1.1% (8663.9)
	8	6.3% (9169.4)	1.9% (9169.4)
	12	9.9% (9470.6)	2.0% (9470.6)
	24	11.9% (10035.2)	2.1% (10035.2)

Note: Standard errors of forecast are in parentheses.

* The estimates come from a 7-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), the federal funds rate (FF), minus the log of nonborrowed reserves (NBRD), the log of total reserves (TOTRES), and net funds raised in the farm sector (FARMNET).

** The estimates come from a 7-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), minus the log of nonborrowed reserves (NBRD), the federal funds rate (FF), the log of total reserves (TOTRES), and net funds raised by the farm sector (FARMNET).

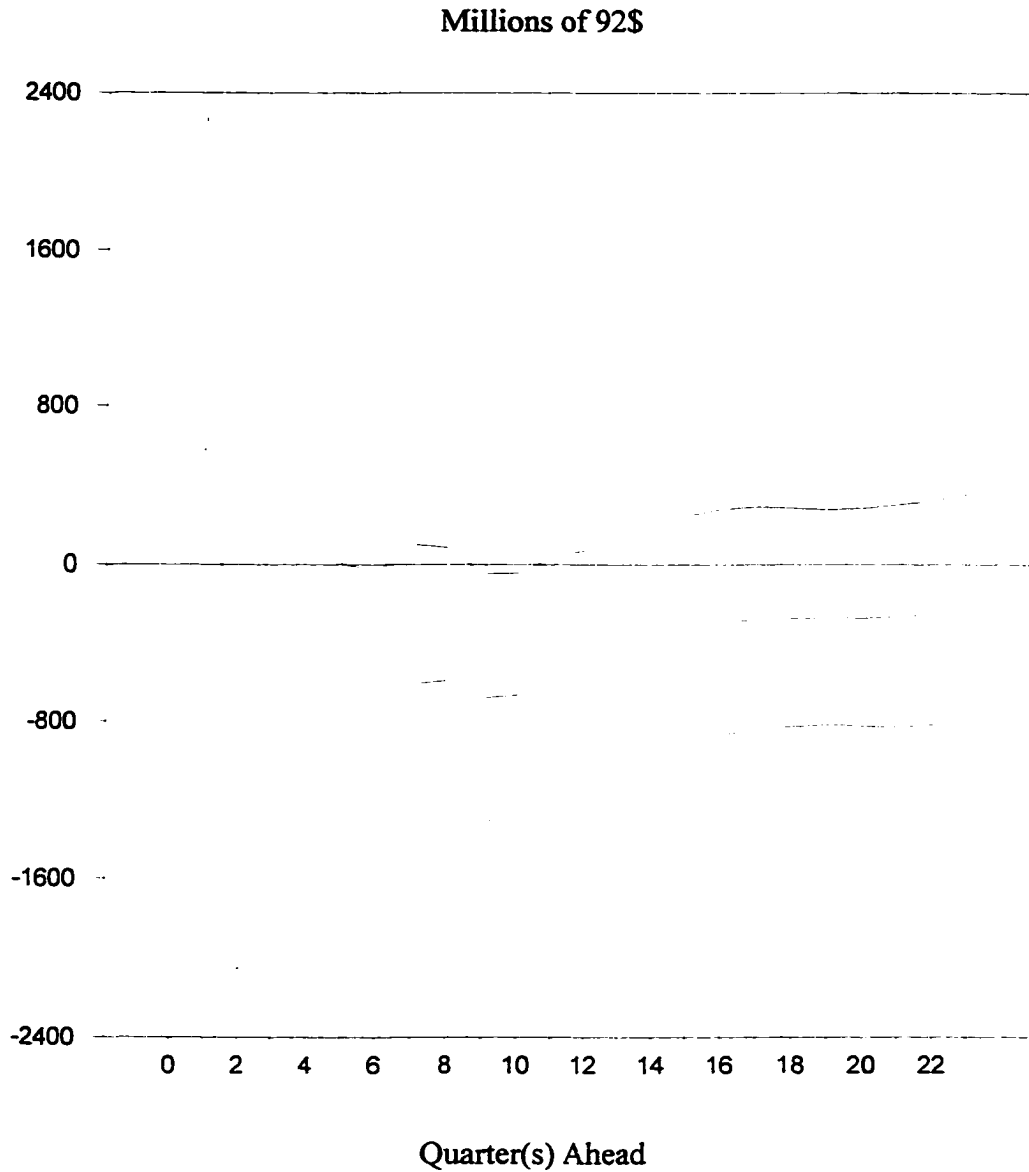


Figure 7.23 Response of FARMNET to FF Policy Shock

The impulse responses comes from estimates from a 6-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), the log of total nonfarm payroll employment (EMPL), the federal funds rate (FF), and net funds raised in the farm sector (FARMNET). The impulse responses are constructed at 24 quarters horizon.

