Carnegie-Rochester Conference Series on Public Policy 39 (1993) 1-45
North-Holland

How important is the credit channel in the transmission of monetary policy?

Valerie Ramey*

University of California, San Diego, La Jolla, CA 92093

Abstract

This paper empirically tests the importance of the credit channel in the transmission of monetary policy. Three credit variables are analyzed: total bank loans, bank holdings of securities relative to loans, and the difference in the growth rate of short-term debt of small and large firms. In order to determine the marginal effect of the credit channel over the standard money channel, the significance of the credit variables is studied in a model that includes money (M2). In most cases, the credit variables play an insignificant role in the impact of monetary policy shocks on output.

Introduction

The mechanism by which monetary policy is transmitted to the real economy remains a central topic of debate in macroeconomics. Much research on the monetary transmission mechanism has been conducted since Ben Bernanke wrote about this topic in the 1986 *Carnegie-Rochester Conference Series on Public Policy* (Vol. 25). While a broad consensus seems to have formed on several aspects of the problem, other areas remain controversial. One area of debate is the relative importance of the money and credit channels in the

*I am grateful to Jan Brueckner, Wouter den Haan, Simon Gilchrist, Allan Meltzer, David Romer, and participants at the Carnegie-Rochester Conference for helpful suggestions, and to Simon Gilchrist and Egon Zakrajsek for kindly providing the data on small and large firms from the *Quarterly Financial Reports*. I thank the National Science Foundation for financial support.

transmission of monetary policy. It is this topic that the present paper will address.

In both the money and credit views, the process begins when the central bank alters the ability of commercial banks to function by manipulating either reserve requirements or the real level of reserves. While it is clear how the central bank can manipulate reserve requirements, the method by which it alters the real level of reserves is controversial. Often models of the process contain some sort of rigidity, such as price rigidity (Mankiw (1985), Ball and Romer (1990)) or limited participation in financial markets (Grossman and Weiss (1983), Rotemberg (1984), and Christiano and Eichenbaum (1992)). It is not the method by which the central bank has an influence on real reserves, however, that distinguishes the money and credit views. Rather, it is the channel by which changes in reserves impinge on real activity that differs.

In the money, or transactions view, there are only two classes of assets: money and all other assets. Reserves have value because they are held against transactions deposits, which can only be issued by banks. A decline in reserves results in a fall in transactions deposits, which drives up the nominal interest rate. The rise in the interest rate can affect the economy in several different ways. In the usual Keynesian-type models, such as the standard IS-LM model, the rise in the nominal interest rate translates into a rise in the real interest rate which depresses aggregate demand. Since output is determined by demand in the short-run, real activity declines. In Christiano and Eichenbaum's (1992) model, the rise in interest rates depresses aggregate supply, so output falls. In all of the models, the monetary transmission mechanism works through the liability side of bank balance sheets. There are two key necessary conditions for the money channel to work: (1) banks cannot perfectly shield transactions balances from changes in reserves; and (2) there are no close substitutes for money in the conduct of transactions in the economy.

The point of departure of the credit view is the rejection of the notion that all nonmonetary assets are perfect substitutes. Earlier work in this literature argued that financial assets and real assets were not perfect substitutes (e.g., Tobin (1970), Brunner and Meltzer (1972)). The standard models were augmented by including various asset markets, and then were used to investigate the role of the interaction of these markets in the transmission mechanism. In more recent work, the focus has been on the imperfect substitutability of various types of financial assets (e.g., Bernanke and Blinder (1988)). This focus is a natural outgrowth of the literature on financial market imperfections arising from information asymmetries between borrowers and lenders. The theoretical models in the credit literature argue that asymmetric information leads to imperfections in financial markets. In particular, because of imperfect monitoring, the cost of external funds will be higher than the cost of internal funds (e.g., Bernanke and Gertler (1989)). Furthermore, many have argued that banks have special access to a monitoring technology, so that they can often provide loans to some firms for whom the cost of alternative sources of funds is very high (e.g., Diamond (1984)). Thus, internal funds, bank loans, and other sources of financing are imperfect substitutes for firms.

According to the credit view of the monetary transmission mechanism, monetary policy works by affecting bank assets, i.e., loans, in addition to bank liabilities, i.e., deposits (Bernanke and Blinder [1992], p. 901). Most versions of the credit view argue that the bank loan channel is a supplement, not an alternative, to the usual money channel. Bernanke and Blinder (1992, p. 901) describe how this supplemental channel might work: "...when the Federal Reserve reduces the volume of reserves, and therefore of loans, spending by customers who depend on bank credit must fall, and therefore so must aggregate demand. This provides an additional channel of transmission for Federal Reserve policy to the real economy, over and above the usual liquidity effects emanating from the market for deposits." The decline in bank loans can affect real economic activity through either rationing of loans (Stiglitz and Weiss (1981)) or market-clearing rises in the premium on bank loans (Bernanke and Blinder (1988)). The key link is that monetary policy shifts the supply of bank loans as well as the supply of deposits. Again, in some models the effect works through aggregate demand (Bernanke and Blinder (1988)), while in others the effect works through aggregate supply (Blinder (1987)). The two key necessary conditions that must be satisfied for a lending channel to operate are: (1) banks cannot shield their loan portfolios from changes in monetary policy; and (2) borrowers cannot fully insulate their real spending from changes in the availability of bank credit.

A broader credit view argues that credit market imperfections may be an important part of the propagation of both monetary and real shocks to the economy, even if the central bank cannot directly regulate the flow of bank credit (Bernanke (1983), Brunner and Meltzer (1988), Bernanke and Gertler (1989), Gertler and Gilchrist (1991)). In this view, credit market frictions may drive a wedge between the cost of internal and external funds. Aggregate disturbances potentially alter the size of this wedge in a way that magnifies the overall importance of the shock. For example, a debt-deflation can decrease the net worth of firms, raising their real cost of borrowing and thus lowering their investment levels.

Distinguishing the relative importance of the money and credit channels is useful for several reasons. First, understanding which financial aggregates are impacted by policy would improve our understanding of the link between the financial and real sectors of the economy. Second, a better understanding of the transmission mechanism would help policymakers interpret movements in financial aggregates. Third, more information about the transmission mechanism might lead to a better choice of targets. In particular, if the credit channel is an important part of the transmission mechanism, then bank portfolios should be the focus of more attention.

This paper analyzes the existing evidence on the monetary transmission mechanism and presents new evidence on the relative importance of the credit and money channels. The focus of the paper is on the propagation of shocks to monetary policy, so the results do not address the broader credit view discussed above. Many of the empirical results favoring the credit view consist of tests of the necessary conditions discussed above. I argue that while these results are an important part of the case for the credit view, they alone should not be used to draw conclusions about the general equilibrium results. In conducting the analysis, I first present a simple model that illustrates the difference between the money and credit views and highlights the problems in testing the hypotheses. Using the model as a guide, the data are analyzed in several ways. The credit variable studied in most detail is total bank loans. I argue that the best way to investigate the relative importance of money and loans in the transmission process is to study their respective deviations from their long-run relationships with output. Using these error correction terms, I analyze the relative importance of money versus credit in terms of their predictive power and their importance in the response of output to shocks to monetary policy. I also analyze two other credit-related variables: the composition of bank portfolios and the differences between small and large firms.

Most of the results heavily favor the money view. All of the credit variables have predictive power for output when the money variables is not included. Once the money variable is included, most of the credit variables no longer affect output in a way that is consistent with the standard credit view of the monetary transmission mechanism. Furthermore, when the credit channel is shut down, the dynamic response of output policy changes little. On the other hand, when the money channel is shut down, the dynamic response of output changes drastically. The only exception is a credit variable that measures the relative growth of short-term debt of small firms to large firms. This variable has a noticeable impact on the dynamic response of output in some cases.

Review of recent results

In this section I will summarize some of the results of the literature that are useful for studying the monetary transmission mechanism. I will discuss not only empirical results, but also some of the general themes that occur in the literature. These results will be organized in the form of general conclusions that one may draw from recent studies.

1. *Statistical innovations to monetary aggregates are a bad measure of monetary policy disturbances.*

Several sets of empirical results have led to this general conclusion. First, King and Plosser (1984) and others have presented convincing theoretical and empirical arguments that many of the movements in monetary aggregates may be endogenous responses to real shocks to the economy. Second, another group of researchers has argued that the operating procedures of the Federal Reserve Board in fact imply that innovations to broad monetary aggregates are primarily shocks to money demand rather than to money supply (e.g., Bernanke and Blinder (1992), Christiano and Eichenbaum (1992), and Strongin (1991)).

As a consequence, many have sought better measures of monetary policy disturbances that correspond more closely to Federal Reserve actions. For example, Romer and Romer (1989) used their readings of the minutes of the FOMC to isolate periods when the Fed clearly stated that it was willing to induce a recession in order to bring inflation down. Thus, their indicator is based on the written intentions of the Fed. Boschen and Mills (1992) extend the Romers' method by creating an indicator of Fed intentions for all time periods. On the other hand, Bernanke and Blinder (1992) argue that innovations to the Federal Funds rate are a good indicator of disturbances to monetary policy. They conduct a careful empirical analysis of the Fed's reaction function that supports their conclusion. In a similar vein, Strongin (1991) argues that the mix of nonborrowed reserves to total reserves is a good indicator of monetary policy. After reviewing actual operating procedures, Strongin concludes that innovations in total reserves are primarily the results of the Federal Reserve's accommodation of innovations in the demand for reserves, and that the Federal Reserve acts by altering the mix of borrowed and nonborrowed reserves. As a result of these efforts, researchers now have much better indicators of monetary policy disturbances.

2. *Innovations to monetary policy alter the composition of bank portfolios.*

Using innovations to the Federal Funds rate as an indicator of shifts in monetary policy, Bernanke and Blinder (1992) find that a positive shock to the funds rate leads to shifts in the portfolios of depository institutions. Deposits begin to decline immediately, reach a trough at nine months, and stay permanently lower. On the asset side of the balance sheet, only securities fall significantly at first. After six months loans begin to decline, followed by an increase in securities. In general, loans begin to fall at about the same time as measures of output begin to fall, about six months after the initial shock. Gertler and Gilchrist (1992) add some detail to the pattern.

Disaggregating bank loans, they find that total commercial and industrial loans do not respond significantly to a monetary tightening, whereas real estate loans and consumer loans account for almost all of the decline in bank loans after a monetary tightening. Thus, the data is at least consistent with one necessary condition for the credit story – that shocks to monetary policy, as defined by innovations to the Federal Funds rate, alter the composition of bank portfolios.

The theoretical implications of this change in the composition of bank portfolios have not been well-developed. Bernanke and Blinder (1988) include both bonds and loans as assets of banks in their model, but do not discuss changes in the composition. If banks sell securities after an open-market sale of bonds by the Federal Reserve, then the nonbank public's holdings of securities must increase by more than the initial sale. The importance of this effect for the credit channel has yet to be analyzed.

3. *The composition of finance affects investment decisions.*

Panel studies uniformly find the composition of finance to be an important predictor of investment activity (Fazzari, Hubbard, and Peterson (1999), Gilchrist (1990), Himmelberg and Peterson (1991), Whited (1993)). Many of these studies use sample splitting methods and find that those firms most likely to be financially constrained (such as small firms and new firms) are those most sensitive to cash flow. Several studies also find that balance-sheet positions matter at a more aggregate level. For example, using Euler equation methods, Hubbard and Kashyap (1992) find that internal net worth affects investment in agricultural equipment. Kashyap, Stein, and Wilcox (1993) find that the aggregate financing mix between bank loans and commercial paper seems to play a key role during monetary contractions. They first show that the issuance of commercial paper jumps relative to bank loans after a monetary tightening. They then show that the mix variable has predictive power in certain investment equations.

