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The Macroeconomic Effects of Monetary Policy and Financial Crisis

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ÖZET Vektör otoregresif (VAR) modeller son yıllarda para politikası şoklarının etkilerini incelemek için yaygın bir şekilde kullanılmıştır. Makalede İkinci Dünya Savaşı sonrası Amerika Birleşik Devletleri'nin verilerine odaklanarak, finans ve para politikası şoklarını VAR sistemlerindeki yeni ölçümlerine yer veriyor ve her iki düzensizliğin çıktı ve ekonominin tümü üzerinde reel etkileri olup olmadığını test ediyoruz. Bu sürtüşmelerin dışsal olduğunu gösteren ekonometrik kanıtlar buluyoruz. Para politikası şoklarının ve borsadaki büyük düşüşlerin dışsal doğası ve ekonomi üzerindeki reel etkileri, finansal kriz sonrası para politikasının rolüne dair tartışmalara ve optimal para politikası ile finansal istikrar arasındaki ilişkiye yeni bir açıdan yaklaşmamızı sağlıyor.

ANAHTAR KELİMELER VAR, mali kriz, para politikası

ABSTRACT Vector autoregressive models have been widely used in recent years to analyze the effects of monetary policy shocks. Focusing on the US postwar data, we incorporate new measures of financial and monetary policy shocks in VAR systems to test whether both perturbations have real effects on output and on the economy as a whole. We find econometric evidences that these frictions are exogenous. The exogenous nature and real effects on the economy of shocks to monetary policy and stock market crashes shed new light on the debate relates to the role of monetary policy in the aftermath of financial crisis, and then the eventual relationship between optimal monetary policy and financial stability.

KEYWORDS VAR, financial crisis, monetary policy

INTRODUCTION

The effects of monetary policy on output and other macroeconomic aggregates generates a vast empirical literature during the last two decades. Much effort has recently been devoted by both policy makers and researchers to study the sources of business cycle fluctuations, with emphasis being placed on various supply shocks and demand changes. An important strand of the rapidly growing literature pays special attention to monetary policy shocks. A typical finding is that monetary shocks affect output with long delays with a highly persistent effect, and this accounts for the movement in aggregate price levels. Inferences that can be made however regarding the quantitative effects of monetary shocks critically depend on underlying identification and estimation schemes.[1]

1. Lawrence J. Christiano, Martin Eichenbaum and Charles L. Evans, "Monetary Policy Shocks: What Have We Learned and to What End?" in John B. Taylor and Michael Woodford (eds.), *Handbook of Macroeconomics* (Amsterdam and New York: Elsevier, 1999), pp.65-148.

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The concept of monetary policy shock is defined here as the portion of central bank policy variation not caused by systematic responses to variations in the state of the economy. With this in mind, the purpose of this study is to determine whether monetary policy shocks have any effect on a real economy, while focusing on the economy's regular responses to shock behavior.

Furthermore, the identification of monetary shocks is not without controversy. Indeed, estimates made of the macroeconomic effects of monetary policy often differ from one study to the next with regard to both their timing and magnitude.[2] We therefore examine whether major conclusions made by alternative specifications of our empirical model still hold. First, given that it is debatable whether monetary policy will respond to variables not already included in empirical work, we examine how controlling for other shocks —namely, market crashes and oil price changes—might alter the apparent real effects of monetary shocks. Second, controversy also exists as to whether monetary authorities should react to asset price movements. We therefore examine the effects of stock market crashes on the real economy. We begin our study by examining the exogeneity of both types of perturbations, and then analyze their implications on various macro variables.

While the exogeneity of monetary policy shocks is well documented in the literature, no study has yet been done regarding the new Romer and Romer measure and regarding stock market crashes. Given that their exogenous nature has been questioned, our objective here is to study the effects of the shocks—to monetary policy and stock market crashes—on various macro variables, and then assess the real effects of these shocks on the economy. The accuracy of estimates of these effects depends fundamentally on the measures for monetary policy and stock market variables being used. For the purposes of this study and in order to construct a dummy variable, we use the new US monetary policy shocks measure recently developed by Romer and Romer along with the dates highlighted by Mishkin and White.[3]

2. See, for example, Lawrence J. Christiano, Martin Eichenbaum and Charles L. Evans, "Identification and the Effects of Monetary Policy Shocks," Federal Reserve Bank of Chicago Working Paper Series, Macroeconomic Issues, 94-7 (1994); Lawrence J. Christiano, Martin Eichenbaum and Charles L. Evans, "Monetary Policy Shocks: What Have We Learnt and To What End?"; David B. Gordon and Eric M. Leeper, "The Dynamic Impacts of Monetary Policy: An Exercise in Tentative Identification," *The Journal of Political Economy*, *102/6* (December 1994), pp.1228-1247; Eric M. Leeper, Christopher A. Sims and Tao Zha, "What Does Monetary Policy Do?" *Brookings Papers on Economic Activity, 2* (1996), pp.1-78.
3. Christina D. Romer and David H. Romer, "A New Measure of Monetary Shocks: Derivation and Implications," *The American Economic Review*, *94/4* (September 2004), pp.1055-1084; and Frederic S. Mishkin and Eugene N. White, "U.S. Stock Market Crashes and Their Aftermath: Implications for Monetary Policy," National Bureau of Economic Research, Working Papers #8992 (June 2002).

We also use a procedure that was first used by Leeper to study the exogeneity of monetary dummies developed by Romer and Romer.[4] This methodology combines the narrative approach with vector autoregression (VAR) in order to verify whether both shocks are contaminated by substantial endogenous components.

For this reason a logit equation for the financial dummy variable is estimated, after which we compute the probabilities that the dummy variable takes a value of one at the date selected by Mishkin and White using a narrative approach.[5] Two VAR systems are then estimated and finally the impulse response functions are analyzed.

Following Leeper,[6] the basic VAR has seven variables: industrial production (Y), consumer prices (P), the 3-month Treasury bill rate (R3), the 10-year U.S. Treasury bond yield (R10), total reserves (TR), the price of commodities (PCM) and finally monetary shocks or a market crash dummy. All variables are measured in logs except for interest rates, which are measured in percentage points.

First, we estimate two VARs: 'Financial VAR' for the one incorporating the financial crisis variable, estimated over a sample period extending from 1960M01 to 2000M12 and 'Monetary VAR' for the new monetary policy measure built by Romer and Romer,[7] covering a period 1969M01 to 1996M12. Then we incorporate the financial crash dummy and the monetary policy shock into the same VAR, combining them both to estimate the effects of each.

As was mentioned above, our measure of monetary shocks is the new measure developed recently by Romer and Romer which they base on their interpretation of the Federal Open Market Committee (FOMC) meeting reports, combined with information on Federal Reserve expected fund rates.[8] See Figure 1 for the new monetary policy measure computed by the authors. For ease of readability, the monthly values are converted into quarterly observations and display a continuous series, capturing changes in the intended

4. Eric M. Leeper, "Narrative and VAR Approaches to Monetary Policy: Common Identification Problems," *Journal of Monetary Economics*, *40/3* (December 1997), pp.641-657; Christina D. Romer and David H. Romer, "Does Monetary Policy Matters? A New Test in the Spirit of Friedman and Schwartz," *NBER Macroeconomics Annual 1989*, *4* (1989), pp.121-170; Christina D. Romer and David H. Romer, "Monetary Policy Matters," *Journal of Monetary Economics*, *34* (1994), pp.75-88. Following this methodology, Leeper (Eric M. Leeper, "Narrative and VAR Approaches to Monetary Policy") argues that the Romers' (Christina D. Romer and David H. Romer, "Monetary Policy Matters") monetary dummy is not exogenous, meaning that this dummy is contaminated by a substantial endogenous component.
5. Frederic S. Mishkin and Eugene N. White, "U.S. Stock Market Crashes and Their Aftermath."
6. Eric M. Leeper, "Narrative and VAR Approaches to Monetary Policy."
7. Christina D. Romer and David H. Romer, "A New Measure of Monetary Shocks."
8. Christina D. Romer and David H. Romer, "A New Measure of Monetary Shocks."

movements in the fund rate around the FOMC meetings. The idea then is that this measure should be purged of any movements in the economy that are anticipated by the Fed, so that it reflects purely exogenous, unanticipated changes in monetary conditions.

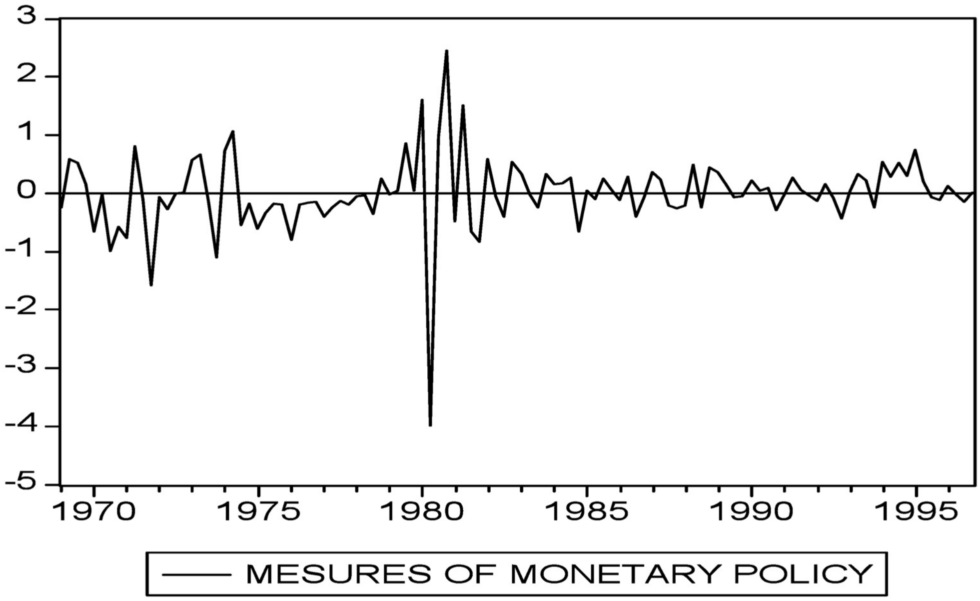

FIGURE 1— Romer and Romer ("A New Measure of Monetary Shocks") New Measure of Monetary Policy Shocks

Romer and Romer incorporate their monetary policy shock measure in a VAR, based on Christiano, Eichenbaum and Evans.[9] They estimate a three-variable VAR including output (measured by industrial production), the producer price index (PPI for finished goods) and their new monetary policy measure. They find that monetary policy shocks have both strong and statistically significant effects on output. They also show that a negative monetary policy shock generates a strong negative price response. They argue that their shock measure creates a stronger effect on output.[10]

9. Christina D. Romer and David H. Romer, "A New Measure of Monetary Shocks"; Lawrence J. Christiano, Martin Eichenbaum and Charles L. Evans, "The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds," *Review of Economics and Statistics*, *78* (1996), pp.16-34.
10. See Lawrence J. Christiano, Martin Eichenbaum and Charles L. Evans, "The Effects of Monetary Policy Shocks"; Christina D. Romer and David H. Romer, "Monetary Policy Matters"; Marvin J. Barth, III and Valery A. Ramey, "The Cost Channel of Monetary Transmission," *NBER Macroeconomics Annual 2001*, *16* (2001), pp.199-240; and Jean Boivin, "The Fed's Conduct of Monetary Policy: Has It Changed and Does It Matter?" Unpublished Paper, Columbia University (1999).

As for stock market crashes,[11] we use the dates computed by Mishkin and White.[12] In the spirit of Hamilton and Romer and Romer, the authors apply a narrative approach to identify the stock market collapses in the United States over the last one hundred years.[13]

In their study, Mishkin and White argue that financial market crashes decrease aggregate demand by reducing wealth and raising the cost of capital.[14] This may also reduce consumer spending and real investment.[15] Thus, stock market perturbations can produce additional stress on the economy, possibly leading to intervention by the central bank.[16] For example, monetary authorities may react to movements in stock prices in order to stop bubbles from getting out of hand, or alternatively try to prop up the stock market following a crash by adopting an expansionary policy stronger than the one indicated by straightforward effects on aggregate macroeconomic variables.[17] These strategies are applied only if stock market crashes have the potential to destabilize the financial system and to produce more stress on the economy.

