# THE RESPONSE OF FINANCIAL AND GOODS MARKETS TO VELOCITY INNOVATIONS: AN EMPIRICAL INVESTIGATION FOR THE US*

by

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ABSTRACT

It is commonly thought that interest rates should decrease in response to a positive velocity innovation. Velocity innovations, therefore, should lead to the same qualitative effects in the financial and goods markets as money supply innovations. The present paper represents an empirical investigation of the above theoretical statements. By using structural Vector Autoregression (VAR) methods, the responses of interest rates, equity prices, consumer prices and output to velocity and money supply innovations are assessed for the United States. The empirical results do not seem to confirm the traditional analysis. In fact, money supply and velocity innovations seem to affect financial markets in opposite directions. While it is observed that money supply innovations cause interest rates to decrease, a certain amount of evidence is presented suggesting that velocity innovations are responsible for interest rate increases. However, both money supply and velocity innovations lead to higher prices and higher output.

* The opinions expressed in this paper are those of the author and do not necessarily represent the views of the Italian Ministry of the Treasury. Thanks to Behzad Diba for suggestions. Earlier versions of the paper have benefited of comments from Matthew Canzoneri and Robert Cumby. Any errors are mine.

**1. Introduction**

Analyzing the effects of velocity innovations on the financial markets and the real economy has long been an important goal for both theoretical and empirical research.

It is commonly recognized that interest rates should decrease, and prices and output should increase in response to a positive velocity innovation. Velocity innovations, therefore, should lead to the same qualitative outcome as monetary innovations.

In textbook explanations for these results, demand for real balances depends negatively on interest rates and positively on real income. If a positive velocity innovation occurs, a downward shift in the demand for money should follow. If the Central Bank does not accommodate this shift, interest rates have to fall in order to re-establish equilibrium in the money market. Lower interest rates lead to a positive shift in aggregate demand and - assuming an upward-sloping aggregate supply schedule - to higher prices and output.

The qualitative outcome following a positive monetary innovation is similar: now, expansionary Central Bank policies lead to excess supply in the money market. Lower interest rates are then necessary to re-establish equilibrium in that market. As before, lower interest rates lead to a positive shift in aggregate demand and, as a consequence, to higher prices and output. The relative magnitude of the price and output increases will depend on the slope of the aggregate supply curve.

The present work is an empirical investigation for the US of the above theoretical statements. The econometric analysis is based on the structural Vector Autoregression techniques used by Bernanke and Mihov (1995), Christiano and Eichenbaum (1992), Christiano, Eichenbaum and Evans (1994), Eichenbaum (1992) and Strongin (1995) to model the market for bank reserves.

In particular, the empirical model I use imposes restrictions suggested by the analysis of

Bernanke and Mihov (1995). My model, however, differs from their set-up in two main respects. First, I add the transaction velocity of money to the set of macroeconomic variables representing the "information set" for the bank reserve market. Second, I also include equity prices in the structural VAR system. In particular, I assume that the stock market responds within the same period to innovations in the bank reserve market, and that nonborrowed reserves are affected within the same period by innovations in equity prices.

With this set-up, it is then possible to analyze the dynamic response of the financial markets and the goods market to both velocity and money supply innovations.

The empirical results do not fully confirm the traditional analysis of the effect of money supply and velocity innovations on the financial markets and goods markets. In fact, money supply and velocity innovations seem to affect interest rates in opposite directions. While it is confirmed that money supply innovations cause interest rates to decrease (a well-known result from the authors mentioned above), a certain amount of evidence is presented suggesting that velocity innovations are responsible for interest rate increases. At the same time, both velocity and money supply innovations seem to lead to higher prices and higher output, which is in line with the traditional analysis.

The study also shows weak evidence of a significant effect of monetary innovations on equity prices. In contrast, equity price responses are significantly different from zero and negative following a positive velocity shock.

The remainder of the study proceeds as follows. In Section 2, I present the empirical model used for the econometric investigation, pointing out the assumptions used to identify its structure. Section 3 describes the data set used and the results of the parameter estimation. Section 4 illustrates the dynamic responses of the financial and goods market to velocity and monetary innovations.

Finally, Section 4 contains some concluding remarks.

## 2. The empirical model

Let us assume that the economy is described by the dynamic movements of eight variables: transaction velocity of money (vm), output (y), prices (p), commodity prices(pcm), equity prices(q), the federal funds interest rate (i), total reserves (tr), and nonborrowed reserves (nbr).

The relationships between the variables are characterized by the following structural model:

$$\boldsymbol{B}\boldsymbol{x}_t = \boldsymbol{k} + \sum_{j=1}^{p} \boldsymbol{B}_j \boldsymbol{x}_{t-j} + \boldsymbol{A}\boldsymbol{u}_t \tag{1}$$

where $\mathbf{x}_t$ represents the transpose of the 1X8 vector [vm y p pcm q i tr nbr] at time t, **B** is an 8X8 sparse matrix of parameters describing the contemporaneous relationships of the variables, **k** is an 8X1 vector of constants, $\mathbf{B}_j$ (j=1,..,p) is an 8X8 matrix of parameters describing the relationships between the lagged and contemporaneous variables, $\mathbf{u}_t$ is an 8X1 vector of "structural" white-noise residuals at time t, and **A** is an 8X8 sparse matrix of parameters describing the contemporaneous relationships between the structural residuals and the variables.

Following Bernanke and Mihov (1995), [i tr nbr] is recognized as the vector of "policy" variables. Accordingly, the vector [vm y p pcm q] contains the "nonpolicy" variables. In particular, I define the nonpolicy variables excluding equity prices as the "nonfinancial nonpolicy" variables, reflecting the circumstance that they represent the real economy section of the model.

By premultiplying both sides of Eq. (1) by the inverse of B, the model can be written in standard VAR form:

(2) $$\boldsymbol{x}_t = \boldsymbol{c} + \sum_{j=1}^{p} \boldsymbol{F}_j \boldsymbol{x}_{t-j} + \boldsymbol{v}_t$$

where $\mathbf{c}=\mathbf{B}^{-1}\mathbf{k}$, $\mathbf{F_j}=\mathbf{B}^{-1}\mathbf{B_j}$, and $\mathbf{v_t}=\mathbf{B}^{-1}\mathbf{Au_t}$.

The relationship between the VAR residuals $\mathbf{v_t}$ and the structural residuals $\mathbf{u_t}$ can be equivalently be expressed as:

(3) $$\boldsymbol{B}\boldsymbol{v}_t = \boldsymbol{A}\boldsymbol{u}_t$$

As in Bernanke (1986), Blanchard and Watson (1986) and Sims (1986), restrictions on Eq. (3) and on the variance-covariance matrix **D** of the structural residuals can be used to identify the structural model in Eq. (1).

First, it is assumed that the structural residuals are mutually uncorrelated so that the variance-covariance matrix **D** is diagonal:

(4) $$\boldsymbol{D} = \begin{bmatrix} d_{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & d_{22} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & d_{33} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & d_{44} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & d_{55} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & d_{66} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & d_{77} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & d_{88} \end{bmatrix}$$

Moreover, as in Bernanke and Mihov (1995) section V, it is assumed that, within the same period:

1) the nonfinancial nonpolicy VAR innovations follow a recursive structure;

2) the policy VAR innovations respond to contemporaneous information about the nonfinancial nonpolicy VAR innovations;

3) the demand for borrowed reserves responds to VAR innovations in the federal funds rate;

4) the demand for total reserves depends only on structural demand shocks and not on interest rate VAR innovations[1];

5) the supply of nonborrowed reserves partially adjusts to structural shocks in both total demand for reserves and in demand for borrowed reserves[2].