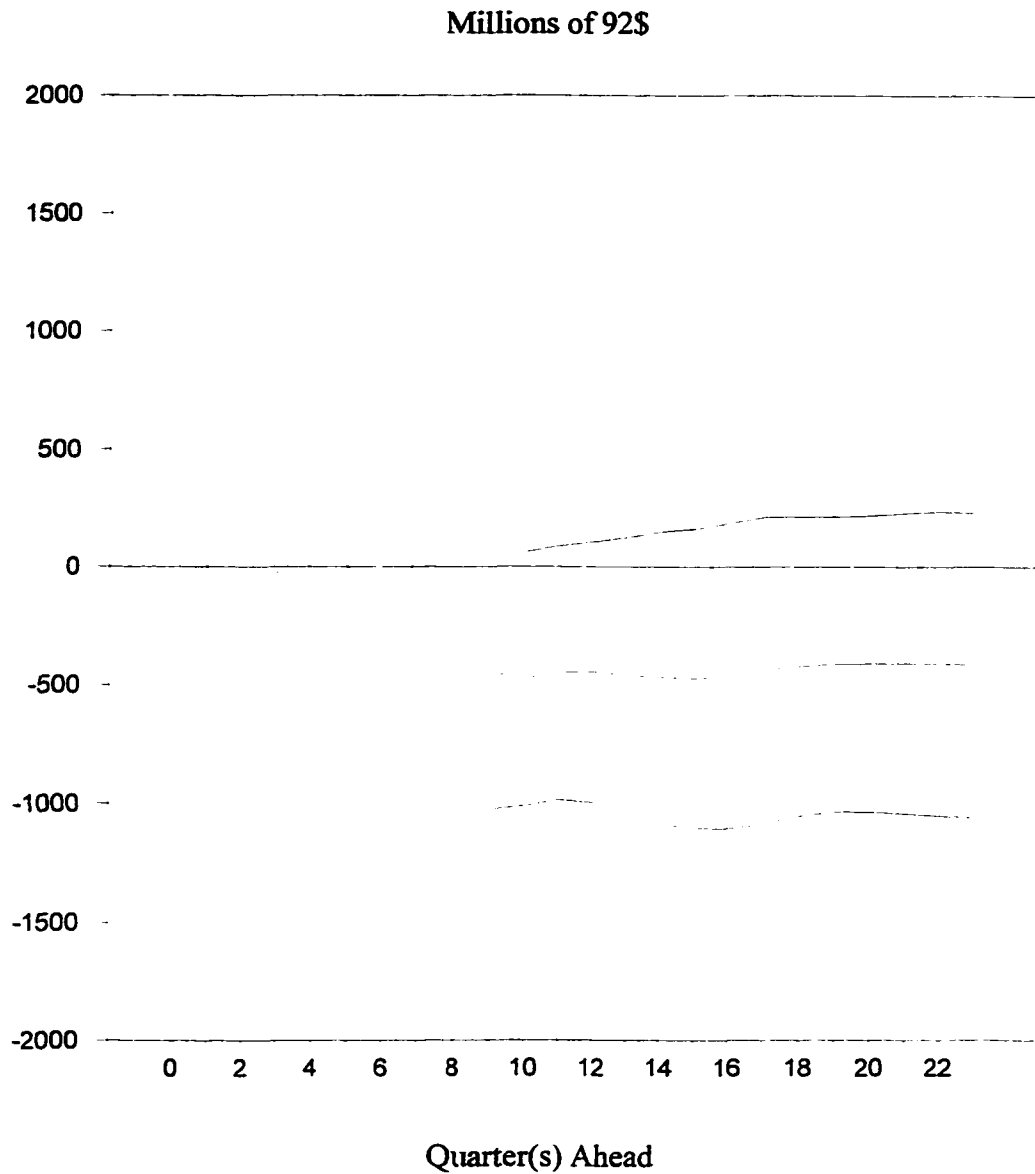


Figure 6.24 Response of FARMNET to NBRD Policy Shock

The impulse responses comes from estimates from a 7-variable quarterly VAR which includes the log of GDP (Y), the log of GDP deflator (P), the commodity price index (PCOM), the log of total nonfarm payroll employment (EMPL), minus the log of nonborrowed reserves (NBRD), and net funds raised in the farm sector (FARMNET). The impulse responses are constructed at 24 quarters horizon.

CHAPTER 8. CONCLUSION

This study applied vector autoregression methodology to develop VAR based monetary policy measures, and used similar identifying restrictions to those used in Christiano, Eichenbaum, and Evans (1996) to identify the effects of monetary policy shocks on the farm sector. It considered two potential channels for the transmission of monetary policy to the farm sector - the "money" channel, where a relative-price model was used to explain the effect of monetary policy shocks on relative farm prices; and the "credit" channel, where the Flow of Funds Accounts (FOFA) data was used to assess the impact of monetary policy shocks on the borrowing and lending activities of the farm sector.

The empirical results for the U.S. economy support the Cairnes-Bordo theory that agricultural product prices respond faster to monetary policy shocks than do manufactured product prices. Contractionary monetary policy shocks have a negative effect on relative farm prices because farm product prices decrease relatively more than nonfarm product prices. The dynamic response function shows a steady and persistent decline in relative farm prices after a contractionary monetary policy shock.

An important focus of the analysis is the response of net funds raised in the farm sector to monetary policy shocks. After a contractionary monetary policy shock, net funds raised in the farm sector increase for roughly a year, then decline. The initial rise in the net funds raised reflects the difficulty for farmers to quickly alter their nominal expenditures. Eventually, they reduce their nominal expenditures and net funds raised decline as predicted by the credit view.

