Jean Boivin and Marc Giannoni

Assessing Changes in the Monetary Transmission Mechanism: A VAR Approach

1. Introduction

Several authors have documented a reduced variability of output and inflation in the United States since the beginning of the 1980s.[1] In fact, a comparison of the 1980:1-2001:2 period with the two preceding decades shows that the standard deviation of quarterly output growth has fallen 30 percent, while the standard deviation of inflation has decreased more than 40 percent. These changes in the time series properties of output and inflation raise a number of important questions for policymakers. For instance, has this increased stability been associated with an alteration of the transmission of monetary policy due, for example, to changes in the behavior of consumers, firms, or the Federal Reserve? Does monetary policy still affect inflation and output as much as it did in the 1960s and 1970s? Should we expect the reduced volatility of the U.S. economy to last?

The answers to these questions depend in fact on the origin of the changes. In particular, they require a determination of whether the reduced volatility of output and inflation is due to smaller and less frequent disturbances, such as shocks to productivity, foreign economies, fiscal policy, and monetary policy, or whether the propagation of these shocks has changed so that output and inflation have become less sensitive to shocks. Clearly, if the main cause of the increased economic stability in the past two decades is a reduction in the importance of exogenous shocks, or special circumstances, then there is a good chance that once confronted again with large successive shocks, the economy will again become more volatile. Alternatively, if most of the reduced volatility is due to a change in the propagation of the disturbances, then it is plausible to expect the greater stability to last. In the latter case, it is also plausible to think that the monetary transmission mechanism has changed.

Several factors may have rendered the economy more immune to shocks. On the one hand, firms and consumers may have changed their behavior and the organization of markets in a way that has reduced the effect of given shocks on output and inflation. For instance, Kahn, McConnell, and Perez-Quiros (2002) argue that a more effective management of inventories has been an important factor behind the reduction in the variability in output. On the other hand, the conduct of monetary policy may have been more responsive to fluctuations in inflation and output since the beginning of the 1980s, partly compensating for the effect that shocks may have had on inflation and output (see Clarida, Galí, and Gertler [2000] and Boivin and Giannoni [2002]).

In this paper, we seek to understand more clearly the nature of the changes in the U.S. economy over the past four decades, and to determine whether the reduction in output and inflation variability has been associated with a change in the transmission of monetary policy. First, we estimate a small vector autoregression (VAR) model using U.S. data from 1960 to 2001 and test for its stability. Our results suggest that

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instability is prevalent both in the systematic part of the estimated VAR and in the variance of shocks. Second, through counterfactual experiments, we assess whether the reduced variability of the economy is due principally to less important shocks (or special events) or to changes in the propagation mechanism of these shocks. We find that the change in the propagation of the shocks in the past two decades accounts for roughly 40 percent of the decrease in the variance of detrended output and for 60 percent of the reduction in the variance of inflation.

Because we find that a significant fraction of the reduced volatility is attributable to a change in the propagation of the shocks, we impose more structure on our empirical model to assess whether there has been a change in the transmission of monetary policy. We find that output and inflation have displayed diminished dynamic responses to unexpected federal funds rate movements since the beginning of the 1980s. Some may conclude from this observation that monetary policy must therefore have had smaller effects in the past two decades. We argue that while it is possible that the functioning of the economy has changed in such a way as to better insulate output and inflation from monetary policy movements, it certainly does not need to be so. In fact, as we show, it is also possible that the diminished estimated response of output and inflation to monetary policy shocks reflects a monetary policy aimed at stabilizing output and inflation to a larger extent. Determining whether the reduced response of output and inflation to monetary policy shocks results from a change in the economy or a change in monetary policy would require a fully specified structural model. An analysis of this kind is beyond the scope of this paper, but it is one that is undertaken in Boivin and Giannoni (2002).

The rest of the paper is organized as follows. In Section 2, we present evidence from a simple reduced-form VAR that the reduced variability in the U.S. economy is due at least in part to a change in the propagation of shocks. In Section 3, we identify the effects of monetary policy shocks and document the changes in the transmission of monetary policy. In Section 4, we discuss the implications of our empirical findings for the effectiveness of monetary policy. Section 5 concludes.