Finally, I assume that the equity market responds to contemporaneous information on VAR innovations in the nonfinancial nonpolicy variables and on VAR innovations in interest rates and nonborrowed reserves. At the same time, nonborrowed reserves VAR innovations are assumed to react to VAR innovations in the equity prices within the same period.

In symbols, the above assumptions amount to writing the matrices **B** and **A** in Eq.(3) as:

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1 This assumption was originally proposed by Strongin (1995).

2 See Bernanke and Mihov (1995) for a detailed description of the assumptions underlying the model for the bank reserve market.

$$(5)\quad \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & \gamma_1 & 0 & -\gamma_2 \\ a_{61} & a_{62} & a_{63} & a_{64} & 0 & 1 & -\frac{1}{\beta} & \frac{1}{\beta} \\ a_{71} & a_{72} & a_{73} & a_{74} & 0 & 0 & 1 & 0 \\ a_{81} & a_{82} & a_{83} & a_{84} & \gamma_3 & 0 & 0 & 1 \end{bmatrix} \boldsymbol{v_t} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -\frac{1}{\beta} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & \varphi^b & \varphi^d & 1 \end{bmatrix} \boldsymbol{u_t}$$

In Eq. (5), the $a_{ij}$ (i ranging from 1 to 8 and j ranging from 1 to 4) describe the reaction of equity prices and policy innovations to a one-unit change in the nonfinancial nonpolicy variables. $\gamma_1$ and $\gamma_2$ represent the response of the equity market to changes in the federal funds rate and nonborrowed reserve innovations, while $\gamma_3$ measures the extent to which nonborrowed reserve innovations respond to changes in equity prices. Finally, $\beta$, $\Phi^b$ and $\Phi^d$ describe the market for bank reserves: $\beta$ is the parameter measuring the reaction of demand of borrowed reserves to the federal fund rate, whereas $\Phi^b$ and $\Phi^d$ represent the degree of adjustment of nonborrowed reserves to structural shocks in demand for borrowed reserves and in total demand for reserves, respectively.

In the following section, I will describe the data used for the variables in the vector $\mathbf{x_t}$ and discuss the estimation results of the parameters in Eqs. (4)-(5). In Section 4, I will show the responses of the monetary aggregates, interest rates, equity prices, output and goods prices to structural innovations in money supply and the velocity of money.

**3. Data and estimation of the model**

The empirical model described in the previous section was estimated using monthly data from January 1968 to April 1997.

The system was estimated four times using four different definitions for the transaction velocity of money. The four measures for the velocity of money are the total value of retail sales divided by M3 plus other liquid assets (L), M3, M2, and M1, respectively. The variables so obtained were converted to log form before being used in the estimation of the model.

The series used for the other variables included in the empirical model are:

y = (the log of) the index of industrial production;

p = (the log of) the consumer price index (all urban consumers);

pcm = (the log of) the IMF all non-fuel commodities price index[3];

q = (the log of) the Standard & Poor's index of 500 common stocks;

i = the federal funds rate;

tr = total reserves of depository institutions normalized by its trend component calculated through the filter proposed by Hodrick and Prescott (1997);

nbr = nonborrowed reserves of depository institutions normalized by its trend component calculated through the filter proposed by Hodrick and Prescott (1997)[4].

The number of lags p was chosen as the smallest value for which the residuals of the VAR

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3 The index has been seasonally adjusted using the method proposed by Sims (1972).

4 As in Bernanke and Mihov (1995), both total reserves and nonborrowed reserves have been normalized rather than logged because the model for the bank reserve market has been formulated in levels.

representation in Eq.(2) are white noise[5]. Using this criterion, p was set at 8 in all the four systems estimated. The parameters of the model were then estimated by Full Information Maximum Likelihood.

Tables 1-4 show the estimates of the parameters in the matrices **A** and **B** describing the contemporaneous relationships between the VAR-based and structural innovations.

Table 1 shows the results when the transaction velocity of L is used in the estimation of the empirical model.

**Table 1. Estimates of the parameters in the matrices A and B. Definition of velocity: consumption velocity of L.**

| COEFFICIENT | ESTIMATE | STANDARD ERROR[a] |
|---|---|---|
| $a_{21}$ | -0.140 | 0.035 |
| $a_{31}$ | -0.008 | 0.010 |
| $a_{32}$ | -0.012 | 0.016 |
| $a_{41}$ | -0.032 | 0.085 |
| $a_{42}$ | -0.126 | 0.179 |
| $a_{43}$ | -1.133 | 0.532 |
| $a_{51}$ | -0.081 | 0.172 |
| $a_{52}$ | 0.194 | 0.589 |

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The absence of serial autocorrelation for the residuals was tested for lags from 1 to 12 using the Ljung-Box statistics.

| | | |
|---|---|---|
| $a_{53}$ | 2.188 | 1.065 |
| $a_{54}$ | -0.168 | 0.102 |
| $a_{61}$ | -0.905 | 3.448 |
| $a_{62}$ | 2.566 | 8.474 |
| $a_{63}$ | 31.185 | 24.452 |
| $a_{64}$ | -0.887 | 2.517 |
| $a_{71}$ | 0.009 | 0.043 |
| $a_{72}$ | -0.003 | 0.078 |
| $a_{73}$ | -0.149 | 0.276 |
| $a_{74}$ | 0.009 | 0.024 |
| $a_{81}$ | 0.019 | 0.082 |
| $a_{82}$ | 0.371 | 0.144 |
| $a_{83}$ | 0.340 | 0.686 |
| $a_{84}$ | -0.056 | 0.046 |
| $\gamma_1$ | -0.020 | 0.023 |
| $\gamma_2$ | -0.176 | 0.434 |
| $\gamma_3$ | -0.146 | 0.157 |
| $\beta$ | 0.022 | 0.009 |
| $\varphi^b$ | -0.632 | 0.219 |
| $\varphi^d$ | 0.808 | 0.071 |

[a] The standard errors were calculated using Monte Carlo methods.

As in Bernanke and Mihov (1995), the parameters describing the bank reserve market are all significantly different from zero and show the expected sign. The sign of $\beta$ is positive, indicating that the amount of reserves that the banks choose to borrow at the discount window depends positively on the level of the federal funds rate. The sign of $\varphi^b$ is negative and the sign of $\varphi^d$ is positive, indicating that nonborrowed reserves respond negatively to shocks to demand for borrowed reserves and positively to shocks to demand for total reserves.

The coefficients $\gamma_i$ (i:1,2) are not significantly different from zero, indicating that the contemporaneous response of the stock market to the policy variables is weak. $\gamma_3$ is not significantly different from zero either: in the period considered, nonborrowed reserves do not seem to have responded to contemporaneous changes in equity prices.

Analyzing the remaining significant coefficients in the matrix **B**, VAR-based innovations in output negatively affected VAR-based innovations in nonborrowed reserves. Positive consumer price innovations are associated with positive commodity price innovations and with negative equity price innovations. Finally, a positive relationship is detected between velocity innovations and output innovations.