4. *Small firms are more sensitive than large firms to monetary contractions and general output declines.*

Gertler and Gilchrist (1991, 1992) and Oliner and Rudebusch (1992) use data from the *Quarterly Financial Reports on Manufacturing Firms* to distinguish the behavior of small and large firms. They find several interesting patterns. First Kashyap, Stein and Wilcox's (1993) mix variable suffers from compositional problems. In particular, large firms increase both their issuance of commercial paper and their use of bank loans after a monetary tightening. Thus, Kashyap, Stein, and Wilcox's argument that individual firms are substituting commercial paper for bank loans does not seem to be true. Small firms do not begin to show a decrease in bank loans until threequarters after the innovation to monetary policy. Oliner and Rudebusch create a broader financial mix variable that includes alternative forms of financing for small firms. The investment of small firms responds much more to the mix variable than the investment of large firms. Particularly interesting is the Oliner and Rudebusch's finding that the importance of cash flow for the investment of small firms increases significantly during a monetary rightening. Gertler and Gilchrist (1991) also show that the sales of small firms tend to fall relative to the sales of large firms in response to both a monetary tightening and to other shocks to GNP. Furthermore, the bank loans of small firms fall relative to the bank loans of large firms after a monetary tightening.

5. *Aggregate empirical results on the importance of the credit channel are mixed.*

One of the first papers to address the importance of the credit channel was by Stephen King (1986). Compared to both commercial and industrial loans and other bank loans, King found that monetary aggregates were superior in both statistical significance tests and variance decompositions in a standard VAR for GNP. On the other hand, using a different VAR methodology, Bernanke (1986) found that aggregate demand innovations depended significantly on shocks to total depository loans.

More recent work on the subject has used the new indicators of monetary policy disturbances. Romer and Romer (1990) use their dummy variables to ask which of two polar views, only money or only credit, is the best approximation to the data. For each of their tests they run two sets of equations, one using a monetary aggregate and one using total bank loans. In general, they find that money leads output during a monetary tightening, but that bank loans move contemporaneously with output. Based on the various analyses they conduct, they conclude that the evidence is more consistent with the traditional money view of the monetary transmission mechanism.

Bernanke and Blinder (1992) and Gertler and Gilchrist (1992) use innovations in the Federal Funds rate as an indicator of monetary policy disturbances. They too find that money (M1 or M2) declines immediately, while bank loans are slower to fall, moving contemporaneously with output.

Assessment of the results

I offer the following assessment of the empirical results in the literature. The panel study results and the small- versus large-firm results are very compelling evidence in favor of the hypothesis that there are credit market imperfections, and that their effects are particularly important during periods of monetary tightening. In most cases, the authors of the studies have been careful in trying to eliminate simultaneity problems.

On the other hand, whether the credit channel is an important part of the aggregate monetary transmission mechanism remains an open question. There are two main reasons. First, none of the studies of firms by size classes have shown that the reaction of small firms has an aggregate impact. This is an important link in the argument because one can think of equilibrium forces that would mitigate the aggregate effect. For example, the loss in output from small firms due to the decline in bank loans might be compensated by a rise in output from large firms. In fact, as discussed above, the evidence shows that large firms increase both commercial paper and bank loans after a monetary tightening. Second, the fact that the overall decline in bank loans does not occur until output itself falls is troubling.

There are two ways to interpret the coincident decline in total bank loans and output. Bernanke and Blinder (1992) argue that bank loans respond with a lag because loans are quasi-contractural commitments that take time to adjust. In the interim, banks sell off securities. Eventually, they decrease their loans, and this has an immediate and dramatic effect on real activity. In their scenario, bank loans are related to output in a Leontief-type of production function even in the short-run, so that a decrease in the equilibrium quantity of banks loans leads to an immediate decrease in output. A related argument (e.g., Gertler and Gilchrist (1992)) is that firms actually require a higher bank loan to output ratio because they must finance unsold inventories. Thus, the fact that bank loans do not increase relative to output is a sign that there is a constriction in the supply of bank loans. The argument made as to why bank loans lag in their response is not complete, though. Bernanke and Blinder's empirical analysis assumes symmetry, so they need to explain not only why loans are slow to fall after a monetary tightening, but also why loans are slow to *rise* after a monetary easing. The obvious alternative interpretation of the results is that the decline in output, brought about through the money channel, is "causing" the decline in bank loans.

In the empirical section, I will study the aggregate effects of monetary policy disturbances through the money and credit channels. Every attempt will be made to adequately capture the various factors discussed above. Before turning to the empirical work, it is important to discuss in a more concrete manner how the money and credit channels work. The next section presents a framework that is useful for discussing the various issues.

A framework for analyzing the monetary transmission mechanism

Ideally, one would analyze the monetary transmission mechanism in a detailed dynamic stochastic general equilibrium model. There is, however, no commonly agreed-upon equilibrium model for studying the effects of monetary policy on the economy. Therefore, I specify a framework that is specific about the aspects of the economy that are the focus of the money-versus-credit debate, but is vague about other aspects. In particular, the model specifies the interaction between firms, banks, and the Fed, but leaves the rest of the economy unspecified. Furthermore, the model does not specify how the Federal Reserve can affect the real level of reserves nor how the price level is determined. Despite its incompleteness, the model is useful in two respects. First, it states in a concrete way some of the aspects of the money and credit views. Second, it serves as a useful guide for the empirical analysis: it indicates how to handle the nonstationarity of the data and directs how to test the relative importance of the money and credit views. The model has much the same flavor as Bernanke and Blinder's (1988) extended IS-LM model, the main difference being that the present model specifies the technology of goods production and banking services production more explicitly.

Suppose the goods and banking sectors of the economy can be described as follows.

Goods-producing firms

The production function for goods of the representative firm is given by:

$$Y_t = f(K_t, N_{yt}, \theta_t M_{ft}/P_t, \eta_t L_t/P_t, \lambda_t) \tag{1}$$

Output Y_t depends on inputs capital K, labor N_y, real money balances M_f/P, and real bank loans L/P. λ is a technology shock, and θ and η are idiosyncratic shocks to the productivity of money and bank loans. This production function is meant to capture in a very general way some of the elements of the money and credit stories. Because the firm must pay at least some of its factors of production before it receives its revenues, it requires liquidity in the form of money. The higher its liquidity, the more smoothly the production process works, so an increase in M_f/P increases output. The firm obtains liquidity by either borrowing from banks, in the form of bank loans L or by floating bonds B in the open market. It is assumed that the firm's only asset is money and its only liabilities are bank loans and bonds. Thus, the balance-sheet identity is $M_f = L + B$. The perfect capital markets' view would argue that L enters only through M and not as a separate argument in the production function, because bank loans and open-market bonds are perfect substitutes. The credit view, on the other hand, would argue that bank loans do have a separate role. Banks have access to special monitoring and evaluation technology that assures that funds are directed to the highest value uses. Thus, when a firm finances through bank loans, it avails itself of the credit services provided by banks.

It is assumed that the firm rents its capital stock from consumers. The current real profits for the representative firm are given by:

$$F_{ft} = Y_t - (\rho_{mt} + i_t)M_{ft}/P_t - (\rho_{1t} - i_t)L_t/P_t - w_t N_{ft} - (i_t - \pi_t + \delta)K_t \tag{2}$$

In this equation, ρ_m is the fee for using bank transactions services, i is the nominal interest rate on bonds, ρ_1 is the interest rate on bank loans, w is the real wage rate, and $i - \pi + \delta$ is the rental price of capital, with π as the inflation rate. In this formulation, the balance-sheet identity has been used to substitute bonds out of the equation. The firm chooses inputs to maximize current period profits in (2), given the technology in (1) and the balance-sheet identity. If the production function is concave, then a supply function is well-defined. The supply function of goods has the following form:

$$Y_t^s = y(\underset{-}{\rho_{mt} + i_t}, \underset{-}{\rho_{1t} - i_t}, \underset{-}{w_t}, \underset{-}{i_t - \pi_t + \delta}, \underset{+}{\lambda_t}, \underset{+}{\theta_t}, \underset{+}{\eta_t}) \tag{3}$$

The signs under the arguments indicate the sign of the derivative with respect to the argument. Equation (3) is a useful equation for distinguishing the money and credit views. The credit view differs from the money view in that it argues that the elasticity of output with respect to $\rho_1 - i$ is negative and economically significant. This condition is essentially the second necessary condition of the credit view discussed in the introduction.

Banking sector

It is useful to begin by discussing the representative bank's balance sheet. For simplicity, assume that the only liability is transactions deposits of firms and individuals, $M = M_f + M_c$. On the asset side are reserves R, loans, L, and bonds issued by firms B. Thus, the accounting identity is $M = R + L + B_b$, where the subscript b distinguishes assets held by banks versus other agents. Real profits are given by:

$$\begin{aligned} F_{bt} = {} & (\rho_{mt} + i_t)M_t/P_t + (\rho_{1t} - i_t)L_t/P_t - i_t R_t/P_t \\ & -b(w_t, (R_t - \tau M_t)/P_t, L_t/P_t, M_t/P_t, \lambda_t) \end{aligned} \tag{4}$$

The first line of the expression represents revenues of the bank. Banks earn ρ_m on transactions services M, ρ_1 on bank loans L, and the nominal interest rate i on bonds. Bonds do not appear because the accounting identity has been used to eliminate bonds and substitute in reserves. The expression on the second line is a type of cost function for the bank. It is assumed that banks use labor services (N_{bt}) to produce transactions and credit services. Thus, the real wage enters the cost function positively. On the other hand, it is assumed that the level of excess reserves helps to economize on labor so real excess reserves, given by $E/P = (R - \tau M)/P$ where τ is the reserve requirement on money, enter negatively in the cost function. Because it requires more resources to produce more transactions and credit services, quantities of these items enter the cost function positively. Finally, λ is the economy wide-technology shock that affects bank services' production as well as goods production. λ enters the cost function negatively.

Profit maximization implies the following supply functions (assuming b is convex in output):

$$M_t/P_t = m^s(\underset{+}{i_t + \rho_{mt}}, \underset{?}{\rho_{1t} - i_t}, \underset{-}{w_t}, \underset{+}{R_t/P_t}, \underset{+}{\lambda_t}) \tag{5}$$

$$L_t/P_t = 1^s(\underset{?}{i_t + \rho_{mt}}, \underset{+}{\rho_{1t} - i_t}, \underset{-}{w_t}, \underset{+}{R_t/P_t}, \underset{+}{\lambda_t}) \tag{6}$$

The supply of each item depends positively on its own price, the level of real reserves (assumed to be exogenous to the bank), and the technology shock, and depends negatively on the real wage. The cross-price effect depends on the interaction between the goods in the cost function.

Statements about equation (6) relate to the first necessary condition of the credit view discussed in the introduction. In particular, for the credit view to hold the bank's technology must be such that the elasticity of loan supply with respect to reserves is high. The elasticity depends on two elements: (1) the degree to which the bank adjusts its holdings of excess reserves in response to a change in total reserves; and (2) the change in the cost of making loans resulting from the change in excess reserves. To see this, consider a specific functional form for the cost function b:

$$b = w\frac{1}{2}[(\frac{M}{P})^2 + (\frac{L}{P})^2]/[\lambda(\frac{E}{P})^\alpha], 0 < \alpha < 1, \tag{7}$$

where E denotes excess reserves. The first-order condition for the choice of L/P gives the following relationship between loans and excess reserves:

$$L/P = (\frac{E}{P})^\alpha(\rho_1 - i)\lambda/w. \tag{8}$$

Thus, for a given loan premium, the effect of an increase in reserves on the loan supply depends on its effect on optimal holdings of excess reserves, and on the effect on the cost function through α.

Romer and Romer (1990) argue that banks can fund loans at the margin by issuing large CDs because they have much lower reserve requirements. The model presented above makes a similar argument, but in terms of another possible alternative. In particular, I argue (based in part on Bernanke and Blinder's (1992) evidence) that banks can fund loans at the margin by selling securities. One could argue that securities (especially Treasury bills) affect costs in a way similar to excess reserves,[1] but in this case too, the effect on

[1] In particular, if the cost function contains the term $(E/P + \theta G/P)^\alpha$, where G is the bank's holdings of government bonds, then government bonds are a substitute for excess reserves. The first-order condition for government bonds would link the spread in interest rates between government and other bonds to the marginal benefit of the liquidity provided by government bonds.

loan supply would operate through the same channel as the one discussed above.