Based on their historical analysis of all stock market crashes in the twentieth century in the United States, Mishkin and White identify different major collapses of the financial market.[18] A stock market crash is defined here as a sudden dramatic loss of share value for corporate stocks. However, as highlighted by the authors, attempting a precise definition and measurement of stock market crashes over the century is a difficult task. Key factors include the stock market index, the size of the collapse and the duration of the crash. Using three stock indices[19] and the universally agreed stock market crashes of October 1929, and October 1987 as benchmarks, they identify 15 major financial crises

11. Also called 'financial crisis' in this work.
12. Frederic S. Mishkin and Eugene N. White, "U.S. Stock Market Crashes and Their Aftermath."
13. James D. Hamilton, "Oil and Macroeconomy since World War II," *The Journal of Political Economy*, *91/2* (April 1983), pp.228-248; Christina D. Romer and David H. Romer, "Does Monetary Policy Matters?"; and, Christina D. Romer and David H. Romer, "Monetary Policy Matters."
14. Frederic S. Mishkin and Eugene N. White, "U.S. Stock Market Crashes and Their Aftermath."
15. Central banks, trying to conduct an optimal policy, should react to these fluctuations. The manner in which this reaction is related to the effect of stock market perturbations on aggregate demand is unclear (Frederic S. Mishkin and Eugene N. White, "U.S. Stock Market Crashes and Their Aftermath").
16. This stress should become visible in risk premiums on interest rates. Note that crashes are not always the main cause of financial instability. Collapses of banking systems or severity of economic contractions are also possible independent factors that could lead to financial instability (Frederic S. Mishkin and Eugene N. White, "U.S. Stock Market Crashes and Their Aftermath").
17. Frederic S. Mishkin and Eugene N. White, "U.S. Stock Market Crashes and Their Aftermath."
18. Frederic S. Mishkin and Eugene N. White, "U.S. Stock Market Crashes and Their Aftermath."
19. The authors use monthly Dow Jones Industrials Index records, the Standard and Poor's 500 Index and finally the NASDAQ Composite Index to identify nominal crashes.

in the last century.[20] Since we have limited our analysis to the US postwar period, we construct a dummy variable to account for the dates identified by Mishkin and White.[21] These dates are: 1962:04, 1970:05, 1973:11, 1987:10, 1990:08, and finally 2000:04.[22]

Our results show empirical evidence that both financial crises and monetary policy shocks are exogenous. These results remain relatively unchanged even when we include other exogenous shocks in the VAR or when different weights are given to financial crisis episodes.[23] Furthermore, the logit equation for the financial crisis dummy does not provide any meaningful help in explaining this shock's exogeneity, since it is imprecisely estimated and leads to puzzling probabilities.

These results suggest that it is important that monetary authorities take disruptions in the financial market into account when assessing monetary policy. Monetary authority response to asset price movements is an expanded and ambitious mission for monetary policy, which could complicate inflation targeting procedures. Indeed, monetary policy is a macroeconomic policy tool that should be used for macroeconomic purposes, not for a single market or for localized events as in the financial market. However, as suggested by advocates of central bank intervention (in case of financial crisis), asset price movements may lead to sizeable debt build-ups, weakened balance sheets and financial imbalances.[24] Such perturbations can generate financial instability and in turn, macroeconomic fluctuations.

Econometric Methodology

The methodology used to investigate the exogeneity of different shocks follows work done by Leeper and Horent in their examination of the exogenous effects of shocks on monetary and fiscal policy.[25]

20. A stock market crash is defined by a 20% drop in the market combined with the speed of the collapse by looking at declines over windows of time, where depth and speed are the main features that define it.
21. With the stock market crash defined as a decline in stock prices, by construction the shocks highlighted by the authors are of the same sign. Depth and speed of collapse might be different but they have the same magnitudes.
22. Since data used in our empirical study covers the period 1960M01-2000M12.
23. Following the classification presented by Mishkin and White (Frederic S. Mishkin and Eugene N. White, "U.S. Stock Market Crashes and Their Aftermath"), we assign different weights to financial collapses, varying from one to four, according to crash category.
24. See Jim Saxton, "Monetary Policy and Asset Prices," *Joint Economic Committee, United States Congress*, April 2003. Web: http://www.house.gov/jec/ for a survey of the literature on cases for or against central bank intervention in financial crises cases.
25. Eric M. Leeper, "Narrative and VAR Approaches to Monetary Policy"; and Eric Horent, An Empirical Analysis of the Macroeconomic Effects of Government Purchases (Ph.D. dissertation, Louisiana State University, Department of Economics, 2002).

In our empirical work, VAR systems have seven variables: output, consumer prices, 3-month Treasury bill rate, 10-year Treasury bond yield, price of commodities, total reserves and finally the shock considered.[26] The variables are in levels rather than in first differences, even though the series may be either non-stationary or cointegrated. The estimates in this case yield consistent values for all parameters, as pointed out by Hamilton and Weise, provided that the lags included in the estimation are long enough.[27]

Enders and Lütkepohl show that in any VAR an important issue is the selection of an adequate lag length and appropriate time trend, and in respect to these choices two main problems can be highlighted.[28] First, if the lag length included in the system is too long, degrees of freedom are squandered. Second, the system may be mis-specified if the appropriate time trend is not included or if the lag length selected is too short; this may yield biased coefficient estimates and create some autocorrelation problems.

In order to test for the presence of a time trend (linear and/or quadratic), we use the Akaike information criterion (AIC) and the Schwartz criterion (SIC).[29] We also make use of likelihood ratio (LR) statistics to test for the presence of the time trend (none or linear) in the VAR.[30]

TABLE 1— AIC and SIC for Time Trend in Financial VAR

Type of Trend	Akaike Criterion	Schwarz Criterion
No time trend	–28.07880	–26.94209
Linear time trend	–28.13752	–26.94098
Linear and quadratic time trend	–28.21531**	–26.95894**

** indicates selection of the criterion.

26. See appendix B for more details about the data used in this work.
27. James D. Hamilton, *Time Series Analysis* (Princeton: Princeton University Press, 1994); and Charles L. Weise, "Severity of Economic Fluctuations under a Balanced Budget Amendment," *Contemporary Economic* Policy, *14* (1996), pp.26-40.
28. Walter Enders, *Applied Econometric Time Series* (New York: John Wiley & Sons, Inc., 1995); and Helmut Lütkepohl, *Introduction to Multiple Time Series Analysis* (Berlin and New York: Springer-Verlag, 1991).
29. We test for both linear and quadratic time trend and the most adequate specification is the one minimizing criterion values.
30. We, therefore, assess a restricted model with no trend, an unrestricted model in which linear and quadratic time trend are included in the VAR. The null hypothesis of 'no trend' against 'linear trend,' and alternatively 'linear and quadratic trend' are tested. See Appendix C for more technical details on the formula used to compute the different criteria.

The results show that including either linear or quadratic time trend is better than not including a time trend in the VAR systems. Indeed, based on our computations of the AIC and SIC criteria, we conclude that the best choices are linear and quadratic time trends in both financial and monetary VARs (see Tables 1 and 2). Table 3 shows the results of the LR test on both VARs. It is shown that Including linear and quadratic time trends does not affect the results significantly and furthermore the results are not sensitive to the addition of quadratic time trends in the VAR systems. In our empirical study we only consider a linear time trend in both VARs.

TABLE 2— AIC and SIC for Time Trend in Monetary VAR

Type of Trend	Akaike Criterion	Schwarz Criterion
No time trend	-26.09796	-24.58702**
Linear time trend	-26.14461	-24.55414
Linear and quadratic time trend	-26.17300**	-24.50302

** indicates selection of the criterion.

Akaike information criterion (AIC) and Schwartz criterion (SIC) are used to determine the variables' lag length to be included in the VAR systems. Models with various lag lengths are estimated and the corresponding AIC and SIC values are computed.[31] The optimal lag length is the one that minimizes the information criterion values.[32]

The likelihood ratio (LR) is also used to validate the choice of AIC and SIC criteria. In their study Romer and Romer use 36 lags in the baseline specification for the monetary VAR.[33] Tables 4 to 6 display the results for the optimal lag length in the VAR

31. Lags from 1 to 36 are included following Leeper (Eric M. Leeper, "Narrative and VAR Approaches to Monetary Policy), who uses 36 lags for the dummy variable and 24 lags for macro variables. Here we use the maximum lag length to test for the optimal one.
32. It should be noted here that various Monte Carlo studies usually compare the lag order selection criterion to find out which one would be best able to select the true lag order most often (Gerald Nickelsburg, "Small-Sample Properties of Dimensionality Statistics for Fitting VAR Models to Aggregate Economic Data: A Monte Carlo Study," *Journal of Econometrics*, *28/2* (May 1985), pp.183-192; Lutz Kilian, "Impulse Response Analysis in Vector Autoregression with Unknown Lag Order," *Journal of Forecasting*, *20* (2001), pp.161-179.). As shown by Kilian, lag order distribution results may be of theoretical interest, but they are of limited interest for applied users interested in VAR statistics such as forecasts or impulse responses.
33. Christina D. Romer and David H. Romer, "A New Measure of Monetary Shocks." Following Leeper (Eric M. Leeper, "Narrative and VAR Approaches to Monetary Policy"), and Romer and Romer

TABLE 3— Likelihood Ratio Test for Time Trend Specifications

Hypothesis		Financial VAR (1960M01-2000M12)		Monetary VAR (1960M01-2000M12)	
Null Hypothesis	Alternative	LR value	P-value	LR value	P-value
No time trend	Linear time trend	40.954*	0.00018	104.0352*	0.0000075
No time trend	Linear and quadratic trend	82.616**	0.00000	109.7788**	0.0000147
Linear time trend	Linear and quadratic trend	41.662*	0.00000	106.9916*	0.0000333

* We impose 7 restrictions in this case, and the $x^2(7)$ at 5% significance level is 14.10.
** Up to 14 restrictions imposed, and $x^2(14)$ at 5% significance level is 23.70.

systems, as well as the appropriate time trend.[34] Based on the SIC, it seems better to include one lag for the endogenous variables in the two systems. However, the AIC suggests 8 lags for the financial VAR and 36 for the monetary system. LR found that 36 and 21 lags for financial and monetary systems respectively is better. This statistical evidence leads to different conclusions regarding the optimal lag length for the two VARs.

Empirically, Killian presents a Monte Carlo study and concludes that the AIC has better finite sample proprieties compared to other information criterion.[35] Horent presents the same evidence by using impulse response functions to compare models where lag length order is selected based on different criteria.[36]

(Christina D. Romer and David H. Romer, "A New Measure of Monetary Shocks"), we consider 36 lags as the maximum lag length for both systems and only the models where endogenous and dummy variables have the same lag lengths are considered. The null hypothesis of 36 lags versus 35 lags is tested. If the likelihood ratio exceeds the critical value for the x2 distribution, at 5% significance level, the null for the 35 lags can be rejected, and the model with 36 lags would be preferred. Otherwise, the null for 34 against the alternative of 35 lags is tested. The same procedure is repeated until a null hypothesis is rejected.

34. It is shown that AIC suggests 8 lags in the financial VAR and 36 lags in the monetary VAR, while on the other hand LR suggests up to 36 and 21 lags in the financial and monetary VAR respectively, while SIC implies that including 1 lag is even better for both systems.
35. Lutz Kilian, "Impulse Response Analysis in Vector Autoregression with Unknown Lag Order."
36. Eric Horent, An Empirical Analysis of the Macroeconomic Effects of Government Purchases.

TABLE 4— AIC, SIC and LR Statistics for Various Lag Lengths

	Financial VAR (1960M01-2000M12)			Financial VAR (1960M01-2000M12)		
Number of lag	AIC	SIC	LR	AIC	SIC	LR
0	-7.406757	-6.582698	NA	-6.188355	-5.154554	NA
1	-28.07865	-26.81086*	9085.964	-26.14461	-24.55414*	6398. 342
2	-28.37954	-26.66803	220. 9674	-26.26522	-24.11810	127. 3961
3	-28.50133	-26.34610	141. 9524	-26.33706	-23.63328	109. 7788
4	-28.48635	-25.88740	82. 96758	-26.26854	-23.00809	65. 82591
5	-28.52532	-25.48264	103. 5194	-26.28649	-22.46938	89. 17110
6	-28.51173	-25.02533	80. 72046	-26.28649	-21.91272	81. 95772
7	-28.56804	-24.63791	106. 7733	-26.30366	-21.37323	84. 62167
8	-28.67460*	-24.30074	124. 2710	-26.28576	-20.79866	73. 09499
21	-28.34826	-18.20599	57. 76975	-26.45829	-13.73458	74. 42541*
22	-28.26722	-17.68123	38. 69207	-26.45844	-13.17807	49. 31751
35	-28.17330	-11.37516	38. 71227	-28.35452	-7.837544	49. 98234
36	-28.33299	-11.09113	68. 63871*	-28.63860*	-7.564961	40. 87790

* indicates selection of the criterion.