2. Evidence from Reduced-Form Vector Autoregressions

2.1 Generalities about VARs

We use a reduced-form vector autoregression (VAR) model to assess whether the reduced variability of output and inflation in the past two decades is due to a reduction in the variability of shocks or whether it is due to a change in the propagation of these shocks. A reduced-form VAR, as proposed by Sims (1980), is a regression of some vector of variables Y_t on lags of this vector. Formally, the reduced-form VAR is a system of equations that can be written in matrix form as

$$Y_t = a + A_1 Y_{t-1} + \dots + A_k Y_{t-k} + u_t, \quad (1)$$

where a is a vector of constants, $A_1, \dots, A_k$ are matrices of coefficients, and u_t is a vector of innovations, that is, serially uncorrelated disturbances that have zero mean and a variance-covariance matrix $E(u_t u'_t) = \Sigma_u$.[2] The evolution of the vector Y_t, which contains the macroeconomic variables whose behavior we seek to understand, depends both on unexpected disturbances, u_t, and on a systematic component, $a + A_1 Y_{t-1} + \dots + A_k Y_{t-k}$, that determines how the shocks are propagated to the rest of the economy. The estimates of $a, A_1, \dots, A_k$, are obtained by applying ordinary least squares (OLS) to each part of equation 1 separately, and the estimate of Σ_u is given by the sample covariance matrix of the OLS residuals.

Based on the estimated reduced-form VAR for different samples, we can determine whether the variance-covariance matrix Σ_u of the shocks and the systematic component—that is, the propagation mechanism—have changed over time. Through counterfactual experiments, we can then determine whether the observed reduced volatility in output and inflation has been due mainly to a change in the shocks or in the propagation mechanism.

The specific VAR that we consider contains four variables: detrended output, the inflation rate, commodity price inflation, and the federal funds rate. Clearly, this VAR provides a very simple or simplistic description of the economy, but it contains at least the minimum set of variables that are crucial for any discussion of monetary policy.[3] Detrended output, which is measured as the percent deviation of real GDP from a stochastic trend, is obtained from a high-pass filter that isolates frequencies associated with cycles with periodicity of less than thirty-two quarters. This variable is often referred to as the "output gap" in the empirical literature.[4] The inflation rate is the annualized rate of change in the GDP deflator between two consecutive quarters. The commodity price measure is the quarterly average of the monthly spot market commodity price index. Commodity price inflation is added to the VAR to limit the extent of a "price puzzle" (see Sims [1992], Chari, Christiano, and Eichenbaum [1995], and Bernanke and Mihov [1998]). The original data set runs from 1959:1 to 2001:2.[5] Four lags are included in the VAR. Because of data transformation (first-differences, high-pass filter, and lags), the analysis is performed on the 1963:1-1997:4 period.[6]

2.2 Empirical Evidence

Stability Tests on the Reduced-Form VAR

The stability of parameters in estimated macroeconomic relationships has been investigated in a number of recent papers. The most general evidence is provided by Stock and Watson (1996), who find widespread instability in bivariate relationships among seventy-six macroeconomic variables. In the VAR context, mixed results have been obtained.[7] Boivin (1999) argues that the different conclusions are due mainly to the small sample properties of the stability tests, and to the effect of the number of parameters tested on the power of these tests. He concludes that there is compelling evidence of parameter instability in monetary VARs.

We now perform a similar stability investigation on the VAR described in the previous section. For each equation of the reduced-form VAR, we test jointly for the stability of all the coefficients on the lags of a given variable using the Wald version of the Quandt (1960) likelihood-ratio test (that is, the Andrews [1993] sup-Wald test). We use a heteroskedasticity-robust version of the test. This test, unlike the well-known Chow test, does not assume knowledge of the date at which the break in the parameters occurs. This test is also known to have power against other alternatives, such as one where the coefficients are following a random walk (see Stock and Watson [1998]).