Federal Reserve

The Federal Reserve sets the level of reserves according to the following reaction function:

$$R_t/P_t = j(Y_t, i_t, \pi_t)\mu_t. \tag{9}$$

The supply of real reserves depends on the current state of the economy and the shock to monetary policy. This specification contains the very strong assumption that shocks to monetary policy can affect the *real* level of reserves. In order for this effect to hold, the model must have some sort of departure from Walrasian equilibrium, such as rigidity in prices or sluggish savings on the part of consumers (Christiano and Eichenbaum (1992)). It is this aspect of the model (and hence how equilibrium prices are determined) that is left unspecified, and hence is a "black box."

Distinguishing the money and credit channels

The monetary transmission mechanism deals with the complete path of the initial disturbance to monetary policy to the ultimate effect on equilibrium output. The relative importance of the money and credit channels depends on how important each quantity is as a transmitter of the shock to output. In the model above, only part of the economy is specified. A complete model would also formulate the optimization problem of the household sector and specify the market-clearing conditions. Presumably, households would also hold money and bonds, so their demands would help determine equilibrium prices and quantities. In general, the equilibrium quantities in the economy should be functions of the shocks hitting the economy, such as the technology shock λ, the shock to money demand θ, the shock to loan demand η, and the shock to monetary policy μ, as well as any other state variables that arise from the dynamics (which are also not fully specified in the framework above). Consider the following expression for equilibrium output:

$$Y_t = j[M(\mu_t, \lambda_t, \theta_t, S_t), L(\mu_t, K_t, \lambda_t, \eta_t, .), \lambda_t, S_t], \tag{10}$$

where $M()$ denotes equilibrium real money balances as a function of the shocks and any relevant state variables, denoted by S, and $L()$ denotes equilibrium real loan balances as a function of the shocks and state variables. The impact of a monetary policy disturbance can be written as:

$$\frac{\partial Y}{\partial \mu} = \frac{\partial j}{\partial M}\frac{\partial M}{\partial \mu} + \frac{\partial j}{\partial L}\frac{\partial L}{\partial \mu}. \tag{11}$$

The "only money matters" story would argue that only the first term on the righthand side is important, while the credit story would argue that the second term is also important. Thus, assessing the relative importance of the money versus credit channels amounts to assessing the magnitude of the two terms. Figure 1 illustrates the same idea graphically. To determine the relative importance of the money and credit channels, one in essence must measure the portion of the monetary-policy disturbance that flows through each of the channels with arrows pointing down to output, a_1, a_2, b_1, and b_2. It is not enough to do a variance decomposition of output response to innovations in money and loans. In fact, in a vector autoregression that also included an indicator of monetary policy, the shocks to money and loans would be orthogonal to monetary policy and thus would not be related to the monetary transmission mechanism. Moreover, standard Granger-causality tests are not sufficient because money and bank loans can lead output if there are lags in production. For example, a shock to technology λ may travel up the paths c or d to money and bank loans before it changes actual output (King and Plosser (1984)). Thus, the predictive power of money and loans could have nothing to do with monetary policy. The direct way to assess the importance of the two channels in the monetary transmission mechanism is to trace policy disturbances through the financial aggregate into output fluctuations.

The analysis by Romer and Romer (1990) is one of the few aggregate studies that attempts to trace a monetary shock directly. The Romers focus on the behavior of money versus loans in the tight-money periods they isolated in their previous work. In various implementations, they attempt to control for the endogeneity problem by either including future output or by comparing instrumental variables' estimates of the effects of money or loans on output (using their dummy variables as instruments) to ordinary least squares estimates. Romer and Romer purposely narrow their analysis in three ways. First, their only indicator of monetary-policy disturbances is a parsimonious set of dummy variables which isolate only six episodes. Thus, their estimates are not sufficiently precise to do any formal statistical tests. Furthermore, the dummy variables do not necessarily represent exogenous shocks to monetary policy. For example, if inflation affects output through some other mechanism, the dummy variables may have predictive power only because they are correlated with inflation.[2] Ideally, one would use the residual of the regression of the dummies on other variables such as inflation as an indicator of the shock to monetary policy. Second, Romer and Romer choose to focus only on certain links of the monetary transmission mechanism in isolation, rather than tracing out the general equilibrium results. Hence, their estimation equations tend to be bivariate equations

[2]See Hoover and Perez (1992) for a complete discussion of this issue.

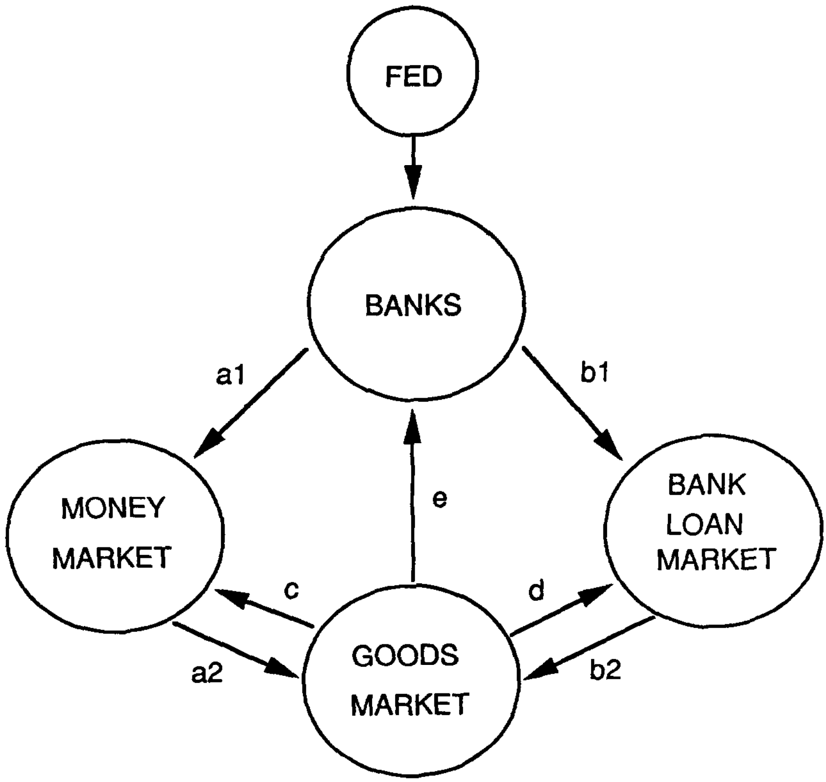


Figure 1
Channels of Monetary Transmission

that do not capture many of the potential links. Third, they ask the more narrow question, which of the polar views — only money or only credit — is a better approximation of the data. This manner of posing the question is not entirely fair to the credit view, since most advocates of the credit view do not argue that money is unimportant.

The current analysis extends on the Romers' work in several ways. First, based on results of Konishi, Ramey, and Granger (1993), it uses the velocity of money and loans. Velocity-type variables, rather than first differences or levels of money and loans, capture the short-run movements of the financial variables in a very efficient way. Using these types of variables has two main advantages. First, they tend to carry much greater information in this form for future movements in output. Second, the variables map very neatly to the various channels of the monetary-transmission mechanism. The second extension in the current work is that it asks the more general question concerning the relative importance of each of the channels, and studies the question in a multivariate setting using different indicators of monetary policy. Third, the analysis also incorporates some of the issues raised by the credit literature, such as the behavior of bank balance sheets, the heterogeneity of large and small firms, and the possibility that loan demand relative to output might vary over the business cycle.

A note on stochastic trends and cointegration

As in almost any analysis of macroeconomic data, the issue of nonstationarity arises. The model presented above provides guidelines for this part of the analysis. As King, Plosser, Stock and Watson (1991) show, in a standard neoclassical model with nonstationary technology shocks output, consumption, investment, and the capital stock will be nonstationary. All four variables, however, will share a common stochastic trend and hence will be cointegrated. Ramey (1992) uses a similar analysis in a model of trade credit and money. What sort of results would one expect in the model presented above? Most would argue that the usual shocks to monetary policy can have only a transitory impact on real reserves, so μ_t should be stationary. If the technology shock is the only source of nonstationarity, then in the model above one would expect output, real money balances, and real bank loans to have the same stochastic trend. There are several reasons, however, why the three variables might not be cointegrated. The first reason is that the nominal interest rate might be nonstationary. In the standard neoclassical model, the real interest rate should be stationary, so nonstationarity of the nominal interest rate could only be due to the nonstationarity of inflation. In fact, a unit root cannot be rejected in either inflation or the real interest rate. Second, changes in the structure of the banking sector, brought about by changes in regulations, can also add another stochastic trend to the system. The empirical analysis of the next section will begin by investigating the most appropriate specification of the stochastic trends.

Empirical analysis of bank loans and money

As discussed above, the credit view of the monetary-transmission mechanism argues that policy—induced shifts in the supply of bank loans have an impact on output over and above the effect of policy—induced shifts in the supply of deposits. One implication of the credit view is that the interest-rate premium on bank loans should increase after a monetary tightening, i.e., the relative price of bank loans should rise when the supply curve shifts back. The reason this implication has not been tested is that there are no reliable data on bank loan premia. Because the price data are not available, quantity data must be used. Most of the tests in this paper answer the following question: after accounting for the behavior of money, does the behavior of bank loans have additional explanatory power for output? I view this type of test as the best way to assess the marginal effect of bank loans. As many of the shocks to money and loans are demand shocks, there should be enough independent variation in the two variables to identify the two channels. If the credit channel is important, bank loans should have additional explanatory power.

Data description

The variables used for this section are monthly from 1954:1 to 1991:12. The variables are industrial production, M1, M2, total bank loans and leases, manufacturing and trade inventories, the consumer price index, the Federal Funds rate (available only 1955:1 to 1991:12), the rate on three-month Treasury bills, the rate on six-month commercial paper, and Boshen and Mills' (1992) monetary policy index.[3] The indicator variable is from Boschen and Mills (1992), updated through the end of 1991. The Data Appendix contains the details on the sources of the data. Industrial production and inventories were only available on a seasonally adjusted basis. The other variables are seasonally unadjusted. All noninterest-rate variables are in logarithms. Finally, the money and loan variables are deflated by the consumer price index.

There are several motivations for choosing this particular set of variables. First, monthly data are chosen to minimize any effects of time aggregation. Due to data availability, this choice necessitates the use of industrial production as the output measure rather than some broader-based measure. This choice is, however, consistent with the work of Romer and Romer (1990) and

[3]The three-month Treasury bill rate was used rather than the six-month rate because the data on the latter extend back only to 1959.

Table 1:
Augmented Dickey-Fuller Tests
1954:1 - 1991:12
(p-values)

Variable	no trend	with trend
industrial product	0.633	0.708
real inventories	0.533	0.993
real M1	0.542	0.157
real M2	0.810	0.469
real bank loans	0.381	0.646
Federal funds rate	0.323	0.656
6-month commercial rate	0.236	0.680
3-month Treasury bill rate	0.313	0.778
inflation rate (CPI)	0.141	0.503

Bernanke and Blinder (1992). Second, inventories are included in order to capture any possible variations in the demand for bank loans due to inventory accumulations and decumulations. Both M1 and M2 are chosen because they are the most widely used measures of money. Total bank loans are used (rather than only commercial and industrial loans) because many have argued that the wider concept is most appropriate (e.g., Bernanke (1986)). The price level is included for purposes of deflation and because the inflation rate is known to have important predictive power for output. The three interest-rate variables are chosen because they are the rates most often used in the recent literature. Bernanke and Blinder (1992) argue that innovations in the Federal Funds rate are a good indicator of shocks to monetary policy. Finally, Boschen and Mills' indicator variable is used as an alternative measure of monetary policy. Boschen and Mills extended Romer and Romer's (1989) indicator by creating an indicator that takes the values -2, -1, 0, 1, and 2 based on statements during Federal Open Market Committee meetings, with -2 indicating very tight monetary policy and 2 indicating very loose policy.[4]

[4]Preliminary analysis indicated that neither changes in reserve requirements nor Strongin's (1991) nonborrowed reserve innovations variables contained additional explanatory power over innovations to the Federal Funds rate and Boschen and Mills' variable. Thus, the former variables were not included in the system.