TABLE 5— AIC Values for Various Lag Lengths and Trend Specifications (FV)
Financial VAR (1960M01-2000M12)

Number of lag	No trend	Linear trend	Linear and quadratic trend
0	0.001422	-7.406757	-8.871593
1	-28.01935	-28.07865	-28.16509
2	-28.35311	-28.37954	-28.44960
3	-28.46500	-28.50133	-28.55322
4	-28.44977	-28.48635	-28.55049
5	-28.48763	-28.52532	-28.58268
6	-28.48231	-28.51173	-28.56402
7	-28.51179	-28.56804	-28.60942
8	-28.60547	-28.67460	-28.70526**

** indicates selection of the criterion.

This section provides evidence as to which optimal lag length and time trend specification would be best used to estimate the systems under study. In what follows, as suggested by the AIC, in Tables 5 and 6 we consider a linear trend in both VARs.[37] Eight lags for macroeconomic variables and financial dummy variables are used in estimating the financial VAR. We use up to 36 lags for the monetary VAR, and include a constant term and seasonal dummy variables in our estimation.

TABLE 6— AIC Values for Various Lag Lengths and Trend Specifications (MV)
Monetary VAR (1969M01-1996M12)

Number of lag	No trend	Linear trend	Linear and quadratic trend
0	0.001422	-7.406757	-8.871593
1	-28.01935	-28.07865	-28.16509
2	-28.35311	-28.37954	-28.44960
3	-28.46500	-28.50133	-28.55322
4	-28.44977	-28.48635	-28.55049
5	-28.48763	-28.52532	-28.58268
6	-28.48231	-28.51173	-28.56402
7	-28.51179	-28.56804	-28.60942
8	-28.60547	-28.67460	-28.70526**

** indicates selection of the criterion.

ECONOMETRIC EVIDENCE

Our previous discussion neglect an obvious question as to whether the studied shocks are exogenous or not.[38] In our study we have two kinds of shocks: monetary shocks and financial shocks. Despite the fact that the exogeneity of monetary policy can be tested using standard methods, the exogeneity of any dummy variable is likely more problematic. Leeper suggests constructing a logit equation in order to establish the binary variable's exogeneity.[39]

37. The inclusion of a quadratic time trend in VAR systems does not significantly change results.
38. There are various notions of exogeneity and different ways to test for it. Indeed, exogeneity, predetermination and causality are three quite different things. Tests for causality can be used to refute or not strict exogeneity but not to establish it.
39. Eric M. Leeper, "Narrative and VAR Approaches to Monetary Policy."

In order to understand the difference between the two methods, we consider the following VAR model:

$$Y_t = a_0 +_{i=1}^{p} \beta_i Y_{t-i} +_{j=1}^{q} \alpha_j X_{t-j} + U_t \tag{1}$$

where X_t is avector of exogenous variables, with the crucial condition being that $E(U_t \mid \{Y_{t-i}\}_{i=1}^{\infty}, \{X_{t-j}\}_{j=1}^{\infty})$ Next, assuming a VAR presentation for X_t itself, i.e.

$$X_t = b_0 +_{i=1}^{r} \lambda_i X_{t-i} + V_t, \text{with } E(V_t \mid \{Y_{t-i}\}_{i=1}^{\infty}, \{X_{t-j}\}_{j=1}^{\infty}) = 0, \tag{2}$$

which reduces to a VAR(p) representation, assuming that $r = q = p$,

$$\begin{pmatrix} Y_t \\ X_t \end{pmatrix} = \begin{pmatrix} a_0 \\ b_0 \end{pmatrix} + \begin{pmatrix} \beta_1 & \alpha_1 \\ \mu_1 & \lambda_1 \end{pmatrix} \begin{pmatrix} Y_{t-1} \\ X_{t-1} \end{pmatrix} + \ldots + \begin{pmatrix} \beta_p & \alpha_p \\ \mu_p & \lambda_p \end{pmatrix} \begin{pmatrix} Y_{t-p} \\ X_{t-p} \end{pmatrix} + \begin{pmatrix} U_t \\ V_t \end{pmatrix}. \tag{3}$$

Here we assume that errors are i.i.d normally distributed that is

$$\begin{pmatrix} U_t \\ V_t \end{pmatrix} : i.i.d \ N[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \Sigma_{11} & \Sigma_{12} \\ \Sigma_{21} & \Sigma_{22} \end{pmatrix}].$$

We impose a restriction whereby $\mu_i = 0$ for $i = 1, ..., p$, implying that Y_t does not appear in the X_t equation or say Y_t does not Granger-cause X_t, which is a weak form of exogeneity. Strong exogeneity requires in addition to weak exogeneity that $\Sigma_{12} = 0$ and thus $\Sigma_{12} = \Sigma_{21} = 0$. In other words, this means that the error vectors U_t and V_t are independent. Testing for weak exogeneity is thus the first steep along the way. The null hypothesis is then given by $H_0 : \mu_1 = \mu_2 = ... = \mu_p = 0$. We then introduce the following variance-covariance matrix

$$\begin{pmatrix} \Sigma_{11} & \Sigma_{12} \\ \Sigma_{21} & \Sigma_{22} \end{pmatrix} = \begin{pmatrix} L_{11} & 0 \\ L_{21} & L_{22} \end{pmatrix} \begin{pmatrix} L_{11} & 0 \\ L_{21} & L_{22} \end{pmatrix}' = LL', \tag{4}$$

and test the null hypothesis of strong exogeneity, with the null given by $H_0 : L_{21} = 0$, which completes the standard approach testing for exogeneity.

The alternative is to use Leeper's method, whereby a logit equation is estimated for the dummy financial variable, in order to test its exogeneity.[40] Let X_t represent the list of independent macro variables. The expectation of the dummy financial variable (D_t), conditional on the information set Ω_t. The time t information set including variables dated in t-1 and earlier is then given by

$$E(D_t \mid \Omega_t) = F(\eta, \beta(L) X_t), \tag{5}$$

40. Eric M. Leeper, "Narrative and VAR Approaches to Monetary Policy."

where $F(.)$ is the logistic function, $\beta(L) = \beta_1(L) + \beta_2(L^2) + ... + \beta_m(L^m)$, L is the lag operator and η includes the constant and the time trend variables.

The methodology consists of estimating the logit equation including all macro variables for the financial dummy variable. We then compute the probabilities that the logit equation has the value one at the dates selected by Mishkin and White.[41]

TABLE 7— Estimation Results for Logit Equation
(Data: 1960M05-2000M12)

Variables	Coefficients Estimate	Standard Error	T-Statistic
Constant	8.94	198.96	0.04494
CRISIS{1}	-28.45	117.63	-2.42533e-06
CRISIS{2}	-22.04	916.97	-2.40463e-06
CRISIS{3}	-26.81	104.67	-2.56014e-06
Y{1}	24.75	72.86	0.33966
Y{2}	151.48	134.47	1.12650
Y{3}	-181.72	103.62	-1.75373
P{1}	387.46	347.54	1.11486
P{2}	30.74	505.52	0.06081
P{3}	-401.77	393.09	-1.02208
PC{1}	-32.78	43.86	-0.74730
PC{2}	-19.32	71.39	-0.27057
PC{3}	42.28	38.22	1.10627
R3{1}	-5.78	3.76	-1.53638
R3{2}	6.79	4.49	1.51061
R3{3}	-1.58	2.33	-0.67912
R10{1}	6.91	4.26	1.62379
R10{2}	-11.32	7.00	-1.61837
R10{3}	4.54	4.25	1.06788
TR{1}	104.54	175.57	0.59543
TR{2}	-532.80	261.65	-2.03631
TR{3}	417.46	180.61	2.31139

41. Frederic S. Mishkin and Eugene N. White, “U.S. Stock Market Crashes and Their Aftermath.”

The logit equation being considered here includes three lagged values of the dependant variable and a constant term, a time trend, as well as seasonal dummy variables. Table 7 displays the estimated coefficients using the logit equation. This equation appears to be imprecisely estimated and none of the individual coefficients is significant even at the ten percent significance level.[42] Table 8 shows the probability predicted by the logit equation, and Figure 2 plots the predicted value against the actual value for the dummy variable.

TABLE 8— Conditional Expectation Computed from the Logit Equation
(Data: 1960M01-2000M12)

Episodes' Date	Predicted Probability (percent)
1962M04	10.02
1970M05	23.59
1973M11	51.55
1987M10	11.52
1990M08	2.57
2000M04	81.77

The conditional expectation for the last financial crisis (2000M04) is puzzling. The predicted probability for this event is 81.77%, implying that the financial crash, which is believed to be unexpected, was predictable by the historical data. This result has to be taken with precaution, given that the logit equation is imprecisely estimated and the value of parameters might affect the predicted probability.[43] We therefore conclude that the logit approach does not help in providing evidence about the financial variable's exogeneity.[44]

Following Leeper, we consider an alternative approach based on two linear systems in which the dummy variable is entered in the VAR as an endogenous variable, and then

42. Including more than 3 lagged values for the macro variables leads to non-convergence even when the seasonal variables are not included in the logit estimation. Similarly, Leeper (Eric M. Leeper, "Narrative and VAR Approaches to Monetary Policy") includes 18 lags for the endogenous variables when estimating the VAR, but only 6 lags when estimating the logit equation.
43. Considering two lags in the logit equation decreases the conditional expectation for the last financial crisis (2000M04) to 13.09.
44. Horent (Eric Horent, An Empirical Analysis of the Macroeconomic Effects of Government Purchases) presents the same evidence about this approach when studying the Ramey and Shapiro (Valerie Ann Ramey and Matthew D. Shapiro, "Costly Capital Reallocation and the Effects of Government Spending," National Bureau of Economic Research, Working Papers # 6283 (November 1997)) dummy variables.

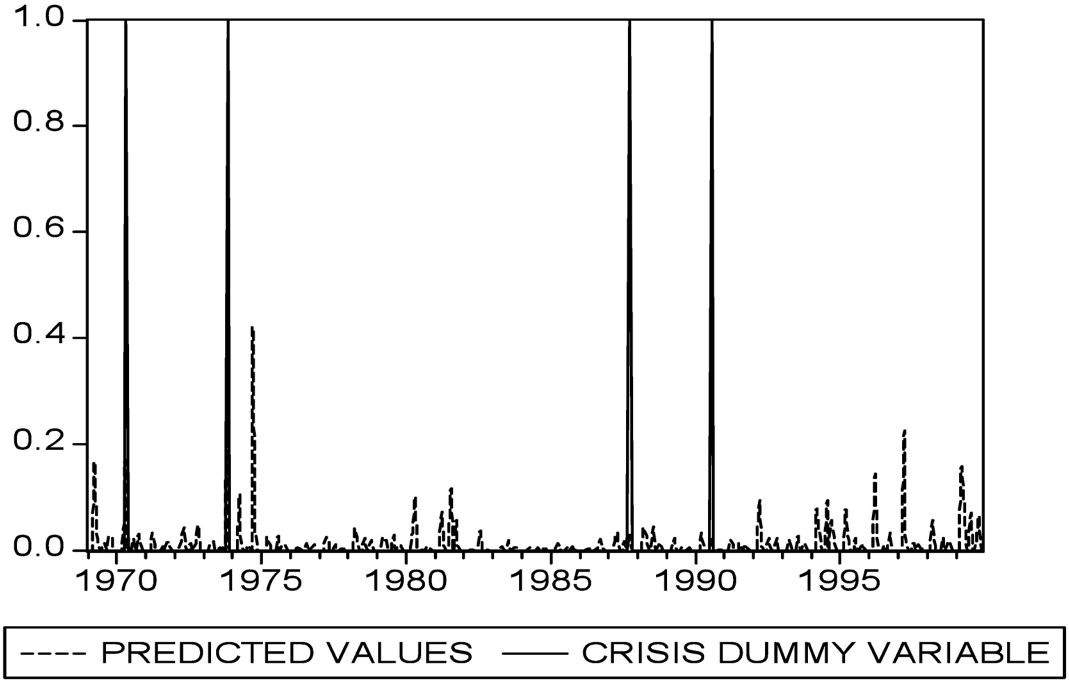

FIGURE 2— Predicted Values from Logit Equation Vs. Actual Dummy

identify the shocks to the financial variable by the Cholesky decomposition.[45] In the first VAR (named VARF1), the financial dummy is ordered first, output is ordered second, followed by price, interest rates (R3 and R10), price of commodities and finally total reserves plus a constant term, a time trend and seasonal variables being deterministic variables. It is assumed here that the shock to the financial dummy may have contemporaneous effects on the other variables. However, shocks to macro variables do not have the same effect on the financial dummy. This can suggest that the financial crises are independent of the current state of the economy.

In the second VAR (namely, VARF2), output is ordered first, price is ordered second, followed by the price of commodities and total reserves. The financial dummy is ordered fifth and the interest rates (R3 and R10) are ordered last. The assumption behind this ordering is that shocks to output, price, price of commodities and total reserves have a contemporaneous effect on shocks to the financial crisis variable. The shocks to the dummy variable have contemporaneous effects only on interest rate innovations.