As illustrated by Tables 2-4, the main results of the parameter estimation of the matrices **A** and **B** are very similar when the velocity of M3, M2, or M1 is used in the system in place of the velocity of L.

**Table 2. Estimates of the parameters in the matrices A and B. Definition of velocity: consumption velocity of M3.**

| COEFFICIENT | ESTIMATE | STANDARD ERROR[a] |
|---|---|---|
| $a_{21}$ | -0.137 | 0.030 |
| $a_{31}$ | -0.009 | 0.008 |
| $a_{32}$ | -0.011 | 0.014 |
| $a_{41}$ | -0.053 | 0.081 |
| $a_{42}$ | -0.122 | 0.153 |
| $a_{43}$ | -1.146 | 0.469 |
| $a_{51}$ | -0.090 | 0.155 |
| $a_{52}$ | 0.005 | 0.486 |
| $a_{53}$ | 2.336 | 1.070 |

| | | |
|---|---|---|
| $a_{54}$ | -0.148 | 0.144 |
| $a_{61}$ | 0.172 | 3.213 |
| $a_{62}$ | 3.156 | 7.600 |
| $a_{63}$ | 29.446 | 22.145 |
| $a_{64}$ | -0.799 | 2.307 |
| $a_{71}$ | 0.026 | 0.043 |
| $a_{72}$ | -0.021 | 0.079 |
| $a_{73}$ | -0.173 | 0.235 |
| $a_{74}$ | 0.008 | 0.028 |
| $a_{81}$ | 0.031 | 0.081 |
| $a_{82}$ | 0.360 | 0.141 |
| $a_{83}$ | 0.314 | 0.635 |
| $a_{84}$ | -0.063 | 0.050 |
| $\gamma_1$ | -0.014 | 0.028 |
| $\gamma_2$ | -0.007 | 0.438 |
| $\gamma_3$ | -0.100 | 0.166 |
| $\beta$ | 0.021 | 0.006 |
| $\varphi^b$ | -0.680 | 0.204 |
| $\varphi^d$ | 0.785 | 0.062 |

[a] The standard errors were calculated using Monte Carlo methods.

**Table 3. Estimates of the parameters in the matrices A and B. Definition of velocity: consumption velocity of M2.**

| COEFFICIENT | ESTIMATE | STANDARD ERROR[a] |
|---|---|---|
| $a_{21}$ | -0.138 | 0.031 |
| $a_{31}$ | -0.002 | 0.010 |
| $a_{32}$ | -0.014 | 0.016 |
| $a_{41}$ | -0.022 | 0.093 |

| | | |
|---|---|---|
| $a_{42}$ | -0.122 | 0.169 |
| $a_{43}$ | -1.158 | 0.569 |
| $a_{51}$ | -0.092 | 0.174 |
| $a_{52}$ | 0.006 | 0.464 |
| $a_{53}$ | 2.229 | 1.016 |
| $a_{54}$ | -0.127 | 0.128 |
| $a_{61}$ | 2.630 | 4.560 |
| $a_{62}$ | 1.391 | 6.999 |
| $a_{63}$ | 29.011 | 28.343 |
| $a_{64}$ | -1.113 | 2.870 |
| $a_{71}$ | 0.036 | 0.045 |
| $a_{72}$ | -0.003 | 0.063 |
| $a_{73}$ | -0.182 | 0.242 |
| $a_{74}$ | 0.001 | 0.025 |
| $a_{81}$ | 0.101 | 0.097 |
| $a_{82}$ | 0.321 | 0.145 |
| $a_{83}$ | 0.287 | 0.631 |
| $a_{84}$ | -0.058 | 0.050 |
| $\gamma_1$ | -0.012 | 0.021 |
| $\gamma_2$ | -0.055 | 0.375 |
| $\gamma_3$ | -0.088 | 0.148 |
| $\beta$ | 0.020 | 0.006 |
| $\varphi^b$ | -0.705 | 0.196 |
| $\varphi^d$ | 0.802 | 0.067 |

[a] The standard errors were calculated using Monte Carlo methods.

**Table 4. Estimates of the parameters in the matrices A and B. Definition of velocity: consumption velocity of M1.**

| COEFFICIENT | ESTIMATE | STANDARD ERROR[a] |
|---|---|---|
| $a_{21}$ | -0.152 | 0.029 |
| $a_{31}$ | 0.009 | 0.010 |
| $a_{32}$ | -0.020 | 0.014 |
| $a_{41}$ | -0.002 | 0.096 |
| $a_{42}$ | -0.015 | 0.150 |
| $a_{43}$ | -1.235 | 0.556 |
| $a_{51}$ | -0.359 | 0.152 |
| $a_{52}$ | 0.089 | 0.484 |
| $a_{53}$ | 2.204 | 0.906 |
| $a_{54}$ | -0.112 | 0.111 |
| $a_{61}$ | 1.908 | 3.657 |
| $a_{62}$ | 2.944 | 8.316 |
| $a_{63}$ | 28.278 | 22.461 |
| $a_{64}$ | -0.268 | 2.171 |
| $a_{71}$ | 0.196 | 0.040 |
| $a_{72}$ | -0.118 | 0.068 |
| $a_{73}$ | -0.068 | 0.248 |
| $a_{74}$ | -0.004 | 0.022 |
| $a_{81}$ | 0.175 | 0.095 |
| $a_{82}$ | 0.290 | 0.122 |
| $a_{83}$ | 0.541 | 0.574 |
| $a_{84}$ | -0.057 | 0.045 |
| $\gamma_1$ | -0.009 | 0.019 |
| $\gamma_2$ | 0.053 | 0.341 |
| $\gamma_3$ | -0.074 | 0.133 |
| $\beta$ | 0.022 | 0.010 |
| $\varphi^b$ | -0.669 | 0.205 |
| $\varphi^d$ | 0.784 | 0.081 |

[a] The standard errors were calculated using Monte Carlo methods.

First, the results for the bank reserve market shown in Table 1 are robust when other measures of velocity are used in place of velocity of L. Indeed, in all the models estimated the signs of $\beta$ and $\varphi^d$ are significantly different from zero and positive, whereas the sign of $\varphi^b$ is significantly different from zero and negative.

Second, the parameters relating interest rate and nonborrowed reserve innovations to equity price innovations are never significantly different from zero. The same is true for the parameter relating equity price innovations to nonborrowed reserve innovations.

Finally, innovations in consumer prices are associated positively with innovations in commodity prices and negatively with innovations in equity prices, a result that confirms the outcome in Table 1. Moreover, the negative relationship between output innovations and nonborrowed reserve innovations and the positive relationship between velocity innovations and output innovations are also robust to different definitions of velocity. However, as shown in Table 4, when velocity of M1 is used, velocity innovations also exert a significant positive effect in the same period t on equity prices, and a significant negative effect on both total reserve and nonborrowed reserve innovations.

## 4. Impulse responses to money supply and velocity innovations

In this section, I illustrate the responses of the financial and goods markets to structural innovations in money supply and velocity. The main goal is to assess whether unexpected changes in money supply and velocity exert similar effects on the economy, as suggested by the traditional view, or whether different outcomes might arise.