In light of this, I have showed, using monetary policy measures based on the Federal Reserve's operating procedures, that monetary policy shocks have an important effect on the farm sector. Although there are some differences between the two policy shock measures considered, the basic qualitative response of the system to the two policy shock measures is quite robust.

I have confined myself to identification schemes that correspond to imposing World casual orderings on the innovations in VARs. By no means does this exhaust the class of identifying assumptions that have been used in the literature. One alternative class of identifying assumptions involves restrictions on the long-run impact of monetary policy shocks. Another alternative class of identifying assumptions employs nonrecursive schemes of the type considered by Bernanke (1986) and Sims (1986), among others. These are sometimes referred to as structural VARs. It would be of interest to investigate the sensitivity of inference to adopting these types of identifying restrictions as well.

Although the identification method works by tracing out the effects of unanticipated policy shocks, this approach takes no stand on whether it is only unanticipated monetary policy that matters. It is possible that anticipated policy changes have a stabilizing effect on the economy. Measuring this effect, however, requires the imposition of more economic structure in the analysis. Because the “semi-structural” VAR method does not account for the possibly stabilizing effects of anticipated policy changes, this approach cannot tell us whether the policy has been stabilizing or destabilizing during the sample period. Thus, variance decompositions that attribute a given percentage of the variance of prices or net funds raised to monetary policy can be misleading. At best, the variance decomposition exercise may suggest the amount by which more predictable policies could have reduced the variances of prices or net funds raised in a given sample period.