The p-values of the stability tests are presented in Table 1. Overall, the results suggest that instability is important in this VAR. Of the sixteen tests performed, six—38 percent—reject the null hypothesis of stability at the 5 percent level.[8] We thus interpret these results as strong evidence of changes in the VAR. It is important to mention that, to the extent that the true functioning of the economy is appropriately described by a linear model, potentially omitted variables do not generate spurious instability; such an omission may bias the estimated parameters of the systematic component, but would not imply changes across samples.[9]

Table 1
Stability Tests on the Reduced-Form VAR

	Regressors			
Dependent Variable	PCOM Inflation	Inflation	Detrended Output	Fed Funds Rate
PCOM inflation	0.003	0.271	0.098	0.064
Inflation	0.064	0.006	0.218	0.000
Detrended output	0.136	0.005	0.691	0.001
Fed funds rate	0.072	0.075	0.006	0.086

Source: Authors' calculations.

Notes: The figures are the p-values for the Andrews (1993) sup-Wald test. Under the null of the test, the coefficients are time-invariant. The test is applied jointly to the constant and the coefficients and the lags of the variable corresponding to the given column. The p-values were computed using the simulation approach proposed by Hansen (1997). PCOM inflation denotes commodity price inflation.

In principle, one could estimate the break date for different subsamples as a by-product of the Quandt likelihood-ratio tests of the previous subsection. Unfortunately for our VAR, the estimated break dates—for each combination of a dependent variable and lags of a regressor—do not provide a consistent picture of the timing of the observed instability. Thus, on the basis of anecdotal evidence on the conduct of monetary policy and previous empirical studies, while making sure that the samples are not too small, we decided to base our benchmark comparison on the subsamples on each side of 1979:4, the date on which Federal Reserve Chairman Paul Volcker announced a shift in policy.[10] As an alternative, we start the second sample in 1984:1 to eliminate the nonborrowed reserves targeting experiment from the second sample. The break date of 1984:1 is also the one estimated by McConnell and Perez-Quiros (2000) for a change in the volatility of output growth. As a result, we consider three subsamples: the first corresponds to 1963:1-1979:3, the second to 1980:1-1997:4, and the third to 1984:1-1997:4.

Using the break dates 1979:3 and 1984:1, we also test for stability of the variance-covariance matrix Σ_u.[11] Table 2 reports the p-values relative to the stability tests on the variance of the innovations u_t. Of the eight tests performed, five—63 percent—reject the null hypothesis of equal variance on both sides of the break date, at the 5 percent level.[12] It appears therefore that not only the propagation of the shocks has changed over the past decades, but also that the variance of the innovations u_t has changed significantly.

Table 2
Stability Tests on the Variance of Innovations in the Reduced-Form VAR
p-Values for Null of Stability

Variance of Innovation in	Break Dates 1979:3	Break Dates 1984:1
PCOM inflation	0.040	0.054
Inflation	0.014	0.023
Detrended output	0.008	0.067
Fed funds rate	0.040	0.117

Source: Authors' calculations.

Notes: The table reports p-values of the x^2 -test for a change in the variance of the innovation of each equation, reported in separate rows, in 1979:3 or 1984:1. Under the null of the test, the variances of the innovations are time-invariant. PCOM inflation denotes commodity price inflation.