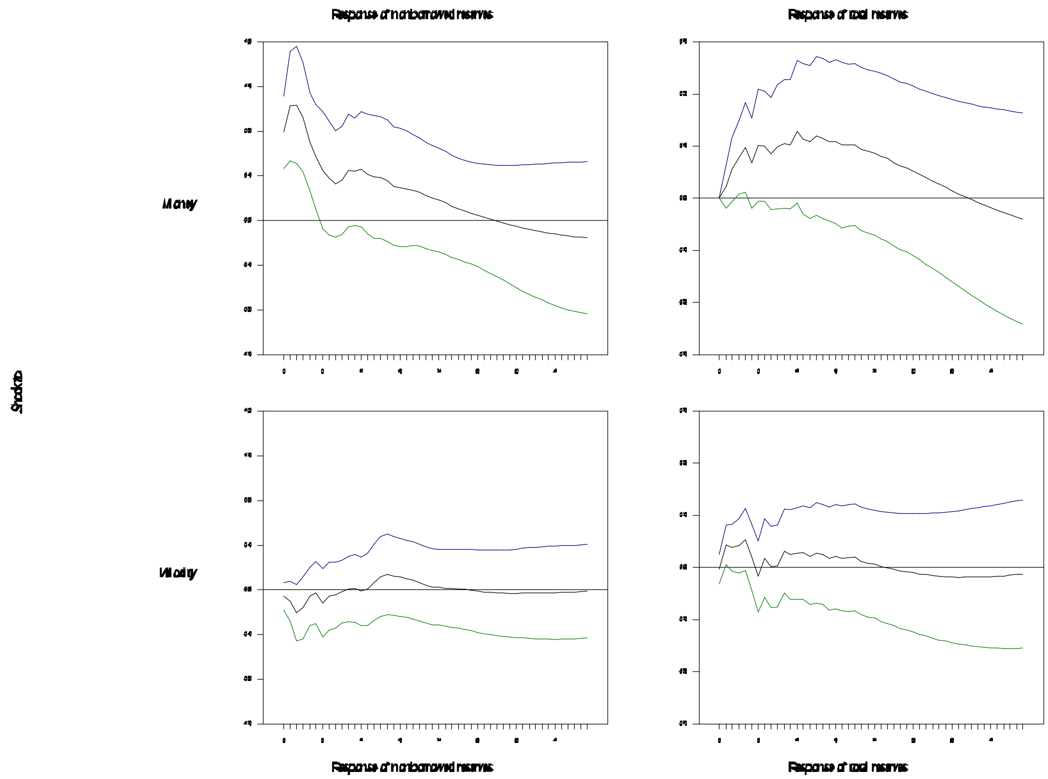
Figs. 1-12 illustrate the 48-month impulse response functions of the monetary aggregates, the federal funds rate, equity prices, consumer prices and output to structural shocks in the supply of nonborrowed reserves and in velocity. Confidence bands of 1.65 standard deviation calculated by Monte Carlo methods are also included in the figures.

Figs. 1-3 show the results when consumption velocity of L has been used to estimate the model in Section 2.

The figures confirm some of the well-known results from the VAR literature on the bank reserve market[6]. A positive structural shock in nonborrowed reserves leads to a positive response of nonborrowed reserves and total reserves and to a negative response of the federal funds rate. The response of consumer prices is initially close to zero, becoming positive only after twenty months. The immediate response of output is also close to zero in the first four months, becoming positive later. Fig. 2 shows that the confidence bands for the response of equity prices to shocks in nonborrowed reserves are very wide and it is difficult to draw any conclusion on the effects of monetary policy on the stock market.

**FIG 1. IMPULSE RESPONSES OF THE MONETARY AGGREGATES TO INNOVATIONS IN MONEY SUPPLY AND IN VELOCITY OF L**

6 Christiano and Eichenbaum (1992), Eichenbaum (1992), Christiano, Eichenbaum and Evans (1994), Strongin (1995), Bernanke and Mihov (1995).


Response of nonborrowed reserves
Response of total reserves
Money
Velocity
Shocks to
Response of nonborrowed reserves
Response of total reserves