45. Eric M. Leeper, "Narrative and VAR Approaches to Monetary Policy." Leeper points out some potential problems with the VAR systems including dummy variables as endogenous. Indeed, the predicted value for the dummy variable may lie outside the [0,1] interval, and regarding the dichotomous nature of the dummy, the relation between this and other system variables may be not linear. In our empirical study, the predicted value for the financial dummy variable, computed for the financial VAR, lies within the [0,1] interval.

As highlighted by Horent, it is difficult to justify the last assumption.[46] Indeed, assuming that shocks to the financial dummy have contemporaneous effects on some macro variables and not on others is a strong assumption. However, if the dummy variable is truly exogenous, the impulse response functions (IRF) computed using the VAR in which the dummy variable is endogenous should not be affected by the ordering of innovations in the Cholesky decomposition.

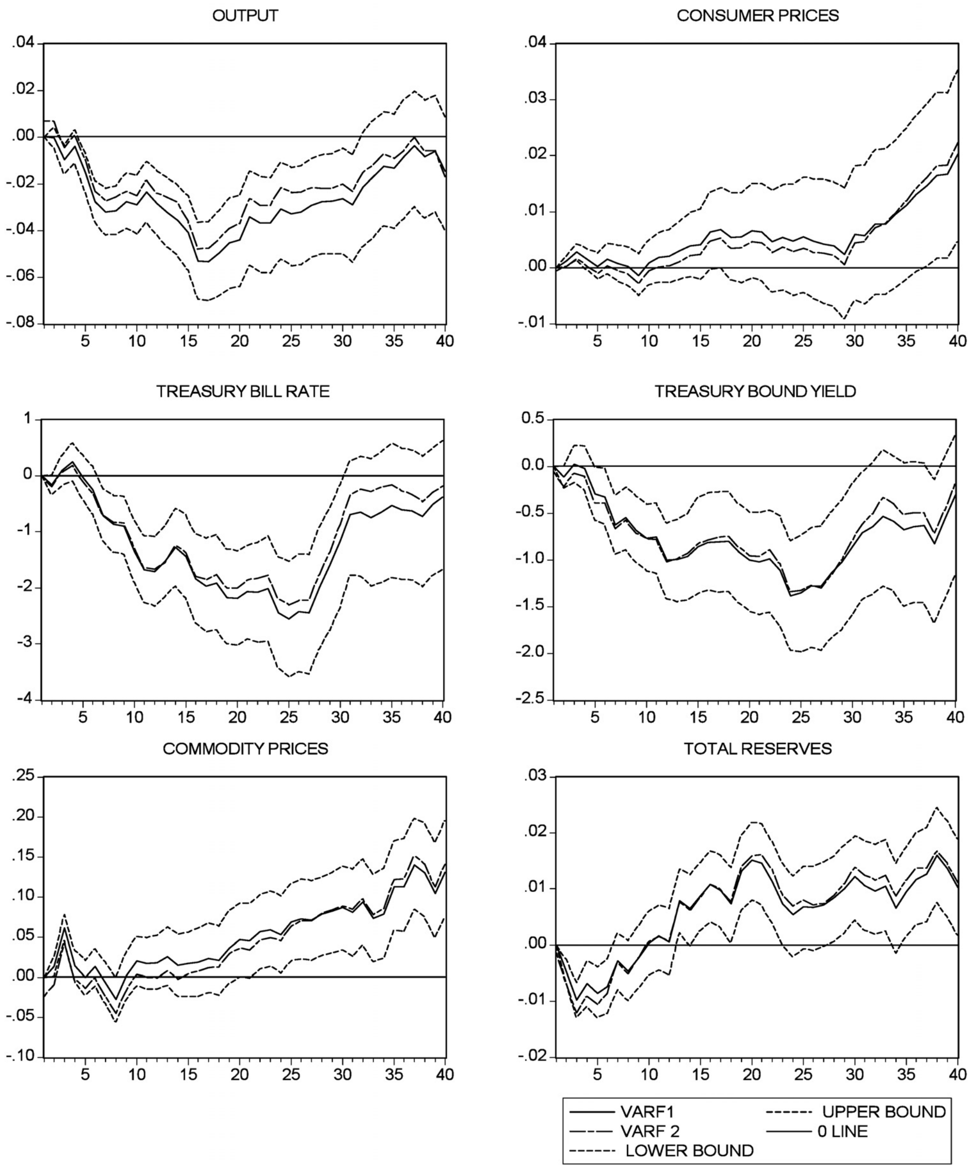

FIGURE 3— Responses to Unit Shock in Stock Market Crisis with Cholesky Decompositions

46. Horent study (Eric Horent, An Empirical Analysis of the Macroeconomic Effects of Government Purchases) analyzes the Ramey and Shapiro (Valerie Ann Ramey and Matthew D. Shapiro, "Costly Capital Reallocation and the Effects of Government Spending") dummy variable.

Figure 3 shows the impulse response functions (IRFs) to a unit shock in stock market crisis computed from VARF1 and VARF2. IRFs are then plotted for output, price, interest rates R3 and R10, price of commodities and total reserves using the Cholesky decomposition. The solid lines display the IRFs when VARF1 is estimated and the dashed lines are for VARF2. The confidence intervals are computed using 2500 replications of the Monte Carlo experiments, using the VARF1.

All the IRFs computed for both VARs lie within the confidence intervals from the financial VAR, and the IRFs from VARF1 and VARF2 exhibit very similar patterns. Even though the ordering in the Cholesky decomposition does not affect the IRFs computed, overall the point estimates of the IRFs computed for VARF1 are close to the corresponding point estimates reported for VARF2.

The two linear systems are estimated following the methodology used in Leeper to examine the exogeneity of the financial crisis variable, where this dummy is entered as an endogenous variable, using the Cholesky decomposition with different ordering for each VAR, and then computing IRFs.[47] This suggests that the financial collapses are exogenous,[48] which leads to conclude that the results reported for the linear systems are consistent with the fact that the financial crisis episodes are exogenous.

TABLE 9— LR Test for Weak Exogeneity of Monetary Shocks
Joint Weak Exogeneity Test

	Value
Log Likelihood For restricted VAR	-786.4347
Log Likelihood For unrestricted VAR	-786.4344
LR Statistic	0.0006
Critical Value at 5% level ($x^2(90)$)	113.1

The standard method is used to test the exogeneity of the monetary policy shocks. Table 10 presents the results on Granger causality test, showing that apart from the interest rates (R3 and R10) and total reserves (TR), we cannot reject the null hypothesis of the no causality. Causality in the Granger sense at 5% significance level cannot be established between macro variables and the monetary policy shocks.

47. Eric M. Leeper, “Narrative and VAR Approaches to Monetary Policy.”
48. As mentioned by Horent (Eric Horent, An Empirical Analysis of the Macroeconomic Effects of Government Purchases), introducing a logit equation in a linear system and replacing the linear equation for a dummy variable leads to a lack of significance while using this non-linear system. Results with this substitution are not presented here.

TABLE 10— Granger Causality Test
Monetary Policy Shocks (Data: 1969M01-1996M12)

Null Hypothesis	F-Statistic	Probability
Monetary Shock does not Granger Cause Y	2.99482	0.00016
Y does not Granger Cause Monetary Shock	1.35341	0.16842
Monetary Shock does not Granger Cause P	1.40780	0.14084
P does not Granger Cause Monetary Shock	1.62567	0.06514
Monetary Shock does not Granger Cause R3	5.40863	8.1E-10
R3 does not Granger Cause Monetary Shock	1.82960	0.02962
Monetary Shock does not Granger Cause R10	2.57655	0.00114
R10 does not Granger Cause Monetary Shock	2.80366	0.00039
Monetary Shock does not Granger Cause PC	0.39860	0.97907
PC does not Granger Cause Monetary Shock	1.07133	0.38207
Monetary Shock does not Granger Cause TR	2.12530	0.00865
TR does not Granger Cause Monetary Shock	1.99577	0.01500

As was mentioned above, we estimate two VARs in order to test for weak exogeneity. In this model we impose the restriction that the macroeconomic variables do not appear in the monetary shock equation, so that all the coefficients μ_t are equal to zero.[49] Using LR statistics show that the null hypothesis cannot be rejected at the 5% significance level (not even at the 1%) as shown in Table 9. In this case the monetary policy variable seems to be weakly exogenous.

49. Dependant variable lags are entered as explanatory variables in the monetary variable equation (the restricted VAR), along with constant term, time trend and seasonal variables.

Furthermore, using the Cholesky decomposition we conclude that the new monetary policy shock measure is exogenous, even when including more macro variables compared to what has been used in the Romer and Romer study.[50] Indeed for the two VARs, Figure 4 shows impulse responses for output, price, interest rates R3 and R10, price of commodities, and total reserves. In the first VAR (named VARM1 with solid line in Figure 4), the monetary policy variable is ordered first, followed by the macro variables. These suggest independence between monetary policy measures and the current innovations on macro variables. In the second VAR (VARM2 with long dashed lines in Figure 4), output is ordered first for the Cholesky decomposition, and then prices, commodity prices, total reserves, monetary shock, and finally the interest rates R3 and R10. Using the same assumptions as in the financial VAR, the innovations of output, price, commodities and total reserves have a contemporaneous effects on monetary policy, while the monetary shocks have contemporaneous effects on interest rates innovations only.

The IRF for output (in Figure 4) computed using VARM2 lies slightly above the 68% confidence interval computed with the monetary VAR (VARM1) for 8 periods.[51] Then it lies very slightly below the lower bound for the next 18 periods after the shock. After that it lies within the confidence interval. The IRF for consumer prices lies below the confidence interval just after 19 periods. The response of R3 interest rate computed from VARM2 lies above the upper bound for 7 months and then lies within the confidence interval until period 16. The same response is displayed by the R10 rate. The IRF for PC and TR lies slightly below the confidence interval for almost all periods.

However, the point estimates of the IRFs computed for the second linear system are close to the corresponding point estimates reported for the first linear system and the patterns for the two VARs (with different Cholesky ordering) are quite similar for all variables. Overall, the IRFs reported for the monetary policy shock are consistent with the new monetary measure being exogenous. Thus, as mentioned by Romer and Romer, the monetary policy shock is relatively free of both the endogenous and anticipatory actions of the monetary authorities.[52]

50. Christina D. Romer and David H. Romer, "A New Measure of Monetary Shocks: Derivation and Implications." The specification used by the authors includes industrial production, the PPI for finished goods and the new monetary policy measure to assess this view.
51. 2500 Monte Carlo replications of VARM1 are used to compute the 68% confidence interval.
52. Christina D. Romer and David H. Romer, "A New Measure of Monetary Shocks: Derivation and Implications."