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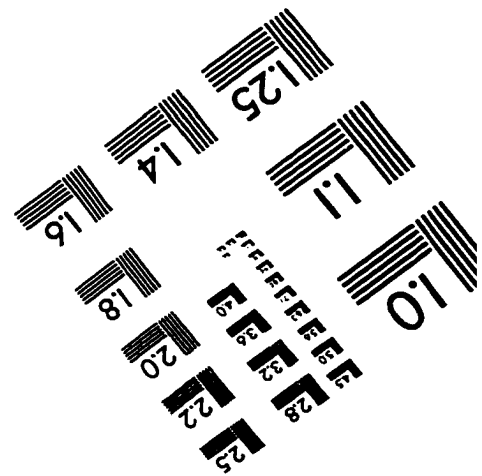
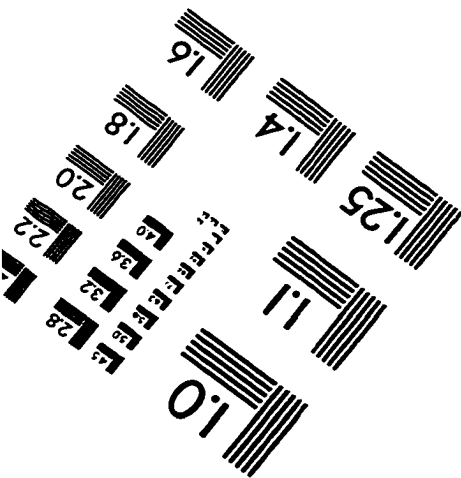
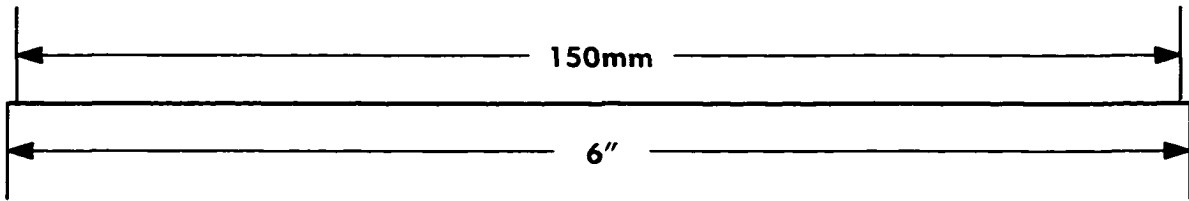
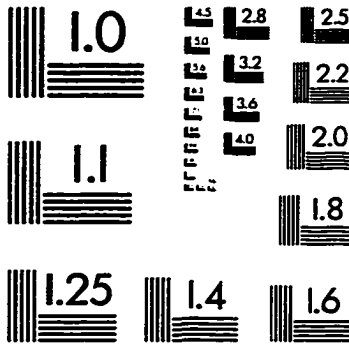
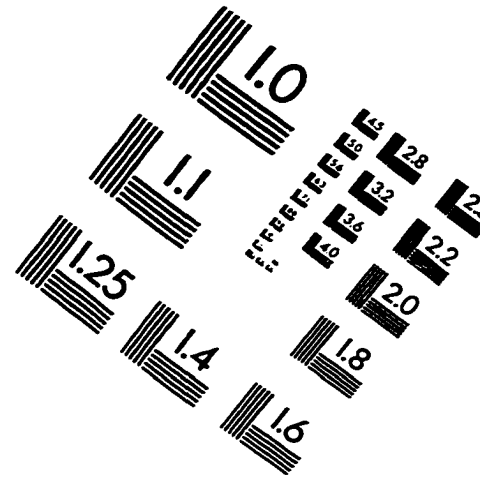
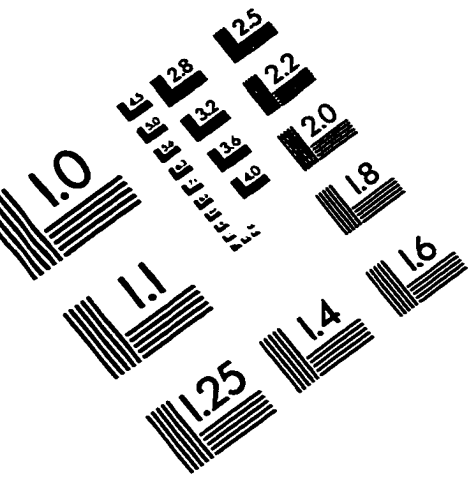
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IMAGE EVALUATION TEST TARGET (QA-3)



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