Counterfactual Analysis with Reduced-Form VARs

Given this evidence of changes in the economy, we now investigate whether the reduced volatility in output and inflation is attributable mainly to a change in the variance-covariance matrix of the disturbances, Σ_u, or to a change in the propagation of the perturbations. We do this by performing counterfactual experiments on the variance of output and inflation, using estimates of the reduced-form VAR over different subsamples. The results are reported in Table 3. The first column reports the variance of detrended output (or output growth) and inflation in the pre-1980 sample. The second column reports the corresponding variances in either the post-1980 or post-1984 sample. The third column contains the change in variances from one sample to the next. The fourth column reports the change in variances obtained from the VAR, assuming that the estimated propagation mechanism, summarized by the collection of matrices $A = \{A_1, \ldots, A_k\}$, has changed from the pre-1980 to the post-1980 (or post-1984) sample, but that the covariance matrix Σ_u of the innovations is kept constant. This provides a measure of the effect upon the variances of a change in the propagation mechanism in the face of unchanged disturbances. Finally, the last column of Table 3 contains the change in variances obtained from the VAR, assuming a constant propagation mechanism, A, but assuming that the variance-covariance matrix Σ_u of the innovations has changed as estimated.[13] For instance, if the observed diminution in the variance of inflation and output (gap or growth) was explained mostly by a diminution in the importance of the shocks hitting the economy, then the reduction in the variances reported in the last column should explain most of the decrease displayed in the third column.

Overall, the results reported in Table 3 suggest that both changes in the propagation mechanism, A, and in the variance-covariance matrix of the innovations, Σ_u, are important in explaining the reduced variability of output and inflation. The variances of output obtained assuming unchanged A are smaller than the ones obtained assuming unchanged Σ_u; in fact, in the pre-1980 versus post-1980 comparison, 62 percent of the reduction in the variance of output can be attributed to a change in Σ_u, and the rest can be explained by a change in A alone. However, the variances of inflation obtained assuming that the propagation mechanism A is unchanged are larger than the ones obtained assuming that the covariance of the innovations Σ_u is unchanged; in fact, in the pre-1980 versus post-1980 comparison, 42 percent of the reduction in the variance of inflation can be explained by a change in Σ_u, while the rest is due to change in A alone. Thus, both changes in the propagation mechanism and in the variance of the reduced-form residuals are important in explaining the decreased volatility of these variables.

So far, we have considered the residuals of the reduced-form VAR as estimates of exogenous disturbances affecting the economy. This is only true, however, under very special conditions. More generally, the residuals of the reduced-form VAR (equation 1) constitute a linear combination of some "fundamental" or "structural" disturbance vector ε_t that also mixes contemporaneous responses among endogenous variables. Suppose, for instance, that the true model of the economy is of the form of a structural VAR

$$(2) \qquad B_0 Y_t = b + B_1 Y_{t-1} + \ldots + B_p Y_{t-k} + \varepsilon_t ,$$

where B_0 is nonsingular and is normalized so as to have only 1's on its main diagonal, and the variance-covariance matrix of the fundamental disturbances $E(\varepsilon_t \varepsilon'_t) = \Sigma_\varepsilon$ is assumed to be diagonal. Then, the matrices of the corresponding reduced-form VAR (equation 1) satisfy $a = B_0^{-1} b$, $A_j = B_0^{-1} B_j$, for $j = 1, \ldots, k$, and the vector of shocks satisfies $u_t = B_0^{-1} \varepsilon_t$, so that $\Sigma_u = B_0^{-1} \Sigma_\varepsilon (B_0^{-1})'$. As a result, if we estimate changes across samples in the variance-covariance matrix of residuals of the reduced-form VAR, Σ_u, it is not possible to determine in the absence of further assumptions whether this is due to a change in contemporaneous relationships among variables represented by B_0, or whether it is due to a change in the variance-covariance matrix of the fundamental shocks, Σ_ε. Therefore, it is still possible that part of the reduced volatility in output or inflation attributed above to the change in Σ_u is in fact due to a change in the propagation of the shocks through B_0. In contrast, if we estimate changes in the coefficients of the matrices $A_1, \ldots, A_k$,

Table 3

Counterfactual Experiments with the Reduced-Form VAR

	Pre-1980 versus Post-1980				
				Part of the Change Due to	
Variance of	1963:1-1979:3	1980:1-1997:4	Change	Propagation	Variance of Innovations (Σ_u)
Detrended output	5.10	2.25	-2.85	-1.07	-1.78
Inflation	8.07	3.05	-5.02	-2.91	-2.11

	Pre-1980 versus Post-1984				
				Part of the Change Due to	
Variance of	1963:1-1979:3	1984:1-1997:4	Change	Propagation	Variance of Innovations (Σ_u)
Detrended output	5.10	1.13	-3.97	-0.87	-3.10
Inflation	8.07	1.11	-6.96	-3.89	-3.07

Source: Authors' calculations.

then we know that the mechanism that propagates the fundamental disturbances ε_t must have changed.[14]

To isolate properly the contribution of changes in the fundamental shocks, more structure needs to be added. We turn to this in the next section.