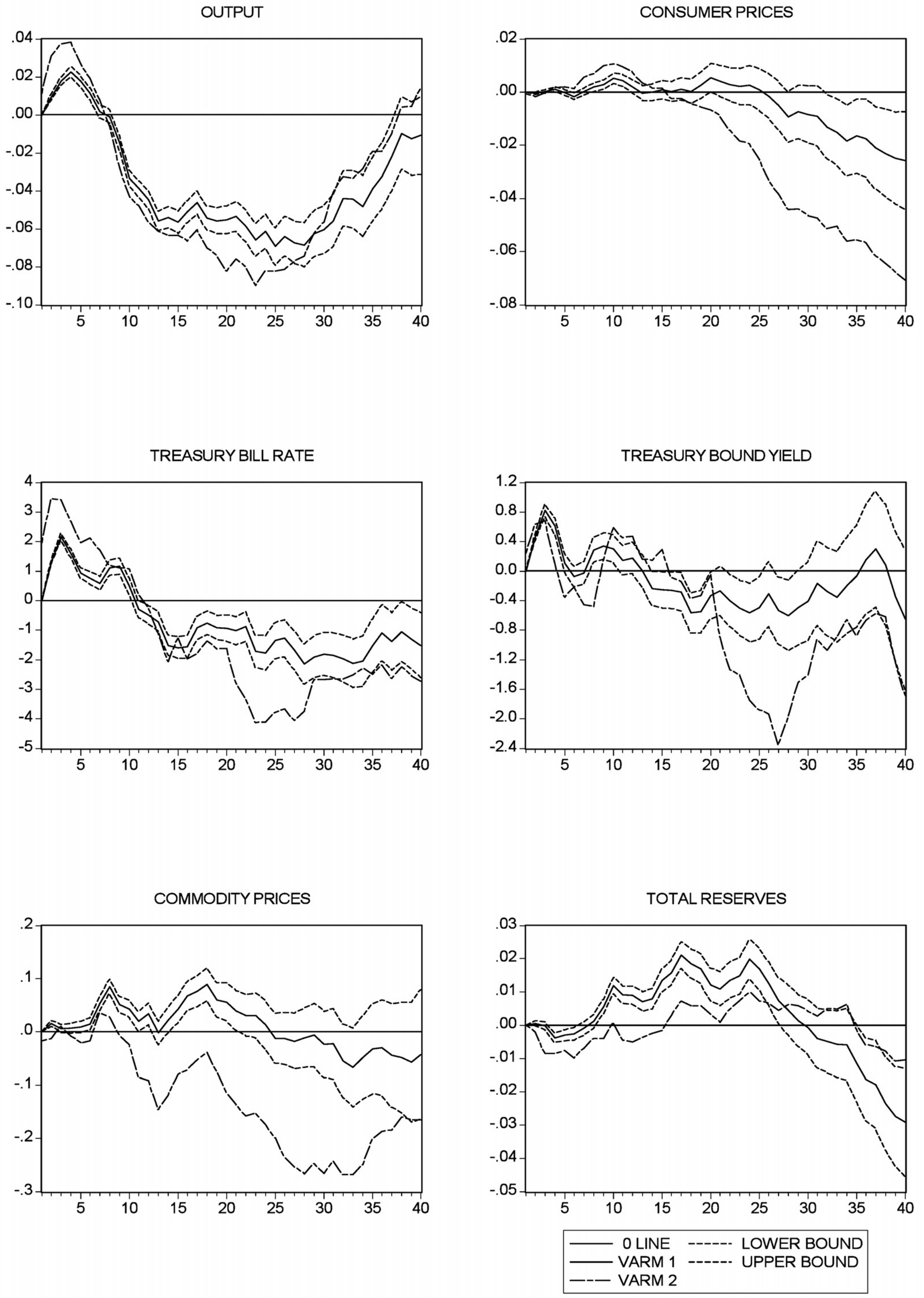

FIGURE 4— Responses to Monetary Shock with Cholesky Decompositions

The impulse response to a unit shock to the dummy variable traces out the average effects on output and other macro variables of the financial crisis shocks and monetary policy measures in the VAR systems. Results from financial VAR estimates are shown in Figure 5. The responses to a unit shock on financial crisis innovations are plotted, along with their standard error bounds, computed using 2500 Monte Carlo replications. The output response is characterized by a decline, reaching its maximum (-5.8%) at month 16 after the shock and then returning to its initial level. This response is in line with what was found by previous studies including Leeper, Sims, Litterman and Weiss and others regarding the impact of monetary policy contractions on production.[53] They argue that there is evidence that these perturbations can reduce nominal aggregate demand and lower output when prices adjust sluggishly.[54] However, there is only one direct link between stock market collapses and monetary policy through the financial instability as pointed out in Mishkin and not all crashes are followed by signs of financial instability.[55]

The consumer prices' impulse response implied by the financial VAR is small and insignificant for the first 10 months, and then becomes more significant, although modestly positive. The responses to interest rates are negative for almost all periods. The Treasury Bill rate (R3) rises for the 3 first periods, falls rapidly to reach its maximum decline (-2.2 points) at month 25 and then returns slowly to its initial value. The response of Treasury bond yield (R10) is negative with a maximum effect of -1.3 points at period 24. The IRF for commodity prices rises by 55% for the first 2 months and then begins to fall, reaching its maximum decline (-2%) at month 8 and then becoming positive after period 10. After period 12 the IRF for total reserves shows a small positive value but a consistent response.

Plotted in Figure 6 are macro variable responses to a unit shock to the monetary policy variable. Solid lines show point estimates and short dashed lines are standard error bands, computed with 2500 Monte Carlo experiment replications. The output response increases for three periods then it falls. The maximum decline is about 3.5%,

53. Eric M. Leeper, "Narrative and VAR Approaches to Monetary Policy"; Christopher A. Sims, "Comparison of Interwar and Postwar Business Cycles: Monetarism Reconsidered," *The American Economic Review*, *70/2* (May 1980), pp.250-257; and, Robert B. Litterman and Laurence Weiss, "Money, Real Interest Rates, and Output: A Reinterpretation of Postwar U.S. Data," *Econometrica*, *53/1* (January 1985), pp.129-156.
54. Ben S. Bernanke and Alan S. Blinder, "The Federal Funds Rate and the Channels of Monetary Transmission," *The American Economic Review*, *82/4* (September 1992), pp.901-921.
55. Frederic S. Mishkin, "The Causes and Propagation of Financial Stability: Lessons for Policymakers," in *Maintaining Financial Stability in a Global Economy: A Symposium Sponsored by the Federal Reserve Bank of Kansas City, Jackson Hole, Wyoming, August 28-30, 1997* (Kansas City: Federal Reserve Bank of Kansas City, [1997]), pp.55-96; and, Frederic S. Mishkin and Eugene N. White, "U.S. Stock Market Crashes and their Aftermath."

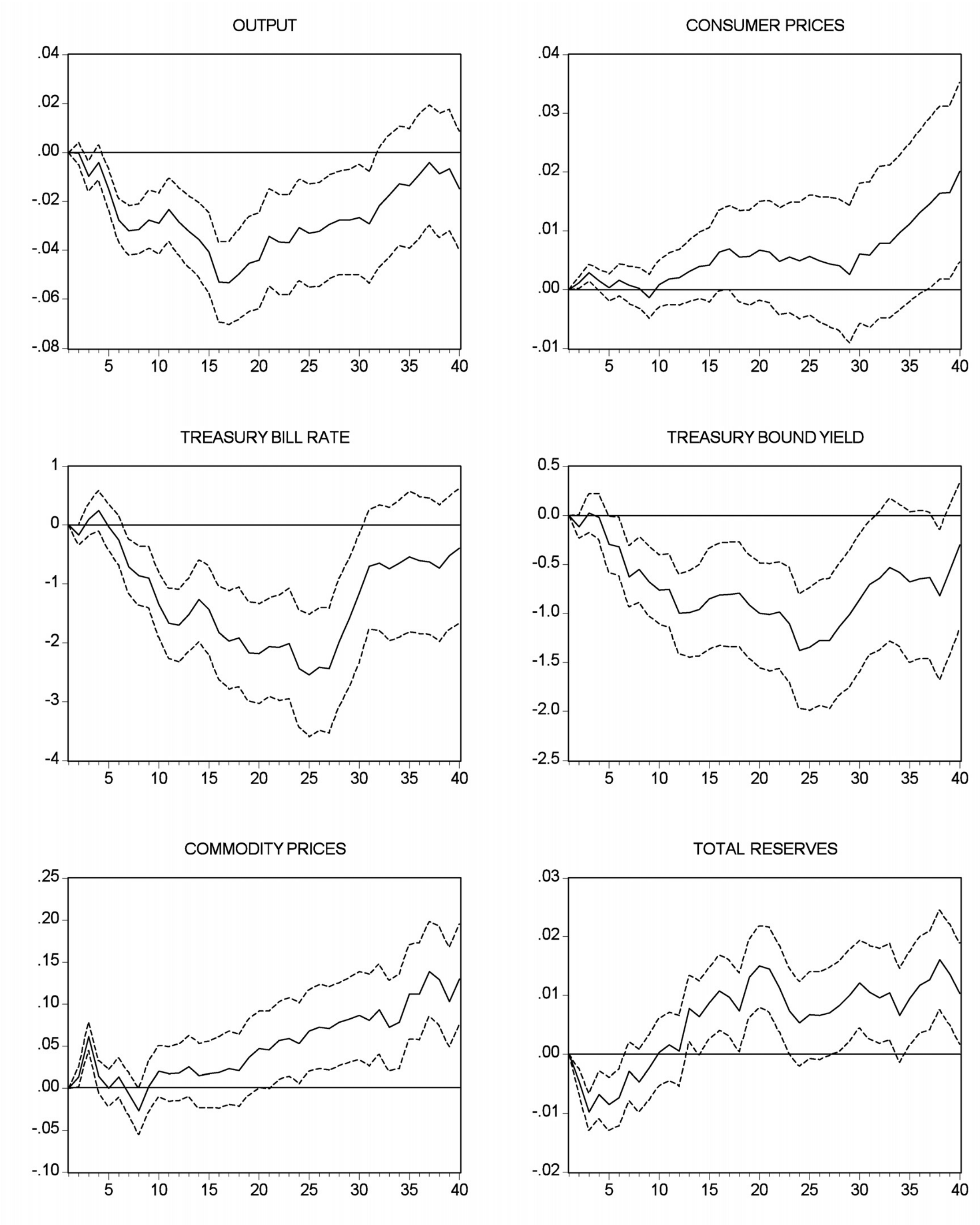

FIGURE 5— Responses to a Unit Shock on Stock Market Crisis Innovations

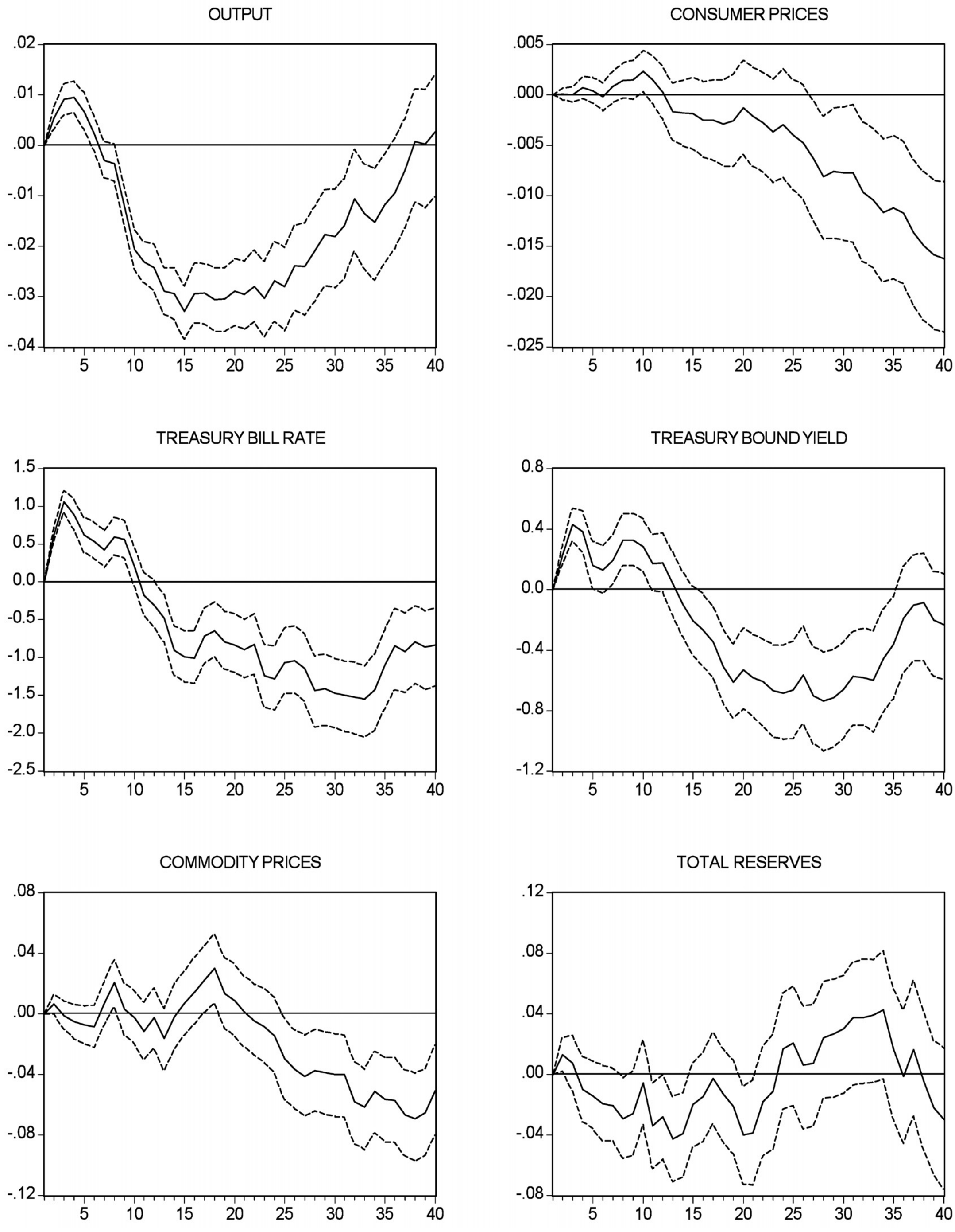

FIGURE 6— Responses to a Unit Shock on Monetary Policy Innovations

and is attained at month 15. It returns back to its initial level afterward. Romer and Romer found that the output response reach its peak effect at about -2.9%.[56]

The response of the consumer price is similar to that reported in the Romers study. Indeed, the IRF of this price is small, irregular for 12 periods and then negative. The IRF computed for interest rates responding to a unit monetary policy shock are quite standard. They are positive for the first 12 periods, reaching 1 point at a maximum increase for R3, and after that reverting to negative values. The IRF for R10 is similar to the R3 response for the 14 first periods, then they become negative and fairly flat. The commodity prices show an irregular response until period 22 when it become negative. While total reserves response rises for the first 2 periods, then becomes negative and irregular until month 23, and finally falls sharply to become negative and slowly returns toward its initial level.