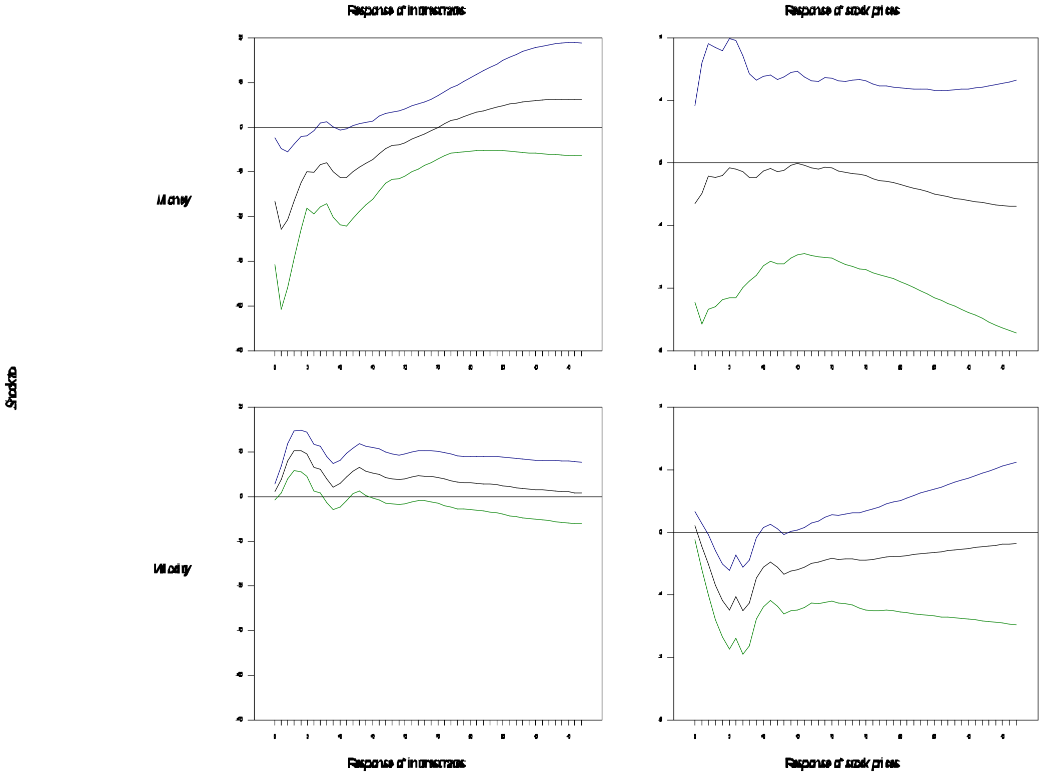



**FIG 2. IMPULSE RESPONSES OF THE FINANCIAL MARKETS TO INNOVATIONSIN MONEY SUPPLY AND IN VELOCITY OF L**

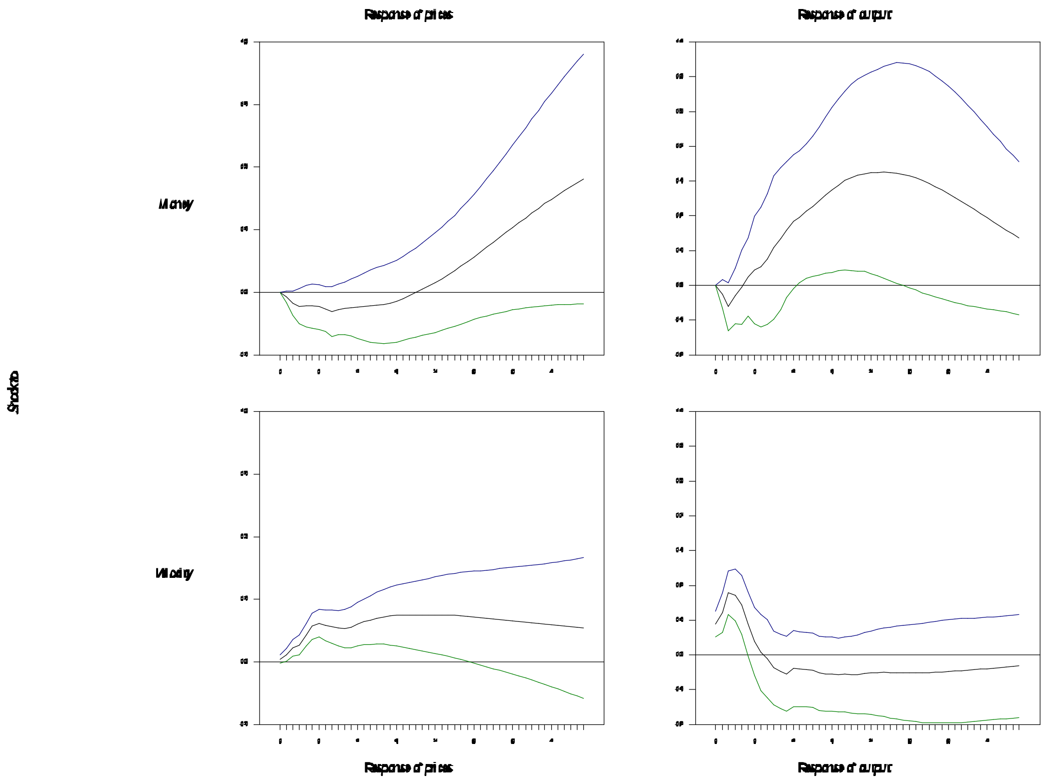
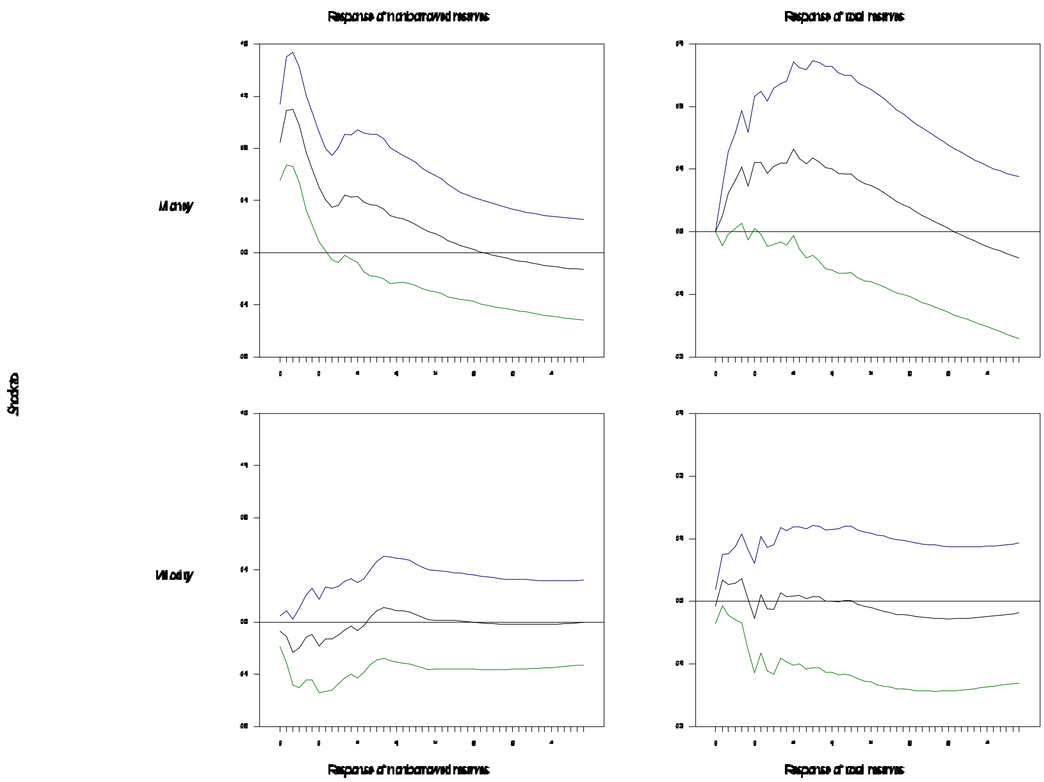



**FIG 3. IMPULSE RESPONSES OF THE GOODS MARKET TO INNOVATIONS IN MONEY SUPPLY AND IN VELOCITY OF L**

The impulse responses to velocity innovations present some results that do not fit with the traditional view. In fact, contrary to the traditional view, the immediate response of interest rates to velocity innovations is significantly different from zero and positive. At the same time, equity prices respond negatively to velocity shocks. Moreover, innovations in velocity do not seem to cause significant responses in either nonborrowed reserves or total reserves. In the goods market, both consumer prices and output responses to velocity innovations are significantly different from zero and positive.

As shown in Figs. 4-9, these results are virtually identical when the consumption velocity of M3 or the consumption velocity of M2 are used in the estimation of the model. The only relevant difference is that the response of nonborrowed reserves to velocity innovations is significantly different from zero and negative in the first four months when the velocity of M2 is used.

**FIG 4. IMPULSE RESPONSES OF THE MONETARY AGGREGATES TO INNOVATIONS IN MONEY SUPPLY AND IN VELOCITY OF M3**


Response of nonborrowed reserves
Response of total reserves
Money
Shocks to
Velocity
Response of nonborrowed reserves
Response of total reserves