Stochastic trends

The data are first analyzed to determine the best statistical approximation for the time series process of their long-run components. Table 2 shows augmented Dickey-Fuller tests for the variables, both with and without deterministic trends. The inflation rate rather than the price level is used since previous evidence indicates that the price level may have two unit roots (King, Plosser, Stock and Watson (1991)). All regressions contain seasonal dummy variables and twelve lagged differences. In no case can one reject a unit root at the usual levels of significance. Thus, industrial production, inventories, the monetary variables, interest rates, and inflation all seem well-approximated as containing unit roots. The seeming nonstationarity of nominal interest rates and inflation is a rather controversial topic in the literature. This issue will be discussed more below.

The next step in the analysis is to determine whether the variables share any common stochastic trends. I conduct the analysis using two different methods: (1) Johansen's (1991) cointegration test on the system of nine variables and (2) Engle-Granger (1987) cointegration tests on all bivariate combinations of the variables. While the Johansen method is perhaps the most natural for a system of this size, it is known that the results can be very sensitive to the variables included and the number of lagged differences included in the vector error correction model (VECM). Thus, I will use both methods to study the problem.

Table 2 shows the results for the sequence of hypothesis tests for the system with twelve lagged differences and seasonal dummy variables included. The test statistics suggest that one can reject six or more stochastic trends but marginally cannot reject five stochastic trends. The same conclusions are drawn when only six lags are included in the system. Thus, the results suggest that the system of nine variables has five stochastic trends and hence four independent cointegrating vectors.

To cross-check the results, I ran bivariate Engle-Granger cointegration tests on the nine variables. The results of those tests are given in Table 3. The number in the table is the p-value on the test statistics. Twelve lagged differences were used because the twelfth lag was almost always significant. The cointegrating regressions also include seasonal dummy variables. The number in cell i, j is from the regression of variable i on variable j. Ideally, the matrix should be symmetric.

Several observations can be made. First, industrial production, real M2, and real bank loans seem to be cointegrated with each other. In all six possible tests the p-values are .08 or below. Thus, the three variables seem to share one stochastic trend. On the other hand, real inventories show some evidence of cointegration with M2, but not with the other two variables.

Table 2:
Cointegration Tests
Johansen Test on 9 Variable System
1954:1 - 1991:12

Eigenvalues	Trace Statistic	Null Hypothesis
0.002	0.938	There is at least 1 stochastic trend
0.012	6.282	There are at least 2 stochastic trends
0.022	15.716	There are at least 3 stochastic trends
0.051	38.221	There are at least 4 stochastic trends
0.059	64.251	There are at least 5 stochastic trends
0.069	95.020**	There are at least 6 stochastic trends
0.109	144.657**	There are at least 7 stochastic trends
0.130	204.459**	There are at least 8 stochastic trends
0.133	266.056**	There are at least 9 stochastic trends

12 lagged differences were included in the VECM. Seasonal dummy variables were also included. ** denotes significant at the 5-percent level.

Table 3:
Bivariate Cointegration Tests
1954:1 - 1991:12
(p-values)

	ip	inv	M2	bl	M1	Δ p	iff	itb	icp
ip		.12	.07	.08	.47	.98	.95	.97	.95
inv	.14		.10	.30	.35	.99	.91	.95	.94
M2	.07	.09		.00	.36	.97	.86	.90	.88
bl	.06	.23	.00		.19	.97	.91	.94	.93
M1	.27	.22	.23	.17		.92	.75	.70	.76
Δp	.44	.36	.35	.43	.40		.37	.37	.35
iff	.52	.42	.38	.50	.61	.56		.00	.00
itb	.68	.56	.48	.64	.61	.60	.00		.00
icp	.55	.46	.37	.52	.55	.54	.00	.00	

12 lagged differences and seasonal dummy variables were included in the tests.

Variable definitions:
ip = log of industrial production
inv = log of real manufacturing and trade inventories
M2 = log of real M2
bl = log real bank loans
Δp = inflation rate
iff = Federal Funds rate
itb = rate on 3-month T-bills
icp = rate on 6-month commercial paper

Cointegrating Vectors
Estimated by Dynamic OLS
(t-statistics in parentheses, based on Parzen Kernel)

zym = ip - 1.157 M2	zyl = ip - 0.716 bl
(72.4)	(68.1)
zct = icp - 1.025 itb	zft = iff - 1.195 itb
(87.3)	(75.9)

Thus, the results for inventories are less clear. M1 and inflation do not seem to be cointegrated with any other variable. Finally, the three interest-rate variables, while not cointegrated with any noninterest-rate variables, show very strong evidence of being cointegrated with each other. Thus, ignoring the results with inventories and M2, the bivariate tests support the results of the Johansen procedure. Industrial production, M2, and bank loans share the same trend; inventories, M1, and inflation each have a different trend; and the three interest-rate variables have a common stochastic trend.

The results are consistent with those found in the literature. In particular, Hallman, Porter and Small (1991) find that M2 velocity is stationary in the post-Korean war period; King, Plosser, Stock and Watson (1991) find that nominal interest rates, inflation, and real interest rates appear nonstationary; Stock and Watson (1992) find that M1 demand is unstable if one studies only the post-war period; while Konishi, Ramey, and Granger (1993) find that for the period starting in 1959 real M2, real business bank loans, and GNP share a common stochastic trend while the interest-rate variables share a different stochastic trend. In the period under study, M2 probably has a more stable relationship with output than does M1 because M1 demand was more heavily impacted by the significant changes in banking regulations. Given that the present study is concerned with the effects of monetary policy, and not deregulations, the results suggest that M2 is the appropriate measure of money.

The system should thus have four independent cointegrating vectors. The cointegrating vectors are estimated using Stock and Watson's (1993) dynamic OLS.[5] The bottom of Table 3 presents the estimates of four linearly independent cointegrating vectors and the names of the associated error-correction terms. The cointegrating vectors were estimated using dynamic OLS, with twelve leads and lags. The t-statistics reported incorporate HAC (heteroskedastic- and autocorrelation-consistent) standard errors, using a Parzen kernel with twelve lags.

The error correction terms have economic interpretations. Consider first the terms involving money and bank loans. The error-correction term between industrial production and M2 is essentially the velocity of money; the only difference is that the cointegrating vector is (1,-1.157) instead of (1,-1). Similarly, the error-correction term between industrial production and bank loans is analogous to the velocity of bank loans. In this case, the cointegrating vector is (1,0.716). The cointegration analysis pins down the long-run relationships, which are presumably independent of open-market operations. The error-correction terms, on the other hand, can be interpreted as the short-run deviations from the long-run growth path. It is exactly these types of variables that should be used to study the short-run fluctuations induced

[5]The results are almost identical when ordinary least squares is used.

by monetary policy.

The error-correction terms in the interest-rate sector are essentially interest-rate spreads. The spread between commercial paper and Treasury bills differs from the spread typically used only in that it also includes a term premium (since the Treasury bill rate is for three-month bills) and the cointegrating vector is slightly, though statistically, different from (1,-1). The error-correction terms will be referred to as velocities and spreads, although the (1,-1) vector is not imposed.

Figure 2 shows graphs of some of the error-correction terms: the two velocity variables, the implied error-correction term between M2 and bank loans, and the spread between commercial paper and Treasury bills. The two interest-rate spreads look very similar, so only one is shown. The error-correction term between M2 and bank loans is just a linear combination of the two velocity variables, but is nonetheless informative. NBER reference cycles are shown in the graph.

The graphs suggest patterns. M2 velocity tends to rise dramatically in the year before a recession begins and peaks some time during the recession. On the other hand, the only obvious pattern for bank-loan velocity is that it tends to decline steeply during recessions. The error-correction term between M2 and bank loans permits a comparison of their relative movements. This term tends to peak in the middle of an expansion and trough sometime during a recession. The final graph shows the behavior of the spread between commercial paper and Treasury bill interest rates. Note that the peaks in the spread tend to correspond to the troughs in the two velocity variables.

Empirical analysis of money and bank loans

In this section the data will be analyzed in a series of steps that begins with particular elements of the transmission mechanism and culminates in an analysis of the complete path of monetary policy shocks. The results will be organized as answers to a series of questions. The basic formulation will be a set of prediction equations that contain twelve lags of the change in industrial production, the velocity of money (M2) and loans, the change in the log of real inventories, inflation, and an indicator of monetary policy. Despite the results from the unit root tests, inflation and the Federal Funds rate are entered in levels. This is done for two reasons. First, many find the nonstationarity of inflation and interest rates to be at odds with their prior beliefs. Second, the levels of these series tend to have more predictive power than the first differences.

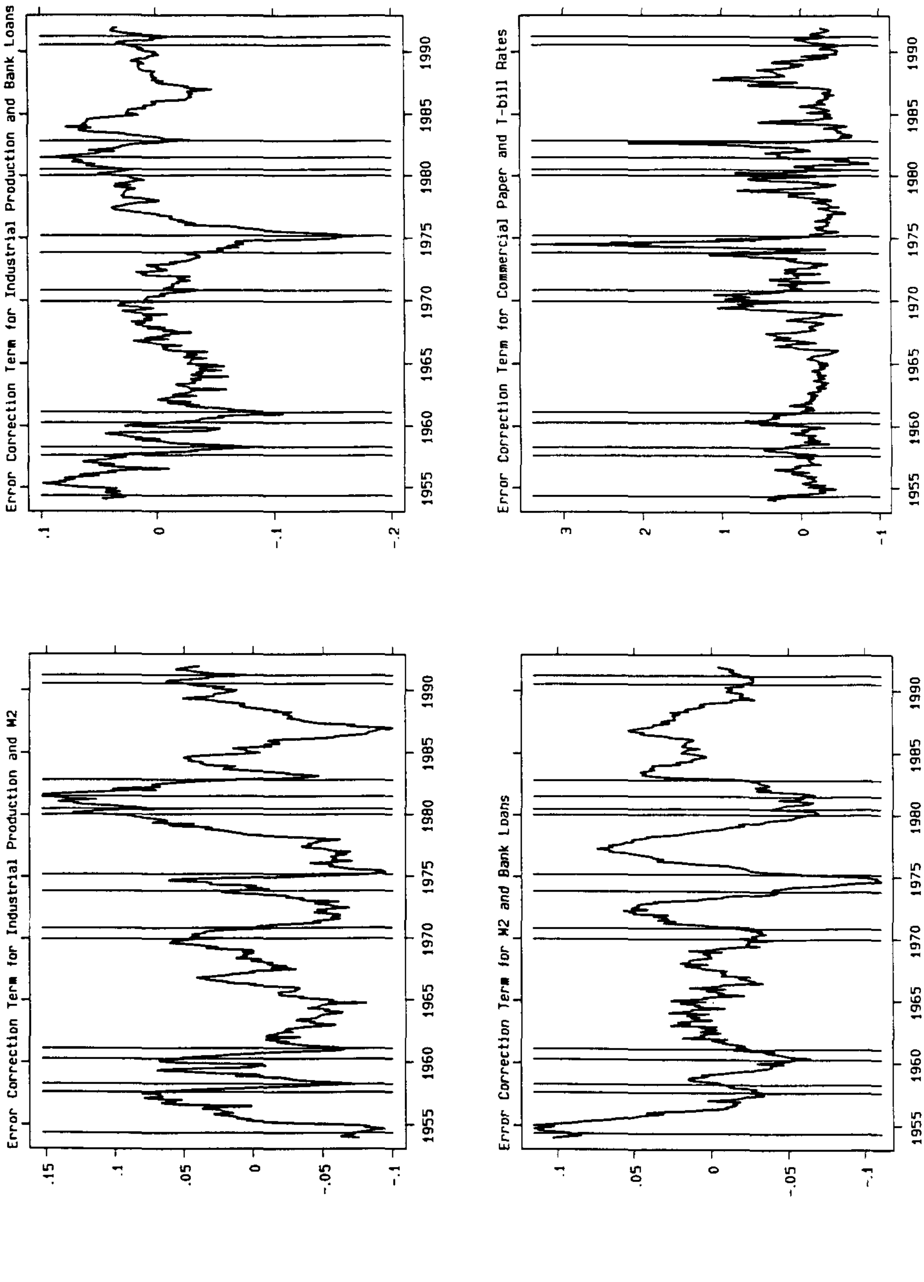


Figure 2
Error Correction Terms

Do money and bank loans Granger-cause output?