Figure 7 shows impulse responses to a one unit shock to the innovations of the financial dummy variable when treated as exogenous. The responses are generally similar to those reported for the financial VAR when the dummy variable is treated as endogenous, apart from the magnitudes which are more important when financial collapses are estimated exogenously in the VAR system.

The same conclusion applies when the monetary policy variable is treated as exogenous. Figure 8 displays the IRFs for the variables in the monetary VAR. The responses are relatively similar to those reported early (in Figure 6), confirming the view that both of these variables (the monetary policy and stock market crisis variables) are exogenous.

In conclusion, the effect of monetary policy and stock market crisis variables on real economic activity is extensive and statistically significant. About the same results are obtained by Romer and Romer in their VAR analysis which includes only 3 macro variables.[57] This is somehow consistent with the idea that monetary policy shock has a temporary negative and persistent effect on output, as implied by the impulse responses obtained by structural VAR systems.[58] The hump-shaped short-run output dynamics following

56. Christina D. Romer and David H. Romer, "A New Measure of Monetary Shocks: Derivation and Implications." However, the inclusion of more macro variables leads to a change in the output response, increasing it to a positive value through month 37. The output returns to its initial value in the same way as in the Romers study.
57. Christina D. Romer and David H. Romer, "A New Measure of Monetary Shocks: Derivation and Implications." The Romers basic VAR includes only output, CPI price and the monetary policy measure as endogenous variables.
58. See Ben S. Bernanke and Alan S. Blinder, "The Federal Funds Rate and the Channels of Monetary Transmission"; Christopher A. Sims, "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy," *European Economic Review*, *36* (1992), pp.975-1011; Steven Strongin, "The Identification of Monetary Policy Disturbances Explaining the Liquidity Puzzle," *Journal of Monetary Economics*, *35/3* (June 1995), pp.463-497; Ben S. Bernanke and Ilian Mihov, "Measuring Monetary Policy," *The Quarterly Journal of Economics*, *113/3* (August 1998), pp.869-902; Fabio C. Bagliano

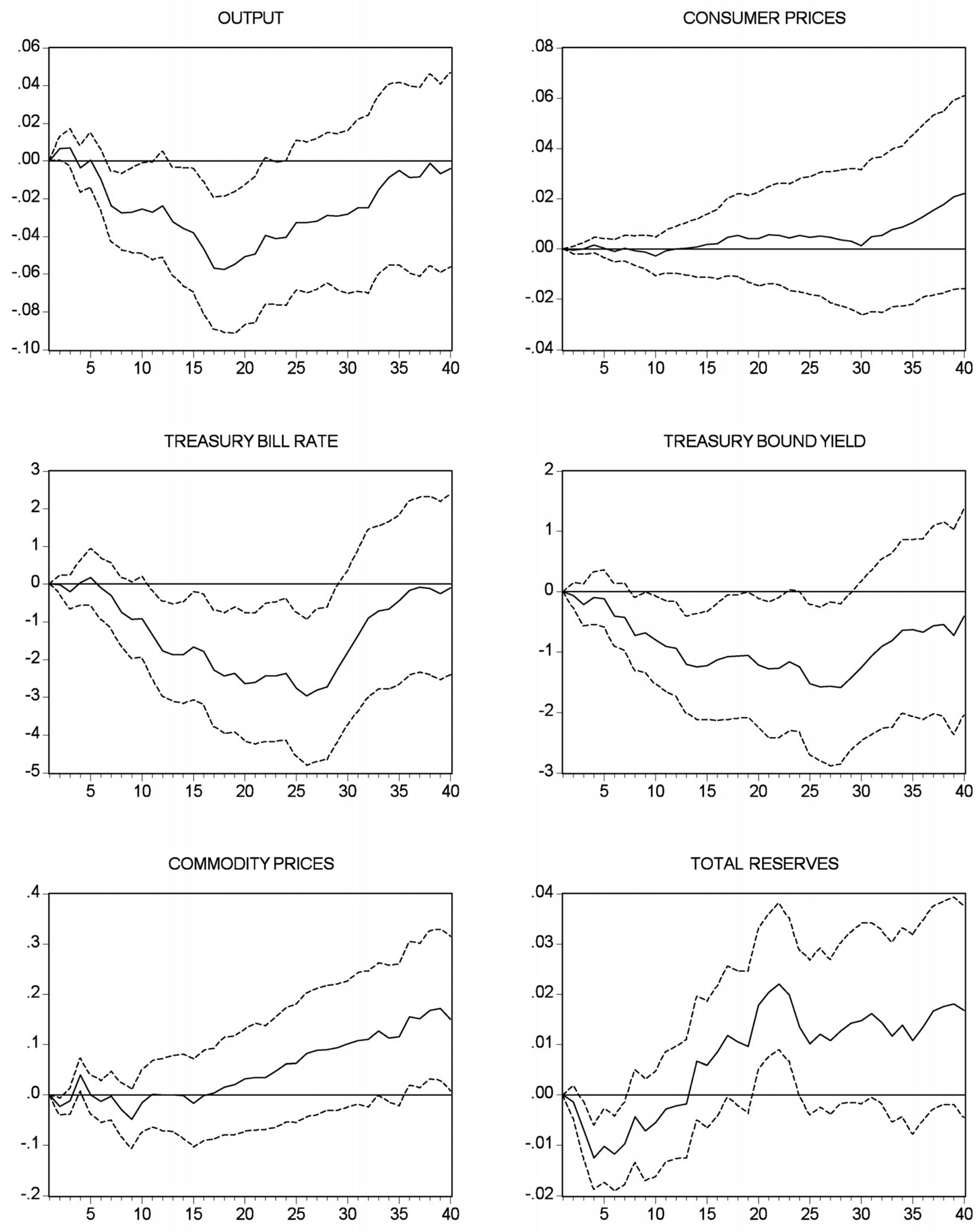

FIGURE 7— Responses to a Unit Shock on Stock Market Crisis Dummy (Dummy Variable Treated as Exogenous)

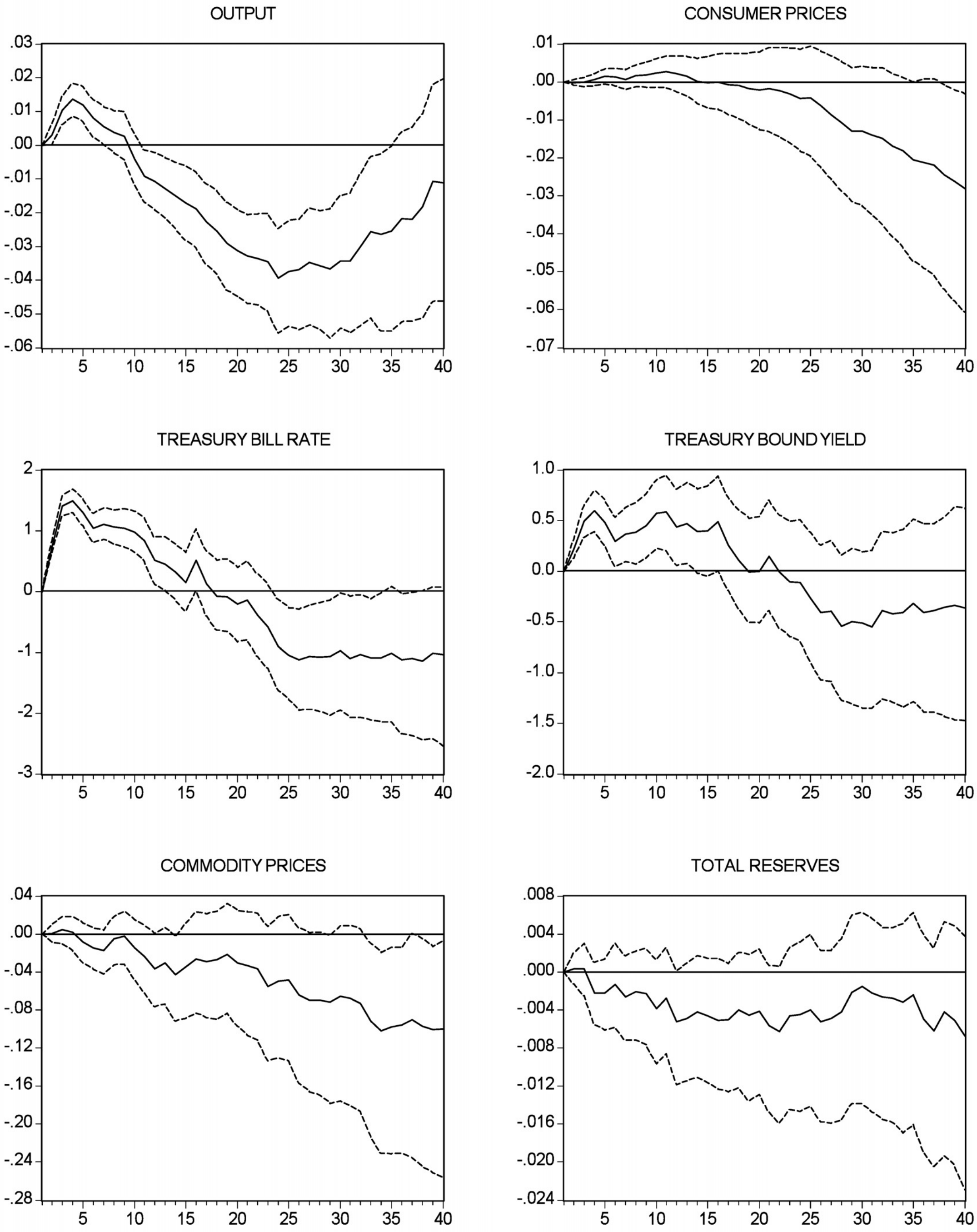

FIGURE 8— Responses to a Unit Shock on Monetary Policy Variable (Monetary Variable Treated as Exogenous)

monetary policy contractions and stock market collapses suggest that both shocks have real effects on economic activity. As such, monetary authorities have to take these facts into account when developing an optimal policy.

Monetary policy and financial crisis episodes may be characterized not only by a shock to monetary policy or financial sector collapse, but also by non-systematic changes in other sectors of the economy, say by other exogenous shocks. We therefore examine the effects that other shocks may have on the results reported for the two main shocks considered here (monetary and financial shocks).

The model constructed includes Hamilton's oil price shocks.[59] Using the dates identified by Hamilton, updated by Hoover and Perez and also Ramey and Shapiro,[60] we construct a dummy variable that takes the value one at the shock dates: 1969M01, 1970M04, 1974M01, 1979M03, 1981M01 and 1990M03, and zero otherwise. VAR system includes the macro variables and three shocks (monetary, financial crisis and oil price shocks). Optimal lag length and an adequate time trend are also included. Thus, to examine the effects of exogenous shocks may have on early reported results, a VAR including these perturbations as exogenous variables is estimated.

Figure 9 shows point estimates of responses for output, consumer prices, interest rates (R3 and R10), commodity prices and total reserves. The solid lines display point estimates for the IRFs and dashed lines display the 68% confidence interval.

The IRFs presented when other exogenous shocks are included to estimate the financial VAR indicate that results reported for price, interest rates and relative commodity prices are not very affected. The output response falls persistently and then becomes flat, reaching -12% declines 3 years after the shock. The IRF for total reserves is negative for a whole period. Additionally, estimating a financial VAR with only two shocks, say the Hamilton oil price dummy and the financial crisis variables, suggests that macro variables responses

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and Carlo A. Favero, "Measuring Monetary Policy with VAR Models: An Evaluation," *European Economic Review*, *42/6* (June 1998), pp.1069-1112; and, Lawrence J. Christiano, Martin Eichenbaum and Charles L. Evans, "Monetary Policy Shocks: What Have We Learned and to What End?"