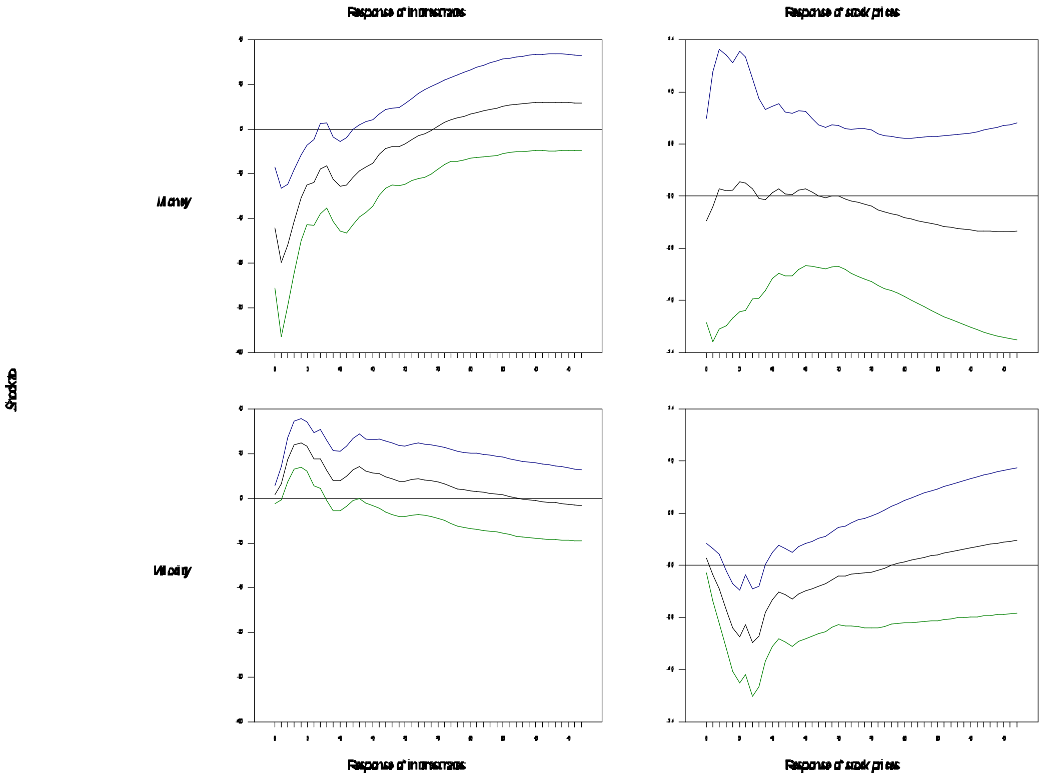



**FIG 5. IMPULSE RESPONSES OF THE FINANCIAL MARKETS TO INNOVATIONS IN MONEY SUPPLY AND IN VELOCITY OF M3**

**FIG 6. IMPULSE RESPONSES OF THE GOODS MARKET TO INNOVATIONS IN MONEY SUPPLY AND IN VELOCITY OF M3**

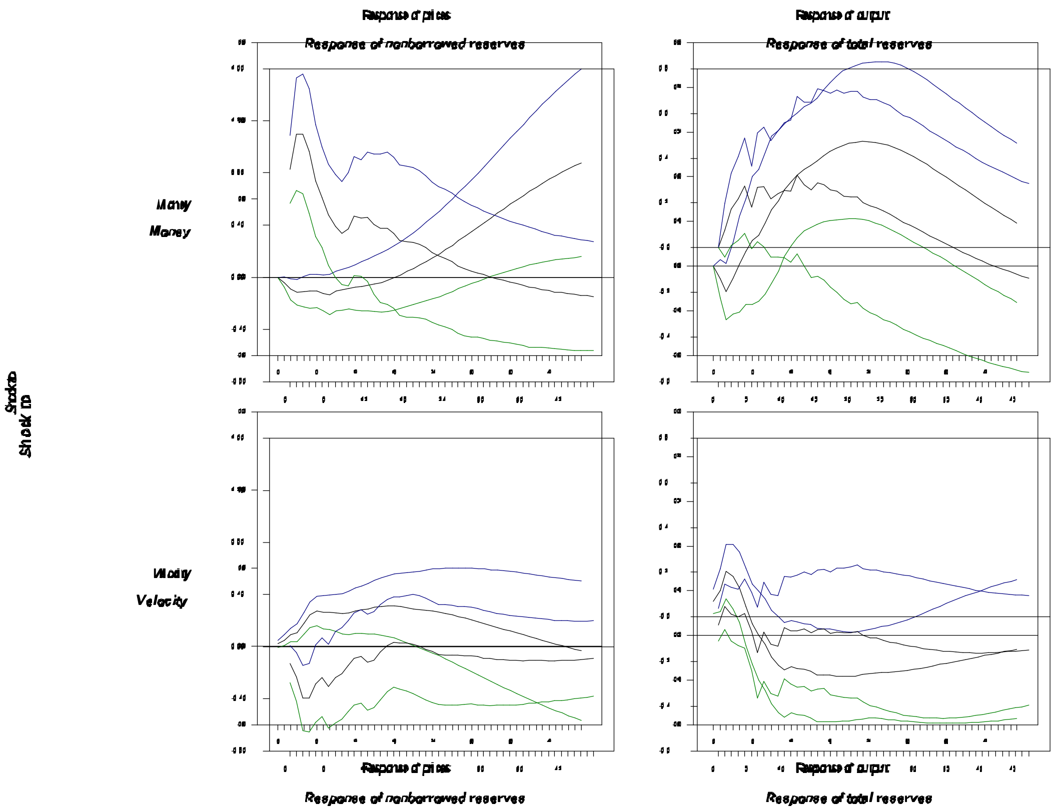



**FIG 7. IMPULSE RESPONSES OF THE MONETARY AGGREGATES TO INNOVATIONS IN MONEY SUPPLY AND IN VELOCITY OF M2**

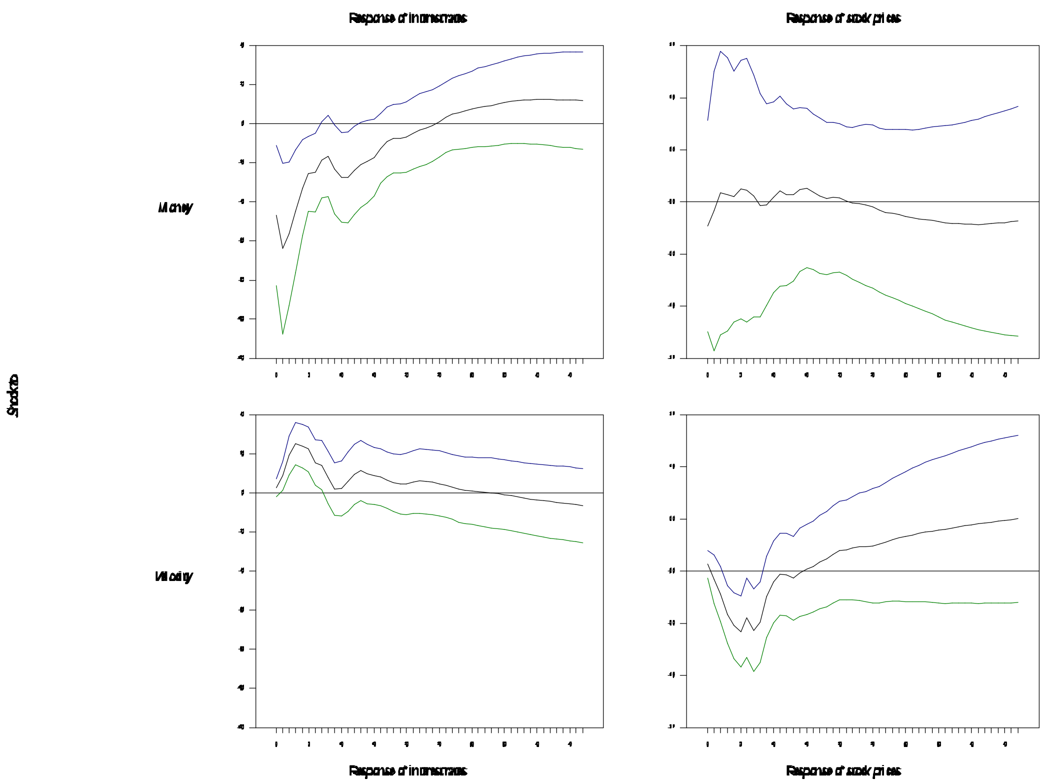
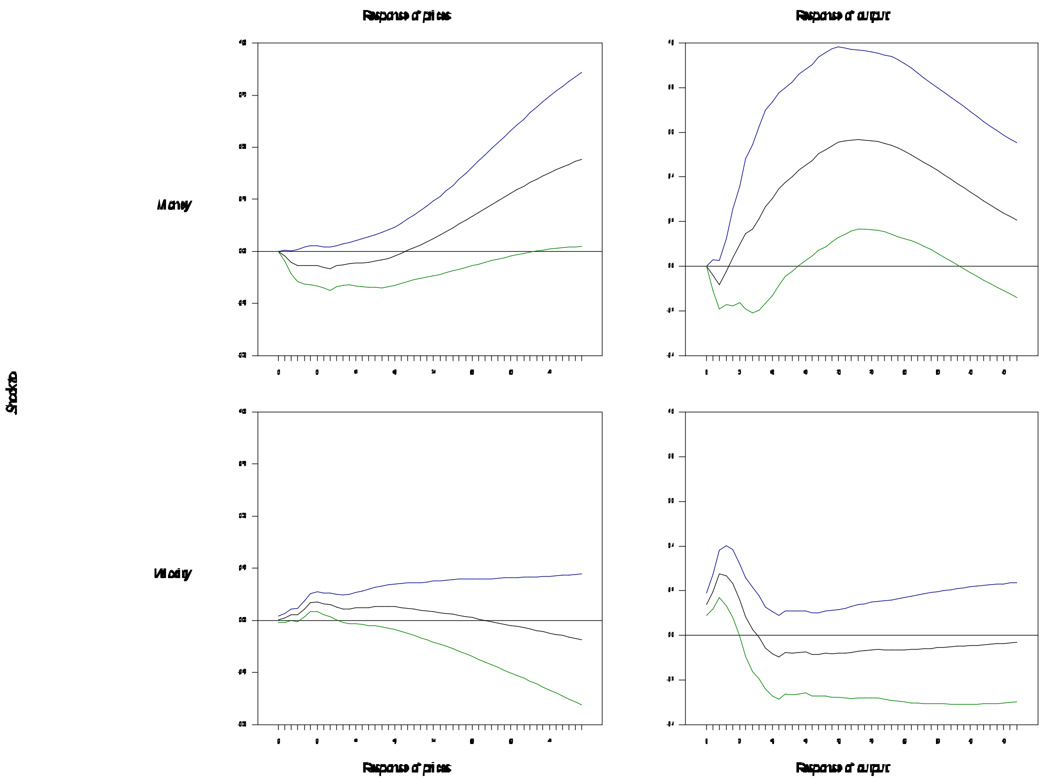