If a particular financial aggregate is the mechanism by which monetary policy impacts output, then one would expect fluctuations in the aggregate to contain information about future movements in output. Table 4 shows the results of a series of Granger-causality tests for the change in industrial production. The first equation shows the results when bank-loan velocity, but not M2 velocity, is included. The p-value indicates that bank-loan velocity is very significant for predicting industrial production. The sum of the lag coefficients, which is shown below the p-value, is significantly negative. The negative value indicates that when bank loans fall relative to their long-run relationship with industrial production, industrial production is predicted to fall in the future. This result is consistent with the credit story.

To establish that the credit channel has a role independent of the money channel, though, one must show that bank-loan velocity retains its predictive power even in the presence of M2 velocity. Part 2 of Table 4 shows the results of the expanded prediction equation. Both velocity variables are significant. Inflation is also significant for predicting output, but the change in inventories is not. Although both velocity variables are significant in predicting industrial production, they differ in one major respect. The bottom of the panel shows the sum of the lag coefficients on each velocity variable. For M2 velocity, the sum is negative and significantly different from zero, which is consistent with the money view. For bank-loan velocity, though, the sum of the coefficients is now *positive*, though not significantly different from zero. Thus, a negative innovation to bank loans relative to industrial production seems to signal a future *rise* in industrial production.

According to the estimates, innovations to bank-loan velocity work in a way that is contrary to the standard credit story concerning the monetary transmission mechanism. The result is not, however, necessarily contrary to the hypothesis of financial market imperfections. The fall in bank loans relative to output might occur for the following reason. Due to a real shock, firms are able to generate more funds internally. Because internal funds have lower costs than bank loans, firms expand production. Thus, once the effects of money are accounted for, the additional information contained in bank loans may be information about varying bank-loan demand rather than varying bank-loan supply.

The last three equations include indicators of monetary policy. The first uses the level of the Federal Funds rate, the second uses the Boschen and Mills (1992) indicator variable, and the third uses the spread between the interest rate on six-month commercial paper and three-month Treasury bills. Several characterizations can be made. First, in every case M2 velocity is very significant and has the lowest p-value of any variable. Bank-loan velocity is also significant in every equation. Thus, like M2, bank loans retain their

Table 4:
Granger Causality Tests for Industrial Production
1955:1 – 1991:12

Each model includes seasonal dummy variables, 12 lags each of the change in log industrial production, the change in log real inventories, the inflation rate plus the variables indicated below. The p-value is for the exclusion test of 12 lags of the variable shown in the row.

1. Bank-loan velocity (zyl)

Variable	p-value	Variable	p-value
zyl	0.002	Δinventories	0.698
		inflation	0.132

sum of coefficients on zyl = -0.032 with t-stat = -2.58

2. M2 velocity (zym), Bank-loan velocity (zyl)

Variable	p-value	Variable	p-value
zyl	0.029	Δinventories	0.847
zym	0.000	inflation	0.011

sum of coefficients on zyl = 0.025 with t-stat = 1.39

sum of coefficients on zym = -0.059 with t-stat = -3.46

3. zym, zyl, Federal funds rate. (1956:1 – 1991:12)

Variable	p-value	Variable	p-value
zyl	0.051	Δinventories	0.709
zym	0.000	inflation	0.003
Fed Fund rate	0.632		

4. zym, zyl, Boschen–Mills indicator variable

Variable	p-value	Variable	p-value
zyl	0.015	Δinventories	0.702
zym	0.000	inflation	0.025
B-M indicator	0.000		

5. zym, zyl, interest rate spread between 6-month commercial paper and 3-month Treasury bills

Variable	p-value	Variable	p-value
zyl	0.034	Δinventories	0.885
zym	0.009	inflation	0.042
spread	0.053		

predictive power in systems with other variables when they are entered in velocity form.

The other variables in the prediction equation vary in significance. The inflation rate is significant in every equation, but the change in inventories is never significant. The results are not uniform for the monetary policy indicators. The Federal Funds rate is not significant for predicting industrial production in the full equation. Thus, any predictive power found by Bernanke and Blinder (1992) seems to be entirely captured by the other variables in the model. The same conclusions are reached when only six lags of the variables are used, when all the variables are entered in levels and a linear trend is included, and when the sample period is changed to 1961:7 to 1989:12, which is Bernanke and Blinder's (1992) sample period. On the other hand, Boschen and Mill's indicator variable is very significant. This variable has predictive power for industrial production beyond that contained in the other variables included. Finally, the interest-rate spread, which some argue is a good indicator of the stance of monetary policy, is also significant.

Do the fluctuations in money and loans that can be linked to policy disturbances predict future output?

Establishing that money and bank-loan velocity predict industrial production is a useful first step. The results by themselves, however, do not supply direct evidence on the relative importance of the money and credit channels. As discussed in the analysis of the theoretical model, fluctuations in velocity could be the result of technology shocks that reveal themselves in financial aggregates before output. Thus, an additional step is required. To be specific, it must be shown that fluctuations in velocities that can be linked to monetary-policy disturbances predict output.

To test the hypothesis, I use instrumental variables to estimate the prediction equation for the change in industrial production. Included in the equation are twelve lags of the change in industrial production, inflation, a velocity variable, and seasonal dummy variables. The change in inventories is omitted because the previous analysis indicated that it did not have additional explanatory power. Twenty-four lags of the funds rate and the Boschen and Mills' index are used as instruments for the twelve lags of the velocity variable. The interest-rate spread was not used because its role as an indicator of monetary policy shocks is not well-established. The significance of the twelve lags of the velocity variable was tested using a pseudo-F test.

Table 5 shows the results of several tests. The first part shows the result for bank-loan velocity. The p-value indicates that one cannot reject the hypothesis that the twelve lags of bank-loan velocity are jointly zero. The third and fourth columns of the table show the estimates of the sum of the coefficients on velocity using instrumental variables (IV) and ordinary least squares (OLS), respectively. The sum of the coefficients from the IV estimation and OLS estimation are negative and of similar magnitude, although the IV estimates are only marginally significantly different from zero. Thus, the evidence that policy-induced fluctuations in bank-loan velocity predict output is weak.

The second part of the table shows the results when M2 velocity instead of bank-loan velocity is included in the model. In this case, the coefficients on the lags are jointly significant. Furthermore, both the IV and OLS estimates are negative, similar in magnitude, and significant. Thus, in comparison to the results with bank-loan velocity, the results for M2 velocity are stronger.

The third part of the table includes both velocities in the model. In this case, the sum of the coefficients on bank-loan velocity is positive and not significantly different from zero. On the other hand, the sum of the coefficients on M2 velocity is negative and at least marginally significant in both the IV and OLS cases.

The results can be summarized as follows. The policy-induced fluctuations in M2 velocity have significant predictive power for output. Furthermore, the impact of the policy-induced fluctuations in M2 velocity is similar in magnitude to the impact of general fluctuations in M2 velocity. The results are somewhat weaker for bank loans. The coefficients on policy-induced fluctuations in bank-loan velocity are not as significant, although the estimate of the impact is similar to the estimate of the impact of general fluctuations in bank-loan velocity. Once M2 velocity is included as well, however, policy-induced fluctuations in bank-loan velocity no longer predict industrial production.

What role do the money and loan channels play in the dynamic response of output to policy shocks?

The results above show that the coefficients pertaining to the money channel are statistically significant, while those pertaining to the loan channel are not. The analysis does not, however, give a complete picture of the dynamic differences. In order to study the dynamic differences, the following analysis is conducted. First, a vector error correction model (VECM) is estimated and a base case impulse response function for industrial production is calculated. Then, various channels are shut down by setting some of the previously estimated coefficients to zero, and the resulting impulse response of industrial production is compared to the base case. A substantial change in the path of industrial production implies that the channel that was shut down was an important part of the transmission mechanism. In this way, the marginal dynamic importance of the two velocity variables can be determined.

The VECM contains the following variables: the change in industrial production, M2 velocity, bank-loan velocity, the inflation rate, and a monetary

Table 5:
The Predictive Power of Policy – Induced Fluctuations in Velocity
1957:1 - 1991:12

The prediction equation contains 12 lags of the change in industrial production, inflation, plus 12 lags of the variables listed below. Seasonal dummy variables were also included. 24 lags of the funds rate and Boschen and Mills' indicator were used as instruments for the velocity variables. The p-value is for the exclusion test of 12 lags of the indicated variable. The number in parentheses is the t-statistic for the indicated estimate.

1. Bank loan velocity (zyl)

Variable	p-value	Sum of Coefficients IV estimates	Sum of coefficients OLS estimates
zyl	0.731	-0.034	-0.031
		(-1.5)	(-2.42)

2. M2 velocity (zym)

Variable	p-value	Sum of Coefficients IV estimates	Sum of coefficients OLS estimates
zym	0.022	-0.041	-0.037
		(-2.2)	(-3.1)

3. Bank loan velocity (zyl) and M2 velocity (zym)

Variable	p-value	Sum of Coefficients IV estimates	Sum of coefficients OLS estimates
zyl	0.896	0.060	0.022
		(0.96)	(1.2)
zym	0.080	-0.092	-0.054
		(-1.8)	(-3.1)

policy variable. The two alternative indicators of monetary policy that are used are the Federal Funds rate and Boschen and Mills' indicator. The system estimated is like a standard VECM with five equations except for one difference: the twelve lags of the policy variable are included only in the equations for the velocity variables and for the policy variable itself. Thus, the policy variable can affect industrial production and inflation only through its effect on the velocity variables.

Figure 3 shows the impulse responses of industrial production, M2 velocity, and bank-loan velocity to a positive one-standard deviation innovation in the Federal funds rate. Industrial production stays constant for four months, and then begins to fall. Three years after the initial shock, it recovers its former level. M2 velocity responds to a positive shock to the Federal Funds rate by jumping up immediately and staying above normal for ten months. Bank-loan velocity, on the other hand, moves much less. After varying around its starting point, it falls to a trough at ten months, but then recovers quickly.

Figure 4 shows the impulse responses due to a negative one-standard deviation shock to the Boschen-Mills indicator. Here industrial production also falls, but for a longer period. M2 velocity increases immediately and returns to normal after three years. Bank-loan velocity rises slightly at first, and then falls during the second year.

The following question is then asked: how would the response of industrial production differ if the monetary policy variable did not have a direct effect on the relevant velocity? Referring back to Figure 1, this is equivalent to closing channels a_1 or b_1. To answer this question, I used the coefficients estimated in the model above, but set the coefficients on the monetary policy variable equal to zero in the equation predicting the velocity variable. Thus, the velocity variable cannot respond directly to the policy variable, but can respond to the other variables in the system.