3. Changes in the Monetary Transmission Mechanism: Evidence from a Structural VAR

Having established that the mechanism that propagates the exogenous disturbances has changed since the beginning of the 1980s, we now determine to what extent these changes have affected the transmission of monetary policy. Many authors have used structural VARs of the form equation 2 to describe the effects of monetary policy on key macroeconomic variables.[15] While the Fed's operating procedure has varied in the past four decades, many authors have argued that the federal funds rate has been the key policy instrument in the United States over most of that period (see, for example, Bernanke and Blinder [1992] and Bernanke and Mihov [1998]).[16] This suggests that we split the vector Y_t of endogenous variables into two components: $Y_t = [Z_t', R_t]'$, where R_t represents the instrument of monetary policy, that is, the fed funds rate, and Z_t is a vector containing all other (nonpolicy) endogenous variables. Accordingly, we decompose the matrices B_i further as

$$B_i = \begin{bmatrix} B_i^{ZZ} & B_i^{ZR} \\ B_i^{RZ} & B_i^{RR} \end{bmatrix},$$

for $i = 0, \ldots, k$. Noting that the scalar $B_0^{RR} = 1$, it follows that our structural VAR (equation 2) can be written as

$$(3) \qquad Z_t = (B_0^{ZZ})^{-1}\left[b^Z + \sum_{i=1}^{k} B_i^{ZZ} Z_{t-i} - B_0^{ZR} R_t + \sum_{i=1}^{k} B_i^{ZR} R_{t-i} + \varepsilon_t^Z\right]$$

$$(4) \qquad R_t = b^R - B_0^{RZ} Z_t + \sum_{i=1}^{k} B_i^{RZ} Z_{t-i} + \sum_{i=1}^{k} B_i^{RR} R_{t-i} + \varepsilon_t^R,$$

where ε_t^Z is a vector of orthogonal disturbances and ε_t^R is a disturbance that is assumed to be orthogonal to ε_t^Z. The first equation describes the evolution of the nonpolicy variables of the model in response to changes in all contemporary and past endogenous variables as well as unforecastable shocks. The second equation characterizes the behavior of the monetary policy instrument in response to other endogenous variables, lagged values of the policy variable, and unforecastable shocks.

Equations 3 and 4 are not identified without further assumptions. Following many papers in the literature—including Bernanke and Blinder (1992), Rotemberg and Woodford (1997), and Bernanke and Mihov (1998)—we make the identifying assumption that the policy variable, R_t, affects nonpolicy variables only with a lag of one period (assumed here to be one quarter). Formally, it is assumed that the vector $B_0^{ZR} = 0$. The fed funds rate, however, is allowed to respond to all contemporaneous variables.[17] As Z_t and ε_t^R are uncorrelated in this case, estimates of the coefficients appearing in equations 3 and 4 are obtained by applying OLS on each equation of that system separately. An estimate of $var(\varepsilon_t^R)$ is given further by the sample variance of the residuals of equation 3.

3.1 On the Interpretation and the Role of Monetary Policy Shocks

The disturbances ε_t^R are often referred to as monetary policy shocks. Several authors like to think of these shocks as representing changes in monetary policy stance. Rudebusch (1998) criticizes the use of VARs for the description of monetary policy effects, pointing out that monetary policy shocks obtained from VARs typically differ substantially from standard interpretations of past policy actions. Specifically, he reports that the correlation between policy shocks obtained from VARs and those derived from federal funds futures are generally very low. Evans and Kuttner (1998) argue instead that such a low correlation constitutes a poor measure of a VAR's performance. Furthermore, in his comments on Rudebusch, Sims (1996) insists that VARs may well provide a correct description of the economy's response to exogenous shocks, even though the interpretation of the residual shocks as historical monetary policy actions may be problematic.