**FIG 8. IMPULSE RESPONSES OF THE FINANCIAL MARKETS TO INNOVATIONS IN MONEY SUPPLY AND IN VELOCITY OF M2**

**FIG 9. IMPULSE RESPONSES OF THE GOODS MARKET TO INNOVATIONS IN MONEY SUPPLY AND IN VELOCITY OF M2**


Response of prices
Response of output
Money
Shocks to
Velocity
Response of prices
Response of output

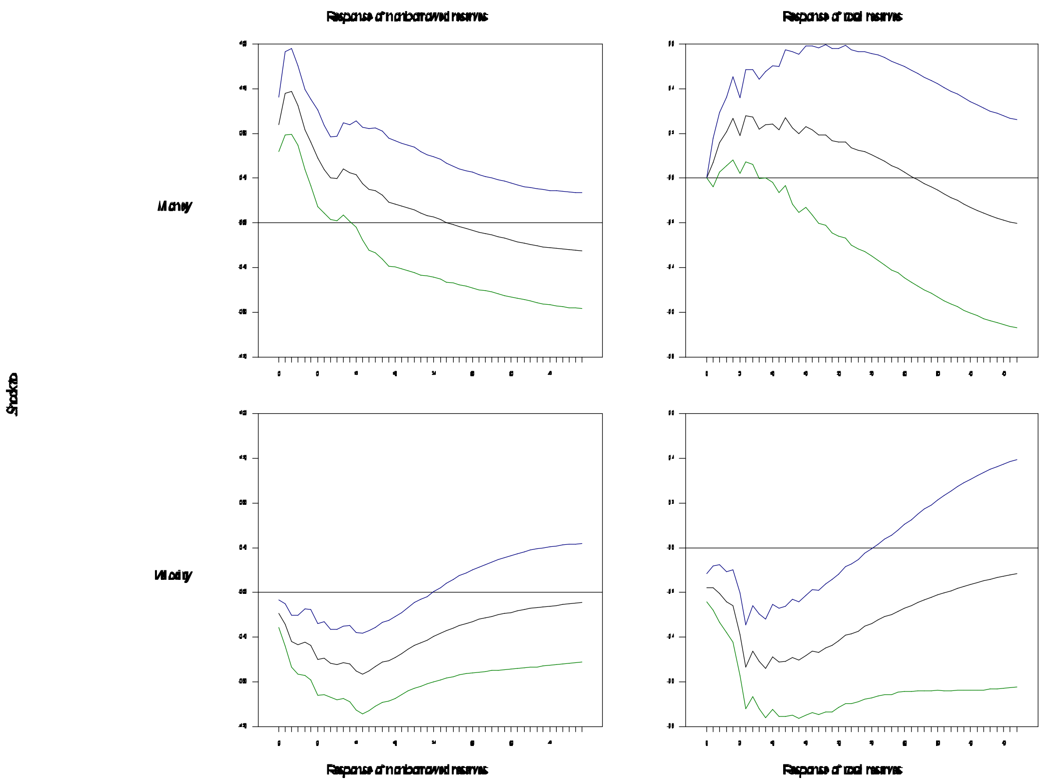
Figs. 10-12 show the results when the consumption velocity of M1 is used in the model. Again, the responses to structural shocks in nonborrowed reserves are virtually identical to those analyzed previously. However, the responses to velocity innovations show some differences.

First, the responses of both nonborrowed reserves and total reserves to velocity innovations are significantly different from zero and negative for the first two years after the shock. Moreover, the response of interest rates is still significantly different from zero and positive, but the response of equity prices is close to zero. Finally, the response of output remains positive, but the effect of velocity shocks on prices does not appear significantly different from zero[7].

**FIG 10. IMPULSE RESPONSES OF THE MONETARY AGGREGATES TO INNOVATIONS IN MONEY SUPPLY AND IN VELOCITY OF M1**

7

As explained in Section 2, I have assumed for the "nonfinancial nonpolicy" variables a recursive contemporaneous structure [vm y p pcm]. The ordering for output, consumer prices and commodity prices is the same used by Bernanke and Mihov (1995). I order velocity of money first because the focus of the paper is on the effect of exogenous shocks to velocity. However, the impulse response functions were calculated also with the recursive ordering [y p pcm vm]. With this ordering, innovations in velocity are to be interpreted as negative exogenous shocks to money demand. In this case, the results are confirmed when velocity of L, M3 or M2 is used. When velocity of M1 is used, the response of interest rates to a positive velocity innovation (or to a negative money demand shock) appears negative in the first three months and not significantly different from zero in the following months. The interpretation of the responses to money demand shocks goes beyond the scope of this paper. Thanks to Behzad Diba for suggesting me this point.