Figure 5 shows impulse responses of industrial production for three different cases. The top graph shows the results for a positive shock to the Federal funds rate. The line labelled "base case" is the result from the full model, and is identical to the graph shown in Figure 3. Consider first the response when policy cannot have an effect on bank-loan velocity. It is clear that the response of industrial production to the funds rate does not change when the link between bank-loan velocity and the funds rate is severed, since the impulse response differs little from the base case response. This means that the marginal impact of channel b_1 in Figure 1 is not economically significant. In contrast, when the link between M2 velocity and the funds rate is severed, the response of industrial production changes dramatically. Industrial production falls very slightly and then actually rises after a year. The difference between the base case line and the top line indicates the magnitude of the importance of M2 velocity in transmitting policy shocks to industrial

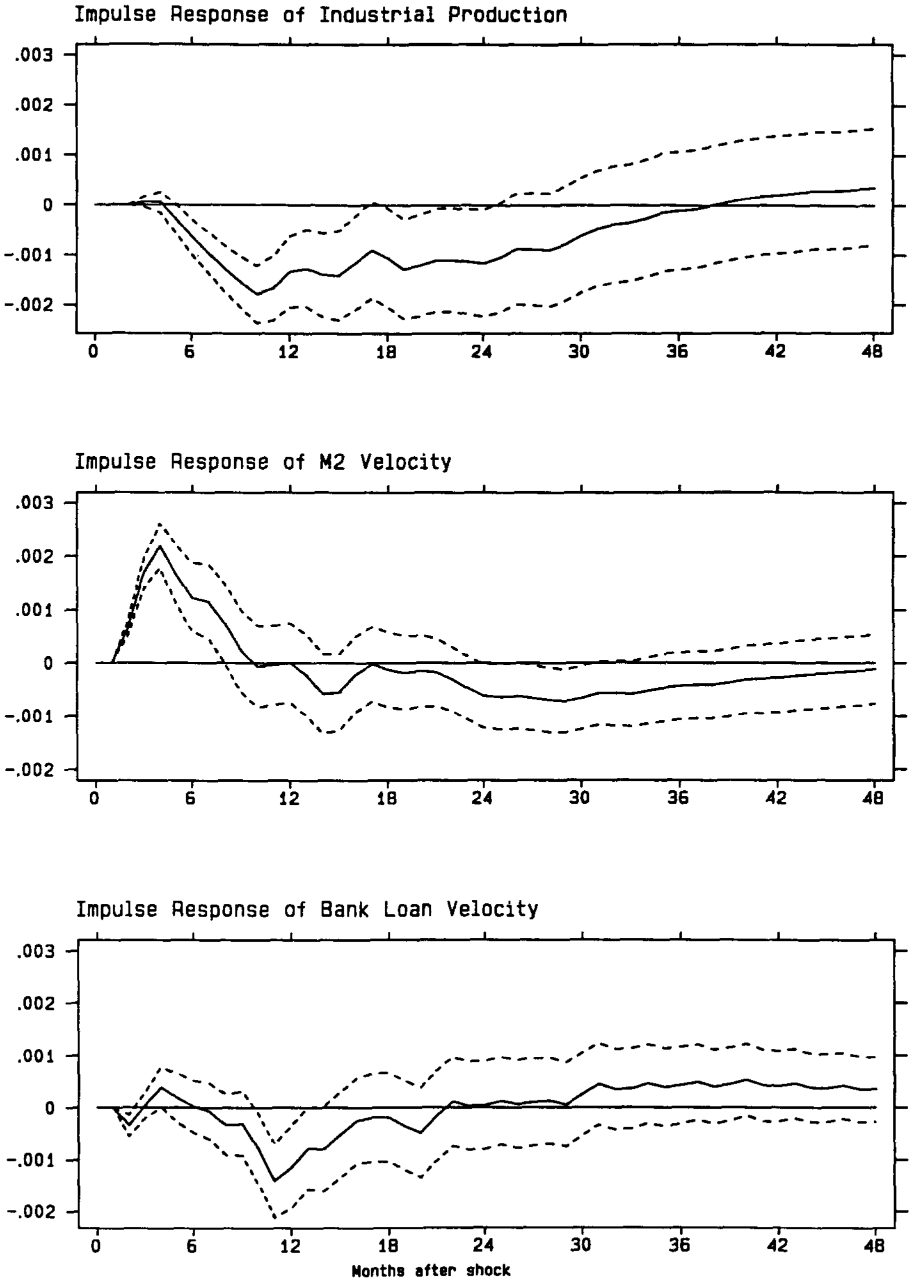


Figure 3
Effect of a Positive Shock to the Federal Funds Rate
(dotted lines are one standard error bands)

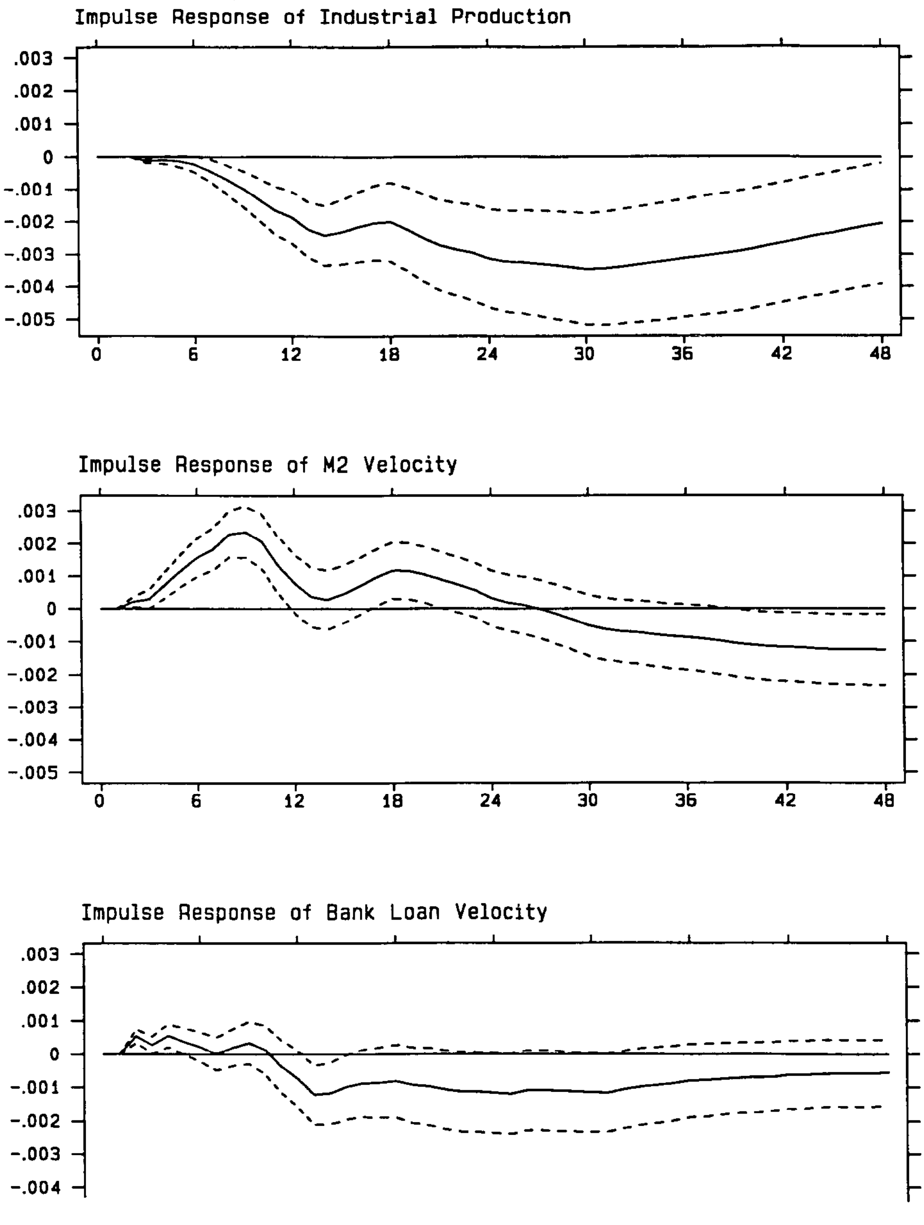


Figure 4
Effect of a Negative Shock to the Boschen-Mill Index
(dotted lines are one standard error bands)

production. Thus, channel a_1 in Figure 1 appears to be the primary channel for policy shocks.

The results are similar when the Boschen and Mills indicator is used instead of the funds rate. Shutting down the bank-loan channel has no noticeable impact on the response of industrial production to policy innovations. On the other hand, shutting down the money channel essentially eliminates the impact of policy on industrial production. Thus, both sets of results cast doubt on the importance of the bank-loan channel in the monetary-transmission mechanism while highlighting the importance of the traditional money channel.

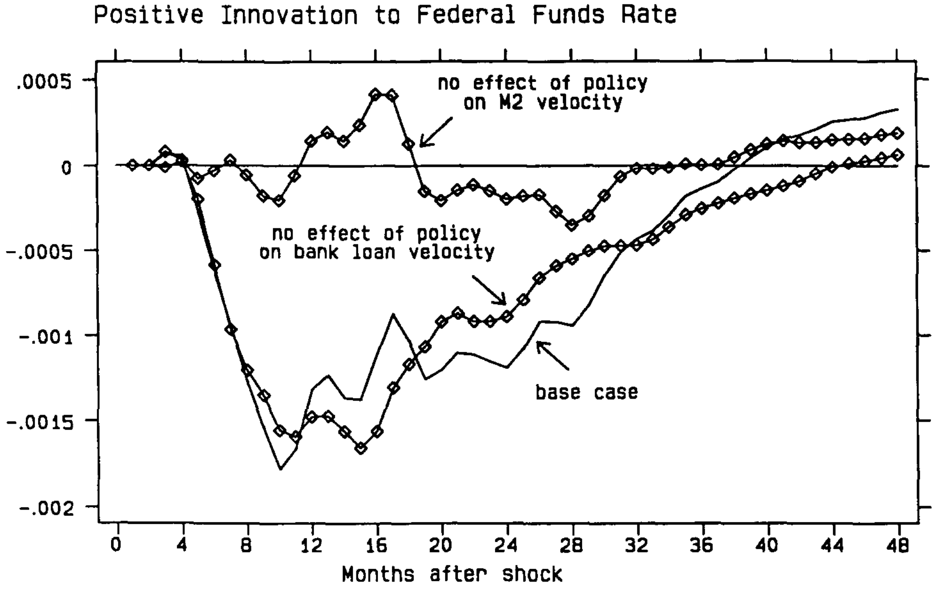
Results using other measures of the credit channel

The analysis above found little evidence that the behavior of total bank loans provided an independent mechanism for the transmission of monetary policy. There are two arguments made by advocates of the credit view that are not addressed by the results above. First, the results do not address Bernanke and Blinder's (1992) finding that banks seem to shield their loan portfolios in the short-run by selling off securities after a monetary tightening. Second, the results do not address the heterogeneity among size-classes of firms found by Gertler and Gilchrist (1992) and Oliner and Rudebusch (1992).

Consider first Bernanke and Blinder's finding that during a monetary tightening, banks sell off securities. If this effect is systematic and is indicative of a credit-channel mechanism, one would expect the relationship between loans and securities held by banks to have predictive power for output over and above the information contained in money. Thus, it would be informative to test this hypothesis.

Following the procedure of the last section, I first determined whether bank loans and securities each appeared to have a stochastic trend and whether the stochastic trend was common. The answer to both questions was affirmative. I then formed an error-correction term based on dynamic OLS estimates. This term was *zls* = log of real bank loans - 2.972 log of real bank securities. I then estimated a variety of equations predicting industrial production, and tested exclusion restrictions for *zls*.

The results are given in Table 6. All equations contain twelve lags of industrial production and inflation and seasonal dummy variables. Once again inventories are omitted because they are never significant. When only the bank loan-bank security term is added, it is found to be very significant for predicting output, with a p-value of 0.015. The sum of coefficients is negative and significant, meaning that a decline in bank securities relative to bank loans signals a future decrease in output. This result is consistent with Bernanke and Blinder's findings.