So what are these monetary policy shocks? Christiano, Eichenbaum, and Evans (1999) suggest that monetary policy shocks may reflect exogenous shocks to preferences of the monetary authority, such as stochastic shifts in relative weights given to unemployment versus inflation stabilization. Bernanke and Mihov (1998) argue that these shocks could also reflect measurement error in the preliminary data. At a different level, the shocks ε_t^R represent all fluctuations of R_t that are unexplained by the systematic response to fluctuations in current and past *Z*s as well as past *R*s included in the VAR. In this respect, the smaller the shocks (relative to the variability of the fed funds rate), the higher the R^2 statistic for this equation, and thus the better the model is able to capture the Fed's actions. In fact, the monetary policy shocks are typically small in VARs of the kind we estimate, as the R^2 statistic for the interest rate equation is above 0.96 in any of the samples considered.

In absolute terms, the monetary policy shocks have decreased dramatically since the mid-1980s. As the first line of Table 4 reports, the variance of monetary policy shocks ε_t^R in the post-1984 sample is only half the corresponding value for the pre-1980 sample.[18] However, the monetary policy shocks display a substantially greater variance in the post-1980 sample, suggesting that the 1980-83 period was one of large monetary policy shocks. This may also indicate that an interest rate equation of the form equation 4 does not provide as good a description of actual monetary policy in this period.

Table 4
Variance Decomposition

	1963:1-1979:3	1980:1-1997:4	1984:1-1997:4
Variance of monetary policy shocks	0.30	0.61	0.14
Contribution to output variance (percent)	19	7	3
Contribution to inflation variance (percent)	14	10	6

Source: Authors' calculations.

3.2 Empirical Results

Variance Decomposition

Regardless of the evolution of the variance of monetary policy shocks, the fraction of variance of output and inflation due to these shocks has decreased dramatically since the beginning of the 1980s. While almost 20 percent of output variance is attributable to monetary policy shocks in the pre-1980 sample, this proportion has fallen to 3 percent in the post-1984 sample (Table 4). Similarly, the variance of inflation due to such shocks has fallen by half from the former sample to the latter. This confirms the finding of many researchers, such as Leeper et al. (1996), that monetary policy shocks have accounted for very little variability in output and inflation since the beginning of the 1980s. Some researchers have concluded from this that monetary policy does not matter much. For many economists (including us), however, monetary policy is mostly characterized by the endogenous response to developments in the economy, and, as we explain in Section 4, even if monetary policy shocks were very small (in fact, even if they were equal to zero all the time), monetary policy could still matter substantially for the determination of output and inflation.