Response of nonborrowed reserves
Response of total reserves
Money
Velocity
Shocks to
Response of nonborrowed reserves
Response of total reserves

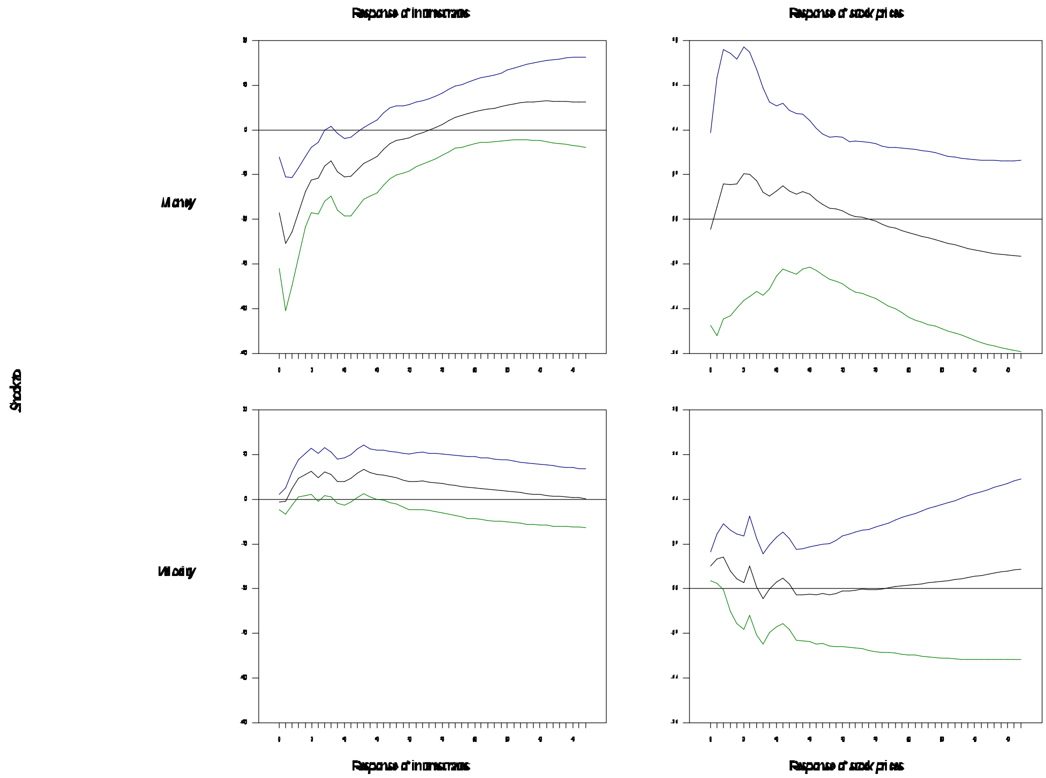
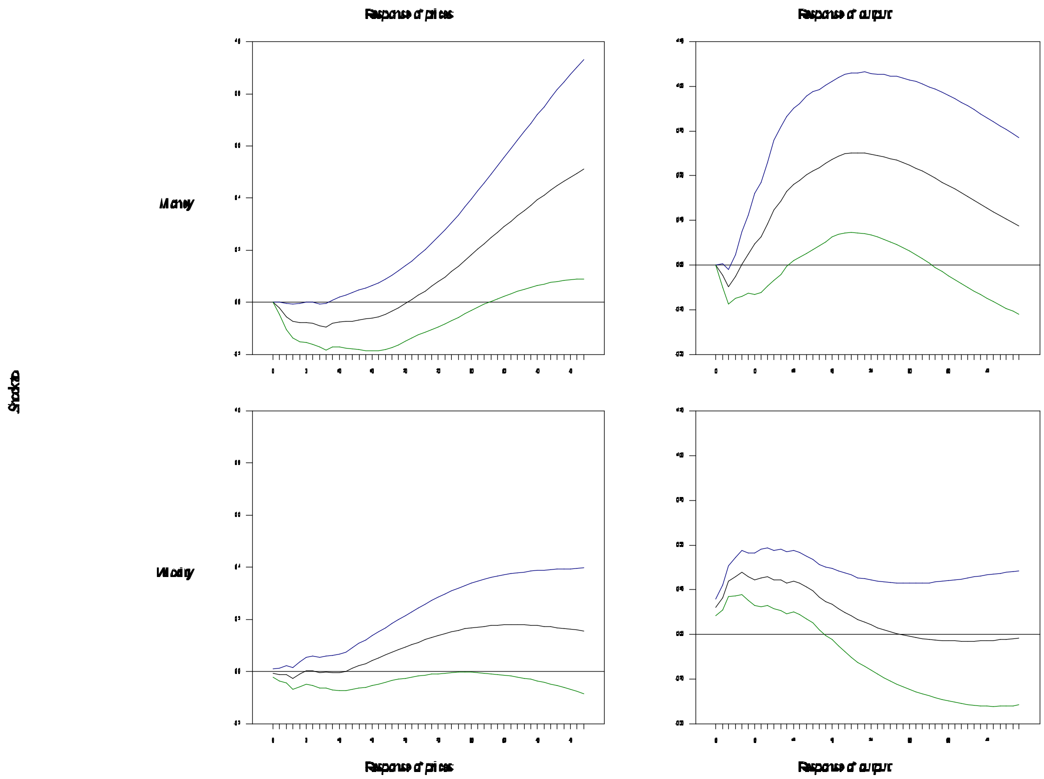



**FIG 11. IMPULSE RESPONSES OF THE FINANCIAL MARKETS TO INNOVATIONS IN MONEY SUPPLY AND IN VELOCITY OF M1**

**FIG 12. IMPULSE RESPONSES OF THE GOODS MARKET TO INNOVATIONS IN MONEY SUPPLY AND IN VELOCITY OF M1.**


Response of prices
Response of output
Money
Velocity
Shock to
Response of prices
Response of output

## 5. Concluding remarks

A large amount of recent empirical literature based on "structural VAR" methodology has been devoted to detecting the effects of money supply shocks on the US economy. The present paper has extended these methods to investigate empirically the effects of velocity innovations in the financial and goods markets.

The results of the empirical investigation seem to suggest that - contrary to the traditional theoretical analysis - innovations in velocity lead to increases in interest rates. At the same time, however, innovations in velocity are usually followed by price increases.

The empirical results therefore suggest that additional theoretical work needs to be done to explain the relationship between velocity innovations and the other variables characterizing financial and goods markets.

In a companion paper[8], I take a first step towards this theoretical task by using the monetary general equilibrium framework of Lucas (1990) and Fuerst (1992).

In the model, the economy consists of a financial market and a goods market. In the financial market, households can deposit money at intermediaries, which in turn either invest in equities or lend to firms to finance labor costs. In the goods market, consumers "exchange" money for consumption goods from firms.

When a monetary innovation hits the financial markets, the increase in liquidity leads to a decrease in interest rates. Indeed, the firms are willing to accept this excess liquidity only if the cost

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[8] Padrini (1996).

of borrowing is lower.

When a velocity innovation hits the goods market, consumers find themselves with more money than necessary and increase spending. Prices rise as a consequence. The consequent increase in the value of the marginal product of labor causes a shift in labor demand. Since firms have to borrow in order to finance labor costs, the process will ultimately lead to higher interest rates.

These theoretical results can adequately represent the empirical evidence I have presented in this paper: a velocity innovation can cause prices and interest rates to rise.

Both the empirical and theoretical analyses, however, are only a first step in the research that needs to be done in order to asses the relationship between velocity of money, the financial markets and the real economy.

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