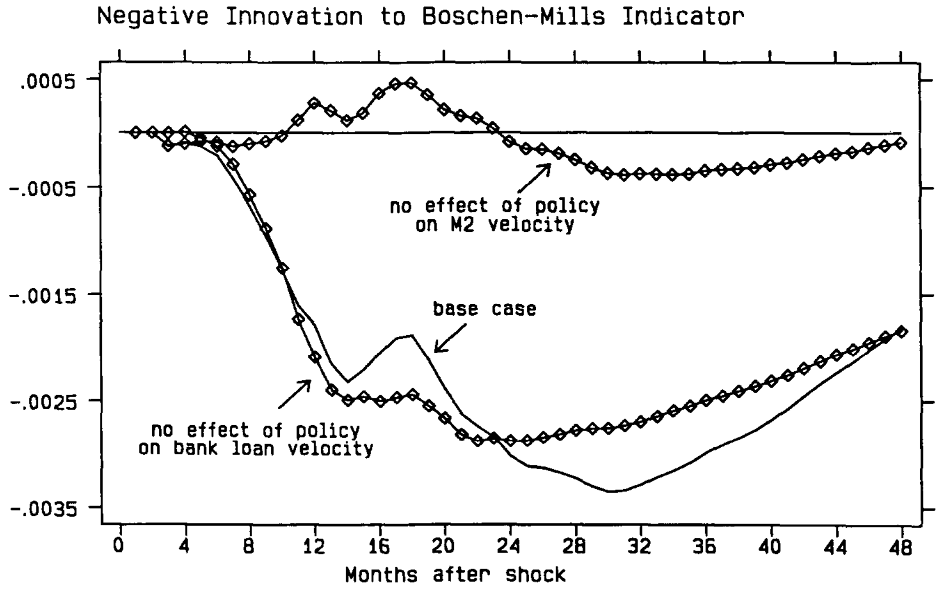


Figure 5
Response of Industrial Production when the Policy-Velocity Channel is Closed: M2 Velocity versus Bank Loan Velocity

Table 6:
Granger Causality Tests for Industrial Production
1955:1 - 1991:12

Each model includes 12 lags of the change in log industrial production and the inflation rate plus the variables indicated below. Seasonal dummy variables are also included. The p-value is for the exclusion test of 12 lags of the variable shown in the row.

1.Loan-Security variable (zls)

Variable	p-value	Sum of Coefficients	t-statistic
zls	0.015	-0.006	-2.42

2. Loan-Security variable (zls), M2 velocity (zym)

Variable	p-value	Sum of Coefficients	t-statistic
zls	0.683	-0.004	-1.38
zym	0.003	-0.027	-1.80

3. Loan-Security variable during periods of very tight monetary policy (nzls), M2 velocity (zym).

Variable	p-value	Sum of Coefficients	t-statistic
nzls	0.066	-0.001	-2.87
zym	0.000	-0.047	-3.73

The second equation adds M2 velocity to the prediction equation. In this specification, all predictive power of the loan-security variable evaporates, while M2 velocity is highly significant. It appears that M2 velocity contains all information that was in the loan-security variable. Thus, the loan-security variable contains less independent information than the bank-loan velocity variable used in the last section. In this case, however, the sum of the coefficients is still negative, though not particularly significant.

As discussed in an earlier section, Bernanke and Blinder's argument is actually asymmetric, and applies mostly to periods of monetary tightening. To see if the effects are asymmetric, I allowed the loan-security variable to have a different coefficient during periods of very tight money, defined as periods in which the Boschen and Mills' indicator variable took the value of -2.[6] The estimates indicated that the loan-security variable was significant only during periods of tight money. The results are shown in the third part of Table 6. The p-value on the loan-security variable during tight money periods is 0.066 and the sum of the coefficients is negative and significant. M2 velocity is significant as usual.

To ascertain the dynamic significance of the loan-velocity variable I conducted the impulse response exercise for a VECM with the following variables: the change in industrial production, M2 velocity (not allowing any asymmetry), the loan-security error correction term only during periods of very tight monetary policy, inflation, and the Boschen and Mills' index. Twelve lags of all variables plus seasonal dummy variables were included. Once again, the policy variable did not enter independently in the industrial production and inflation equations.

Figure 6 displays the results. Shutting down the effect of policy on the behavior of loans relative to securities does not noticeably change the impulse response of industrial production. In contrast, shutting down the effect of policy on M2 velocity does significantly alter the dynamic response of industrial production. Thus, although the behavior of bank loans and securities is statistically significant for predicting output, it does not have an important part in the dynamic response of output to policy.

Finally, I considered the possibility that the credit channel works through heterogeneity of firms. To investigate this possibility, I used *Quarterly Financial Reports* (QFR) data provided by Simon Gilchrist. Gertler and Gilchrist (1992) found that the difference in the growth rates of small firm short-term debt (consisting mostly of bank loans and trade debt) and large firm short-term debt responds significantly to shocks to monetary policy. To investigate any potential aggregate effects, I studied the variable's predictive power for output. Because the QFR data are quarterly (from 1959 to 1991), the output

[6]The months when the index took the value -2 are: 1955:8–55:11, 1965:12–66:0, 1969:1–69:7, 1973:4–73:9, and 1979:10–80:7.

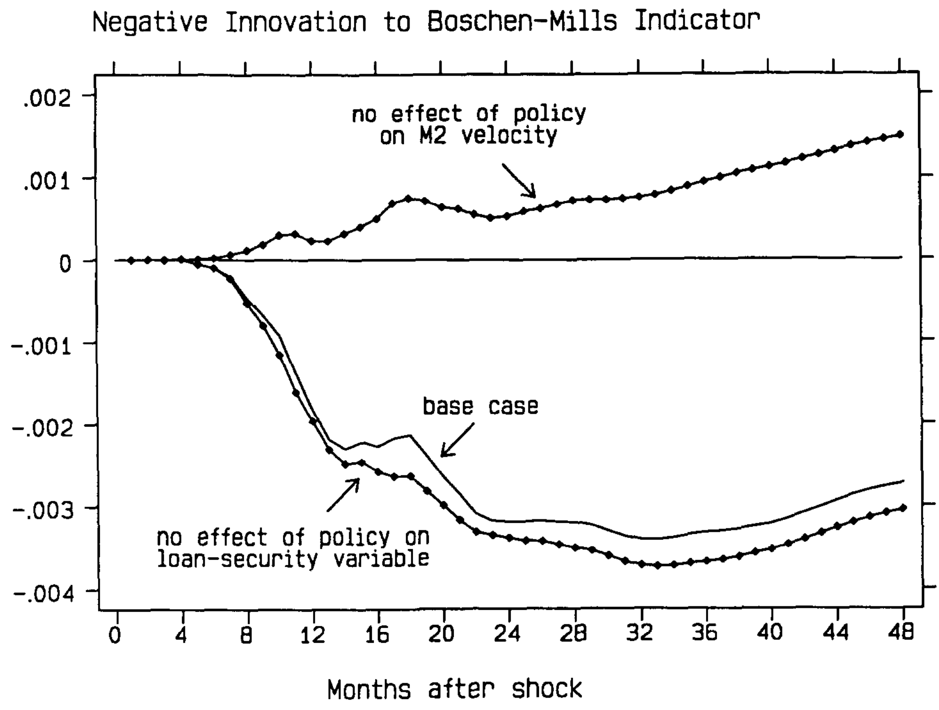


Figure 6
Response of Industrial Production when the Policy-Velocity Channel is Closed:
M2 Velocity versus Bank Portfolio Composition

variable in this analysis is real GNP and the price variable is the GNP deflator. The monthly M2 data are converted to a quarterly basis by using the last month of the quarter. In this case, M2 velocity is the difference between the log of real GNP and the log of real M2, since the cointegrating vector is not statistically different from (1,-1).

Table 7 shows a series of prediction equations for GNP growth. All equations include four lags of the growth of GNP, the inflation rate plus the variables listed in each section. All equations contain seasonal dummy variables. The first part shows the results when only the QFR variable is included. The p-value indicates that this variable is very significant in predicting GNP growth. Furthermore, the sum of the coefficients is positive and significant, consistent with the findings of Gertler and Gilchrist. When the growth rate of debt of small firms rises relative to large firms, output is predicted to increase. The second part of the table shows the results when M2 velocity is also included. Although one cannot reject the hypothesis that the coefficients on the debt variable are jointly zero, the sum of the coefficients is still estimated to be positive and significant. Thus, the relative behavior of the debt of small and large firms is statistically significant for industrial production, even after M2 velocity is added.[7]

To determine the role of short-term debt growth in the dynamic response of output, I conducted the impulse response exercise for a VECM with the following variables: real GNP growth, M2 velocity, the relative short-term debt growth variable, inflation, and a policy variable. Four lags of all variables plus seasonal dummy variables were included. The policy variable did not enter directly in the real GNP growth and inflation equations.

Figure 7 displays the results using the Federal funds rate at the top and the Boschen and Mills index at the bottom. As with the other cases, shutting the channel involving money substantially alters the dynamic response of output, although in this case output still falls somewhat. Shutting down the relative growth of short-term debt has a small effect on the dynamic response of output when the funds rate is the policy variable, and a more noticeable effect when the Boschen and Mills indicator variable is used. The effect in the latter case is strongest during the third and fourth years after the initial shock. The graph indicates that if policy did not affect the relative growth rate of loans, output would not fall as much and would recover more quickly. Thus, the heterogeneous credit variable is the only credit variable that displays an economically significant effect on the dynamic pattern of industrial production, and it does so only when the Boschen and Mills index is used as the indicator of policy.

It is difficult to interpret these results for two reasons. First, the debt

[7]The results of tests for asymmetric effects (not shown in the table) suggested no change in the coefficients during periods of tight money.

Table 7:
Granger Causality Tests for Real GNP
1961:1 - 1991:4

Each model includes 4 lags of the real GNP growth and the inflation rate plus the variables indicated below. Seasonal dummy variables are also included. The p-value is for the exclusion test of 4 lags of the variable shown in the row.

1.Small firm-large firm difference in loan growth (smlgloan)

Variable	p-value	Sum of Coefficients	t-statistic
smlgloan	0.001	0.002	3.87

2.Small firm-large firm difference in loan growth (smlgloan), M2 velocity (zym)

Variable	p-value	Sum of Coefficients	t-statistic
smlgloan	0.306	0.001	1.98
zym	0.009	-0.082	-2.28