59. The Ramey and Shapiro (Valerie Ann Ramey and Matthew D. Shapiro, "Costly Capital Reallocation and the Effects of Government Spending") dummy variable is not included in the system because of data limitation (the Romer's monetary measure begin 1969M01). Indeed, the Korean War which was known to have important effects on macro variables cannot be included in our sample period. This loss of information can significantly affect our results.
60. James D. Hamilton, "Oil and Macroeconomy since World War II"; Kevin D. Hoover and Stephen J. Perez, 1994, "Post Hoc Ergo Propter Hoc Once More: An Evaluation of 'Does Monetary Policy Matter?' in the Spirit of James Tobin," *Journal of Monetary Economics*, *34/1* (August 1994), pp.47-73; and, Valerie Ann Ramey and Matthew D. Shapiro, "Costly Capital Reallocation and the Effects of Government Spending."

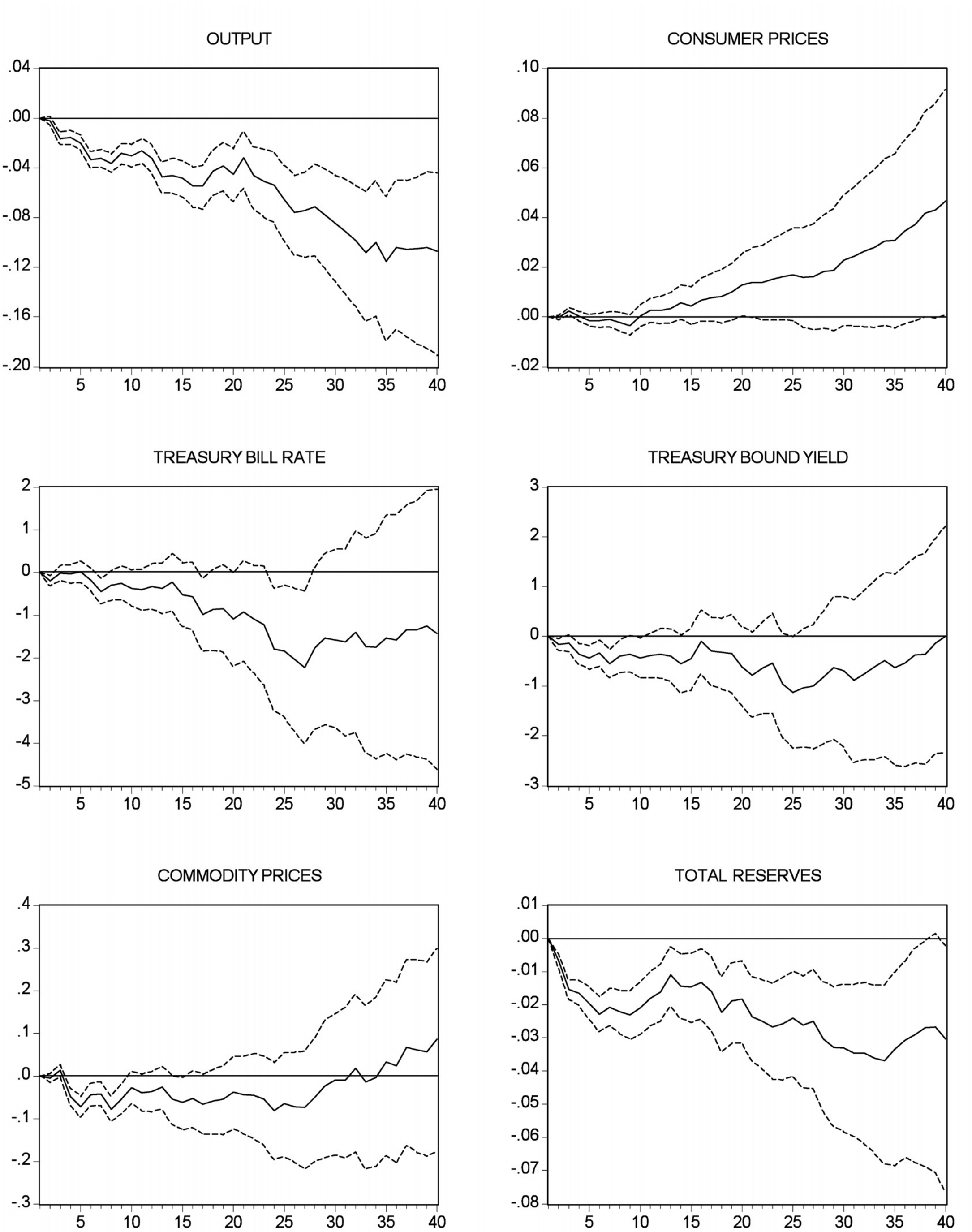

FIGURE 9— Responses to a Unit Shock on Stock Market Crisis Dummy (Financial VAR with Other Exogenous Shocks)

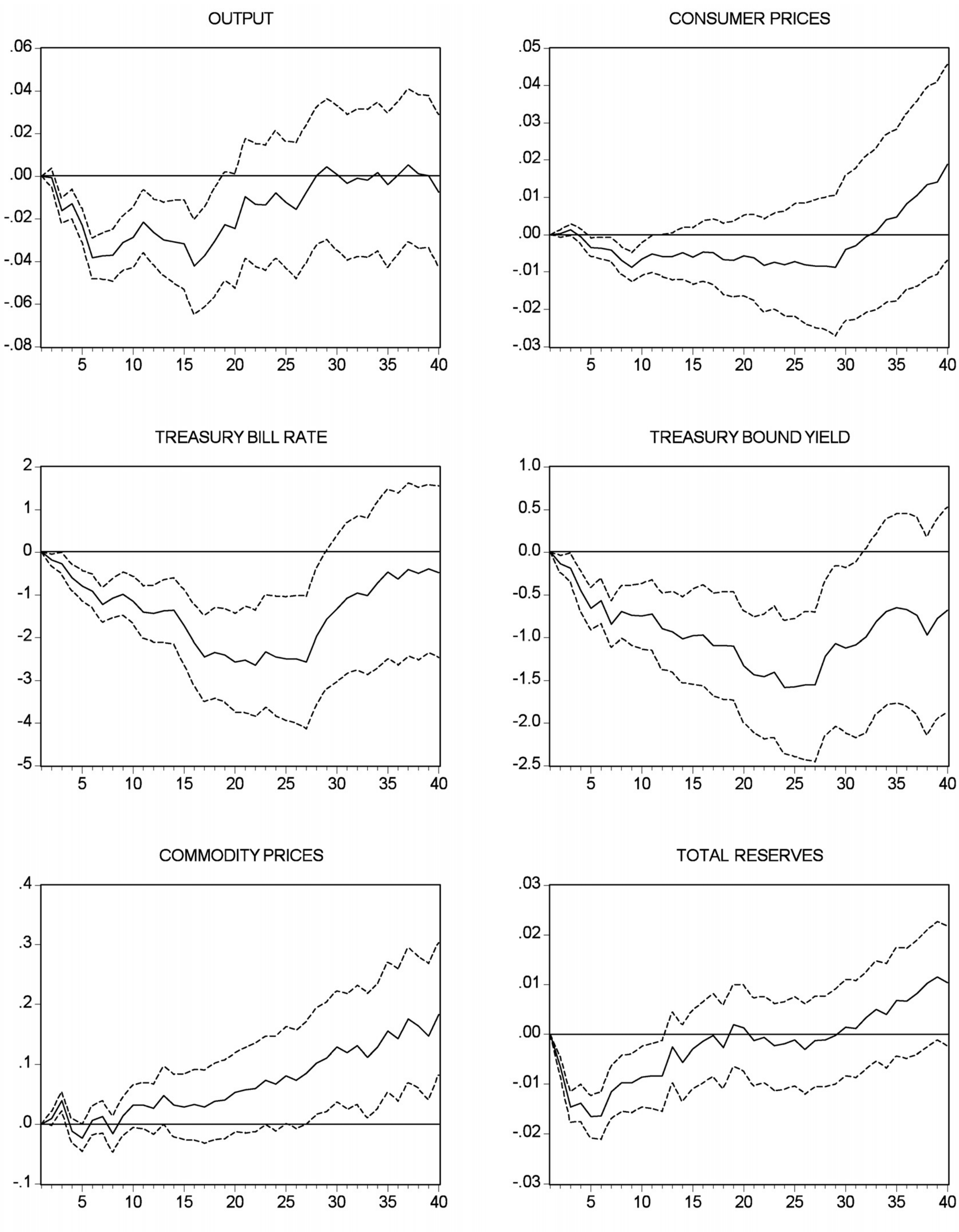

FIGURE 10— Responses to a Unit Shock on Stock Market Crisis Dummy (Financial VAR with Other Exogenous Shocks)

remain relatively unchanged. Indeed, Figure 10 shows that the output responses are the same as in the standard financial VAR until month 27, when it became insignificant. The price response is weakly negative, and then significantly positive through period 32. The responses for other variables are relatively the same as in the standard financial VAR.

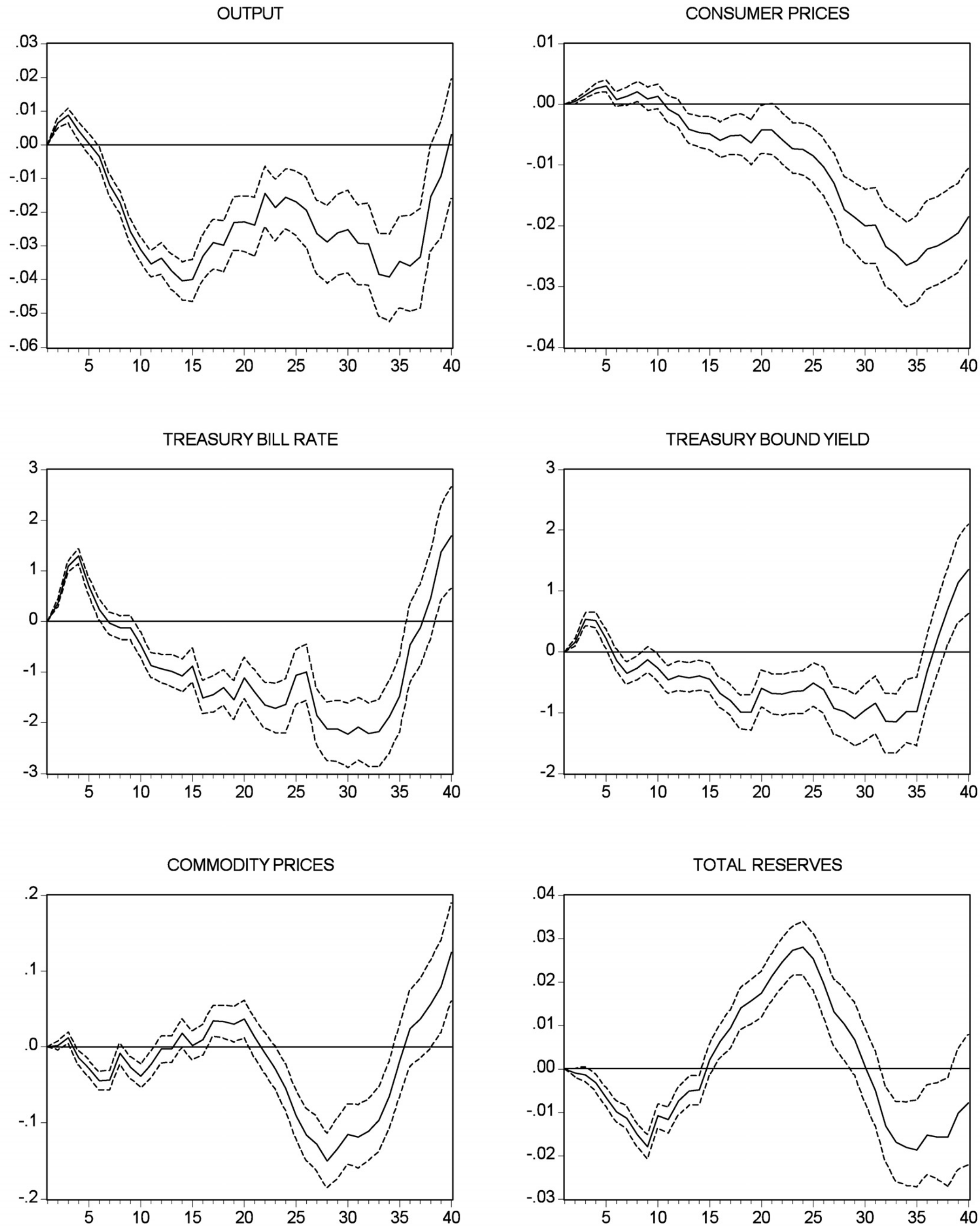

FIGURE 11— Responses to a Unit Shock on Monetary Policy Variable (Monetary VAR with Other Exogenous Shocks)