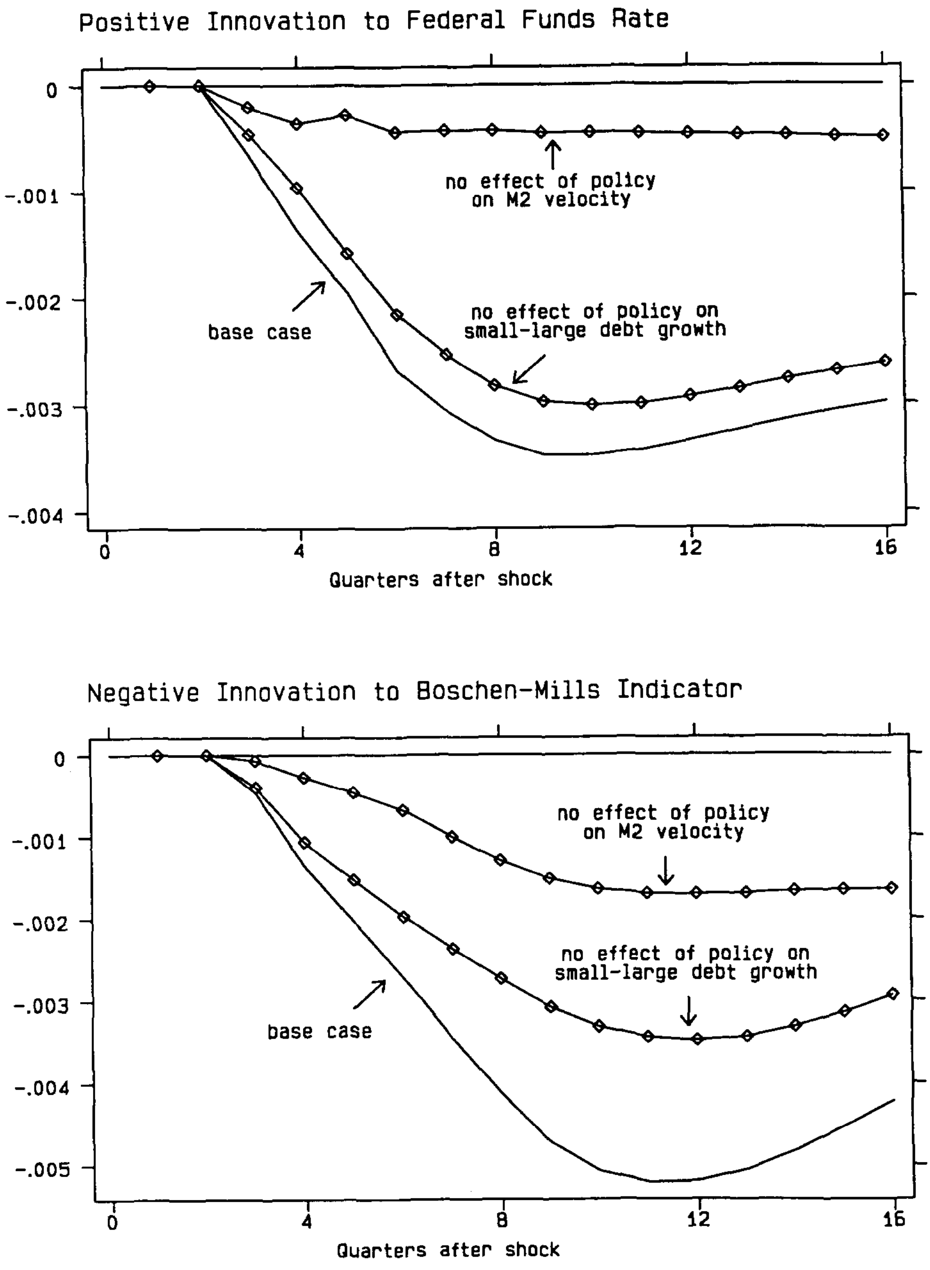


Figure 7
Response of Industrial Production when the Policy-Velocity Channel is Closed:
M2 Velocity versus Relative Debt Growth of Small and Large Firms

variables also contain trade credit, so they are not pure measures of the supply of bank loans to the two classes of firms. Second, as discussed earlier, the growth rate of sales of small firms falls relative to large firms at the same time the relative debt growth slows. The change in relative debt growth may be just a response to the change in relative sales growth. If the change in relative sales growth occurs because of the aggregate decline in output, then the impact of the relative debt growth variable on output may be due to features of the economy associated with the broader credit view rather than a direct channel of transmission. The fact that the importance of the impact of the debt variable on the dynamic pattern of output increases over time supports this view.

Conclusions

This paper has analyzed the existing evidence on the monetary-transmission mechanism and has presented new evidence. When M2 velocity and bank-loan velocity are compared in terms of their link to monetary policy, their predictive power for output, and their role in the dynamic response of output to monetary-policy shocks, the results strongly suggest that the money channel is much more important than the credit channel in the direct transmission of policy shocks. The marginal effect of bank loans on industrial production is not economically significant. Furthermore, fluctuations in bank portfolios do not have a significant impact on output once M2 velocity is included. The only result in support of an independent credit channel is the finding that the difference in the loan behavior of small and large firms seems to exacerbate the policy effects during the second, third, and fourth years after the initial shock.

The estimates are, of course, specific to the particular empirical framework used. Furthermore, because no effort was made to subdivide the sample into different time periods, the analysis only summarizes the average behavior over the 1954 through 1991 period. Konishi, Ramey and Granger (1992) have found, however, that M2 velocity seems to be the financial indicator that is most consistently linked with output over different subperiods. The results of the current paper also suggest that the marginal effect of some of the leading credit-channel variables is negligible.

Data Appendix

Monthly data:
Industrial Production: seasonally adjusted, from CITIBASE (IP).

Inventories: manufacturing and trade inventories in 1982 dollars, seasonally adjusted, from CITIBASE (IVMT82).

Price index. Consumer price index, both seasonally adjusted and unadjusted, from CITIBASE (PUNEW and PZUNEW).

Bank loans: Total loans held by commercial banks, nonseasonally adjusted. 1954:1–1970:12 from *Banking and Monetary Statistics*, 1971:1–1991:12 from *Annual Statistical Digest* and *Federal Reserve Bulletin*, table titled "Loans and Investments at Commercial Banks" or "Loans and Securities, Commercial Banks."

M1: nonseasonally adjusted. 1959:1–1991:12 from CITIBASE (FZM1). 1954:1–1958:12 from *Banking and Monetary Statistics.* Series spliced by multiplying pre-1959 series by 142.2/145.5

M2: nonseasonally adjusted. 1959:1–1991:12 from CITIBASE (FZMS2). 1954:1–1958:12 data were constructed as follows. The Business conditions Digest seasonally adjusted series for real M1 and real M2 were multiplied by the CPI to derive nominal values. The difference in the two series was multiplied by a seasonal factor based on the adjusted and unadjusted "time deposits" series from *Banking and Monetary Statistics.* Call this difference the nonseasonally adjusted difference. M2 was set equal to M1 plus the nonseasonally adjusted difference times a splicing factor 286.7/176.225.

Interest rates: the 6-month commercial paper rate, the 3-month Treasury bill rate, and the Federal funds rate were all taken from CITIBASE.

Quarterly data:

Real GNP: from CITIBASE.

Price: GNP deflator, from CITIBASE.

M2: converted from the monthly series described above by using the last month of the quarter.

References

Ball, L. and Romer, D., (1990). Real Rigidities and the Nonneutrality of Money. *Review of Economic Studies*, **57**: 183–203.

Bernanke, B., (1983). Nonmonetary Effects of the Financial Crisis in the Propagation of the Great Depression. *The American Economic Review*, **73**: 257–26.

Bernanke, B., (1986). Alternative Explanations of the Money-Income Correlation. *Carnegie-Rochester Series on Public Policy*, **25**: 49–100

Bernanke, B. and Blinder, A., (1988). Credit, Money and Aggregate Demand. *The American Economic Review*, **78**: 435–39.

Bernanke, B. and Blinder, A., (1992). The Federal Funds Rate and the Channels of Monetary Transmission. *The American Economic Review*, **82**: 901–21.

Bernanke, B. and Gertler, M., (1989). Agency Costs, Net Worth and Business Fluctuations. *The American Economic Review*, **79**: 14–31.

Blinder, A., (1987). Credit Rationing and Effective Supply Failures. *Economic Journal*, **97**: 327–52.

Boschen, M. and Mills, L., (1992). The Effects of Countercyclical Monetary Policy on Money and Interest Rates: An Evaluation of Evidence from FOMC Documents, manuscript, College of William and Mary.

Brunner, K. and Meltzer, A.H., (1972). Money, Debt, and Economic Activity. *Journal of Political Economy*, **80**: 951–77.

Brunner, K. and Meltzer, A., (1988). Money and Credit in the Monetary Transmission Process. *The American Economic Review*, **78**: 446–51.

Christiano, L. and Eichenbaum, M., (1992). Liquidity Effects, Monetary Policy and the Business Cycle, Federal Reserve Bank of Chicago, WP-92-15.

Diamond, D., (1984). Financial Intermediation and Delegated Monitoring. *Review of Economic Studies*, **51**: 393–414.

Engle, R.F. and Granger, C., (1987). Co-Integration and Error Correction: Representation, Estimation and Testing. *Econometrica*, **55**: 251–76.

Fazzari, S., Hubbard, R., and Peterson, B., (1988). Financing Constraints and Corporate Investment. *Brookings Papers on Economic Activity*, **1**: 141–95.

Gertler, M. and Gilchrist, S., (1991). Monetary Policy, Business Cycles and the Behavior of Small Manufacturing Firms, manuscript, New York University.

Gertler, M. and Gilchrist, S., (1992). The Role of Credit Market Imperfections in the Monetary Transmission Mechanism: Arguments and Evidence, manuscript, New York University.

Gilchrist, S., (1990). An Empirical Analysis of Corporate Investment and Financing Hierarchies using Firm Level Panel Data, manuscript, Federal Reserve Board of Governors.

Grossman, S. and Weiss, L., (1983). A Transactions Based Model of the Monetary Transmission Mechanism. *The American Economic Review*, **73**: 871–80.

Hallman, J., Porter, R., and Small, D., (1991). Is the Price Level Tied to the M2 Monetary Aggregate in the Long Run? *The American Economic Review*, **81**: 841–58.

Himmelberg, C. and Peterson, B., (1991). R&D and Internal Finance: A Panel Study of Small Firms in High-Tech Industries. Federal Reserve Bank of Chicago, WP-91-25.

Hoover, K. and Perez, S., (1992). Post Hoc Ergo Propter Hoc Once More: An Evaluation of "Does Monetary Policy Matter?" in the Spirit of James Tobin, manuscript, University of California, Davis.

Hubbard, R. and Kashyap, A., (1992). Internal Net Worth and the Investment Process: An Application to U.S. Agriculture. *Journal of Political Economy*, **100**: 506–34.

Johansen, S., (1991). Estimation and Hypothesis Testing of Cointegration Vectors in Guassian Vector Autoregressive Models. *Econometrica*, **59**: 1551–80.

Kashyap, A., Stein, J., and Wilcox, D., (1993). The Monetary Transmission Mechanism: Evidence from the Composition of External Finance. *American Economic Review*, **83**: 78–98.

King, R.G. and Plosser, C.I., (1984). Money, Credit, and Prices in a Real Business Cycle. *The American Economic Review*, **74**: 363–80.

King, R.G., Plosser, C.I., Stock, J., and Watson, M., (1991). Stochastic Trends and Economic Fluctuations. *The American Economic Review*, **81**: 819–40.

King, G., (1986). Monetary Transmission: Through Bank Loans or Bank Liabilities? *Journal of Money, Credit and Banking*, **18**: 290–303.

Konishi, T., Ramey, V., and Granger, C., (1993). Stochastic Trends and Short-Run Relationships between Financial Variables and Real Activity, NBER working paper No. 4275.

Mankiw, N., (1985). Small Menu Costs and Large Business Cycles: A Macroeconomic Model of Monopoly. *Quarterly Journal of Economics*, **100**: 529–39.

Oliner, K. and Rudebusch, G., (1992). The Transmission of Monetary Policy to Small and Large Firms, manuscript, Federal Reserve Board of Governors.

Ramey, V., (1992). The Source of Fluctuations in Money: Evidence from Trade Credit. *Journal of Monetary Economics*, **30**: 171–193.

Romer, C. and Romer, D., (1989). Does Monetary Policy Matter? A New Test in the spirit of Friedman and Schwartz. *NBER Macroeconomics Annual*, **4**: 121–70.

Romer, C. and Romer, D., (1990). New Evidence on the Monetary Transmission Mechanism. *Brookings Papers on Economic Activity*, **1**: 149–213.

Rotemberg, J., (1984). A Monetary Equilibrium Model with Transaction Costs. *Journal of Political Economy*, **92**: 40–58.

Stiglitz, J. and Weiss, A., (1981). Credit Rationing in Markets with Imperfect Information. *The American Economic Review*, **71**: 393–410.

Stock, J. and Watson, M., (1993). A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems, *Econometrica*, forthcoming.

Strongin, S., (1991). The Identification of Monetary Policy Disturbances: Explaining the Liquidity Puzzle, manuscript, Federal Reserve Bank of Chicago.

Tobin, J., (1970). A General Equilibrium Approach to Monetary Theory. *Journal of Money, Credit and Banking*, **1**: 15–29.

Whited, T., (1993). Debt, Liquidity Constraints and Corporate Investment: Evidence from Panel Data. *Journal of Finance*, forthcoming.