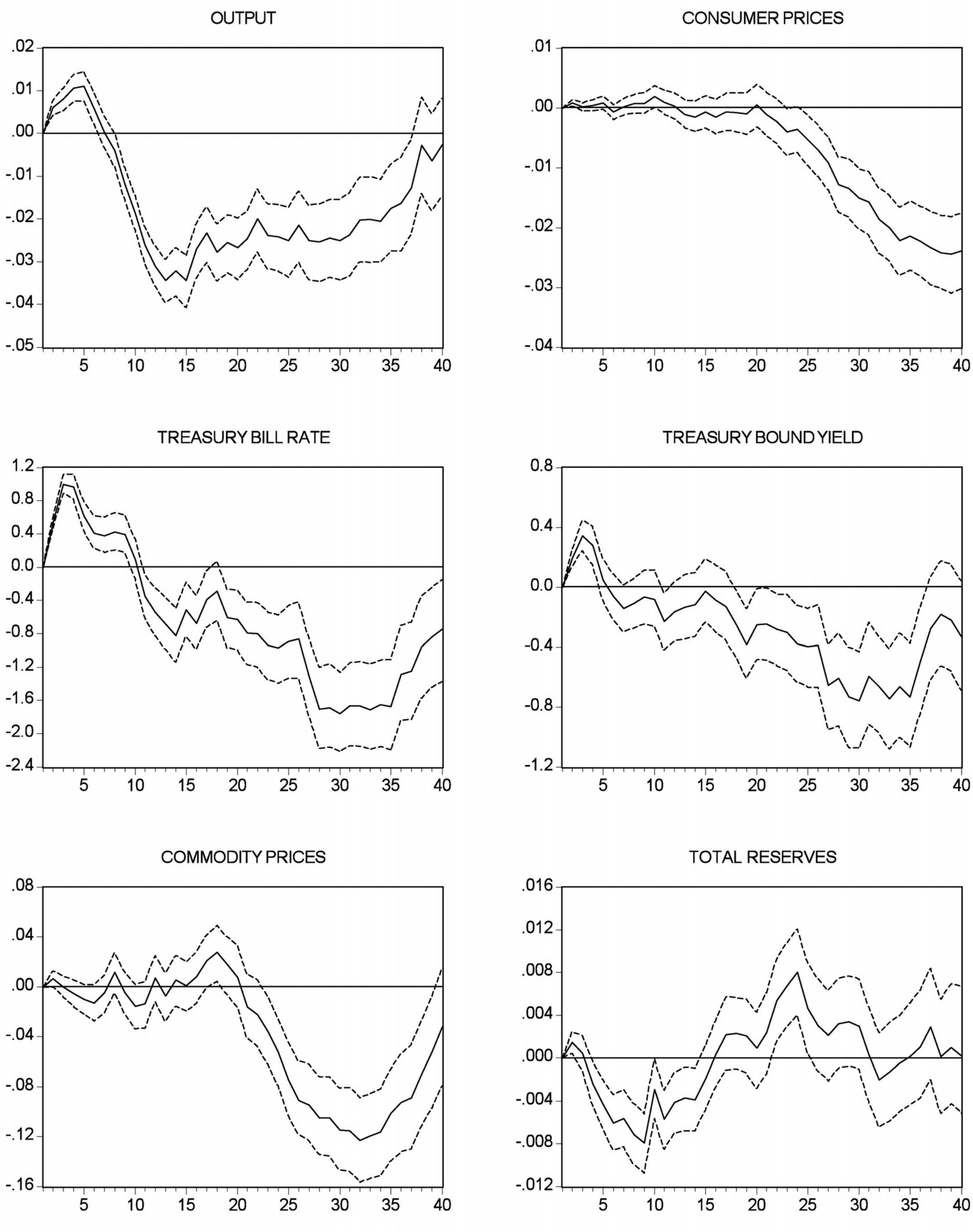

FIGURE 12— Responses to a Unit Shock on Monetary Policy Variable (Monetary VAR with Hamilton Oil Price Exogenous Shocks)

Furthermore, the magnitude of the effect of a shock to financial crisis is significantly similar to that reported for the standard financial VAR, and the pattern of the effect is very similar. Thus, it does not appear that the inclusion of other exogenous shocks substantially alters the results reported earlier. Figure 11 shows evidence on the effect of the Romer monetary policy variable in a model that alternatively includes financial crisis and oil price shocks as exogenous variables. The IRFs computed for output, price, interest rates, commodity prices and reserves are responses to a one unit shock on monetary policy variable. The solid lines display the point estimate and dashed lines display the 68% confidence interval. Figure 12 shows the IRFs from monetary VAR, including only the Hamilton oil price dummy, which was used in order to isolate the effects of this variable on the responses given by the monetary policy variable. All the IRFs computed for the monetary system including other exogenous shocks are relatively similar to those reported earlier for the standard monetary VAR, apart from the total reserves variable (for the system including all shocks), which becomes negative for a whole period. Thus it appears that this last variable is affected by the inclusion of all shocks in VAR estimates. Therefore, it is concluded that the results reported for the monetary policy system variable are not sensitive to the addition of other shocks, confirming the view that this shock is exogenous.

Furthermore, to investigate the impact of the size given to the financial crisis episodes, we construct a weighted financial variable to which we assign a different weight to each crash, following the classification given by Mishkin and White.[61] Indeed, the authors place them into four categories depending on whether or not the episodes appear to place (or not) stress on the financial system.[62] Figure 13 shows the IRFs computed for output, price, interest rates, commodity prices and reserves as responses to a one unit shock on a weighted financial variable. The patterns for the IRFs are relatively the same, which means that seemingly the size attributed to financial episodes alters results reported early in any substantial way

61. Frederic S. Mishkin and Eugene N. White, "U.S. Stock Market Crashes and Their Aftermath."
62. The classification is as follows:
   - Category 1: episodes 1962 and 2000 (weight = 1),
   - Category 2: episode 1987 (weight = 2),
   - Category 3: episode 1974 (weight = 4),
   - Category 4: episodes 1969-70 and 1990 (weight = 3).

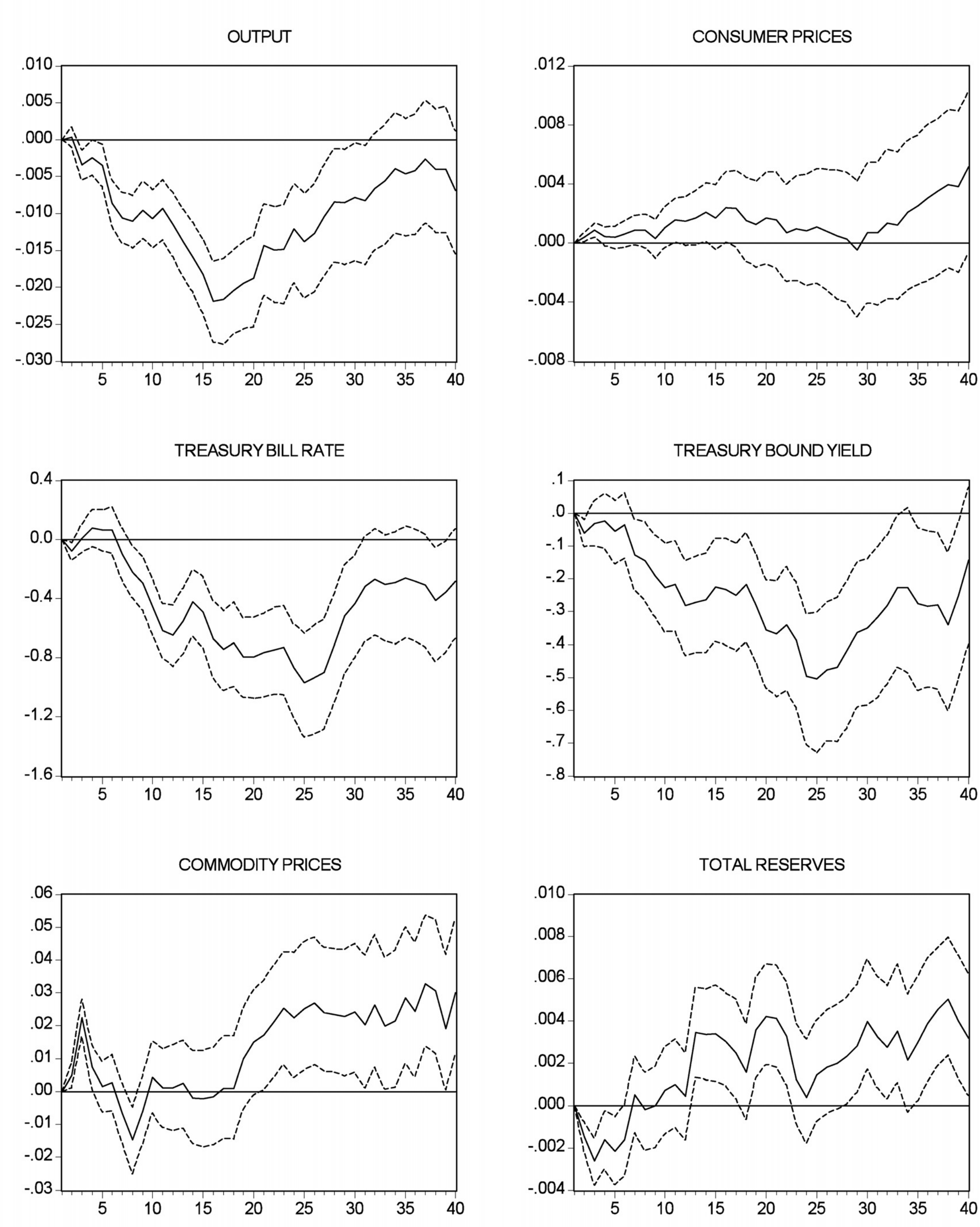

FIGURE 13— Responses to a Unit Shock on Weighted Stock Market Crisis Variable Innovations (Extended Financial VAR)

Conclusion

Many previous studies on the effects of monetary policy shocks on macroeconomics aggregates have used alternative methods of identifying these policy shocks and employed different VAR systems and sample periods in their analyses. Moreover, there has been recently considerable discussion regarding the appropriate monetary policy in the aftermath of a financial crisis. This suggests that there is a relation between monetary policy and financial stability, but there is still no clear consensus on how one affects the other. As pointed out in Mishkin and White,[63] the key problem facing monetary policymakers is not stock market crashes, but rather financial instability. Indeed, not all stock market collapses are associated with financial instability, for they can also arise from other sources such as a banking system crisis.

In this chapter we study the new monetary policy measure constructed by Romer and Romer in combination with a stock market crash measure based on dates highlighted by Mishkin and White, in order to test whether these shocks are exogenous.[64] The impulse response functions for the monetary and financial model reveal that monetary policy and financial shocks considered in this study have significant effects respectively on output, price level and on other variables.

Our results also show that even when including more macro variables than those used by Romers' study, the new measure is exogenous. Then, by applying the statistical methodology used by Leeper, we conclude that both shocks are truly exogenous.[65] This suggests that central banks must take the effects of financial collapse into account when conducting monetary policy, even when they're targeting price stability. The link between both targets is unclear at this point, and more research is needed in this direction.

Data Appendix

Data sources and definitions of variables: All macro data series are monthly and cover the period 1960:01 to 2000:12. The new measure of monetary shock is monthly and covers the period 1969:01 to 1996:12 (retrieved from Romer and Romer, "A New Measure of Monetary Shocks: Derivation and Implications").

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63. Frederic S. Mishkin and Eugene N. White, "U.S. Stock Market Crashes and Their Aftermath."
64. Christina D. Romer and David H. Romer, "A New Measure of Monetary Shocks"; and, Frederic S. Mishkin and Eugene N. White, "U.S. Stock Market Crashes and Their Aftermath."
65. Eric M. Leeper, "Narrative and VAR Approaches to Monetary Policy."

To avoid the complications introduced by the seasonal adjustment methods, the data we use here are in their non seasonally adjusted forms and we include monthly seasonal dummy in our VARs.

The industrial production data, used as output series (Y), are from the Board of Governors Web site (series B50001).

Consumer price index, all urban consumers are used as our price (P), from the Bureau of Labor Statistics Web site (series CUUR0000SA0).

The three-month Treasury bill rate used as short term interest rate (R3), quoted on discount basis, secondary market, average of business day, from Federal Reserve Board (Bank of St-Louis Web site), (series tbsm3m).

Ten-year U.S Treasury bond yield used as long term interest rate (R10), constant maturity, average of business day figure, from Federal Reserve Board (Bank of St-Louis Web site), (series tcm10y).

For Total reserves (TR), we use Board of Governors Monetary Base, Not Adjusted for Changes in Reserve Requirements, from Board of Governors of the Federal Reserve System (series BOGUMBNS).

Producer Price Index-Commodities, crude materials is used as commodity prices (PCM), from the Bureau of Labor Statistics Web site (series WPUSOP1000).