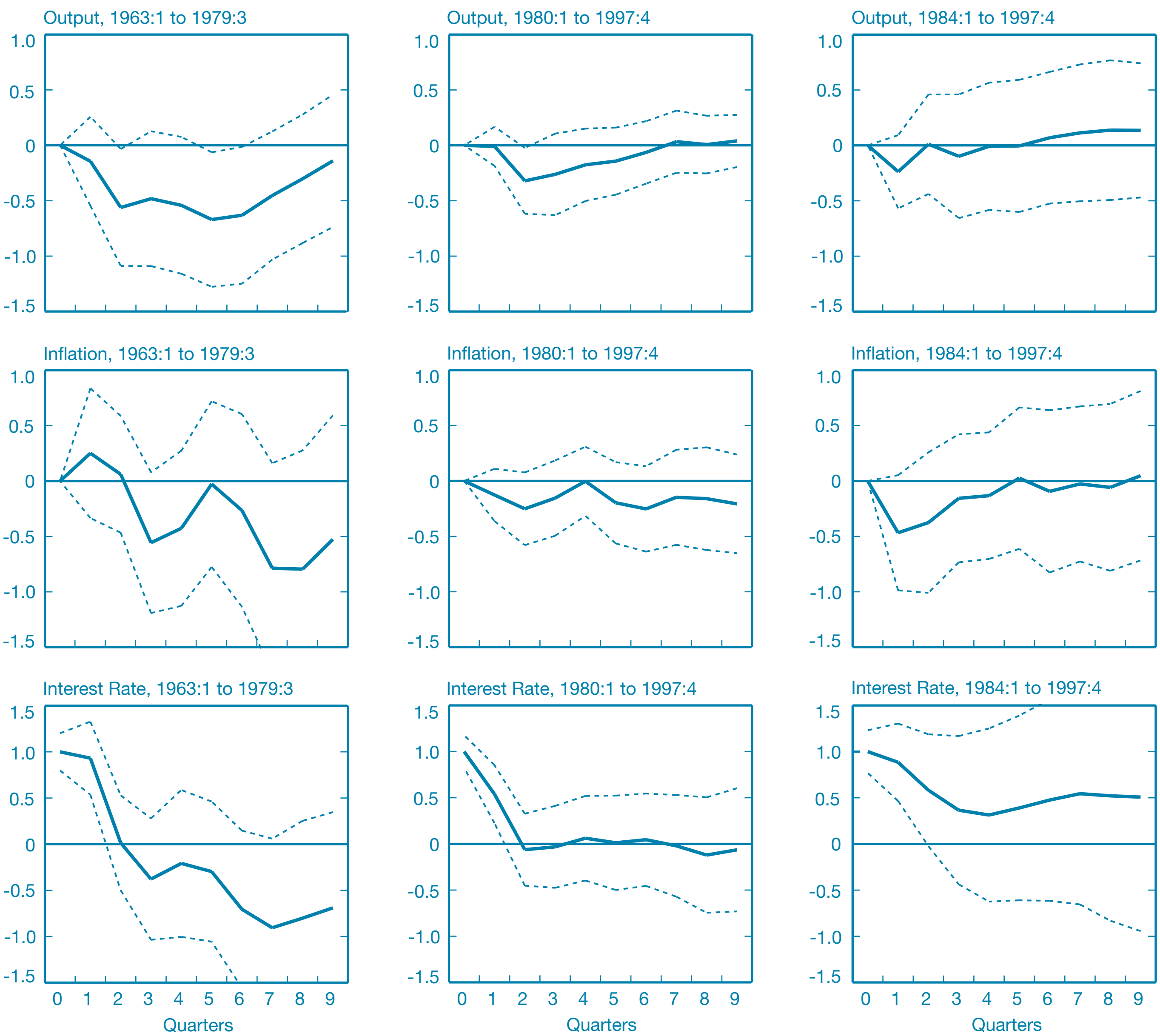
Impulse Responses to Monetary Policy Shocks

No matter the size and the interpretation of monetary policy shocks, these shocks provide an exogenous source of variation that allows us to identify the response of the economy to monetary policy. Such responses will allow us to determine whether and how the transmission of monetary policy has changed over time. Chart 1 displays the impulse response functions to an unexpected 1-percentage-point increase in the fed funds rate and the associated 95 percent confidence intervals for all three samples.

The key result from the comparison across samples is that the response of detrended output and inflation is much less pronounced and persistent since the beginning of the 1980s

Chart 1

Impulse Responses to a Monetary Shock over Different Samples



Source: Authors' calculations.

than in the pre-1980 period; the trough of the response of output is more than twice as large in the pre-1980 sample as in the post-1980 or post-1984 samples. This result, which has already been documented in the literature (see, for example, Gertler and Lown [2000] and Barth and Ramey [2001]), suggests that the effect of monetary policy shocks was stronger before the 1980s. While this last conclusion is robust to the use of the post-1980 or post-1984 sample in the comparison, there are still notable differences between these two samples. In particular, the response of inflation appears somewhat stronger when the VAR is estimated on the post-1984 sample, and the response of output, while of similar shape overall, becomes positive after six quarters, though not significantly so.[19]

Counterfactual Analysis with Structural VARs

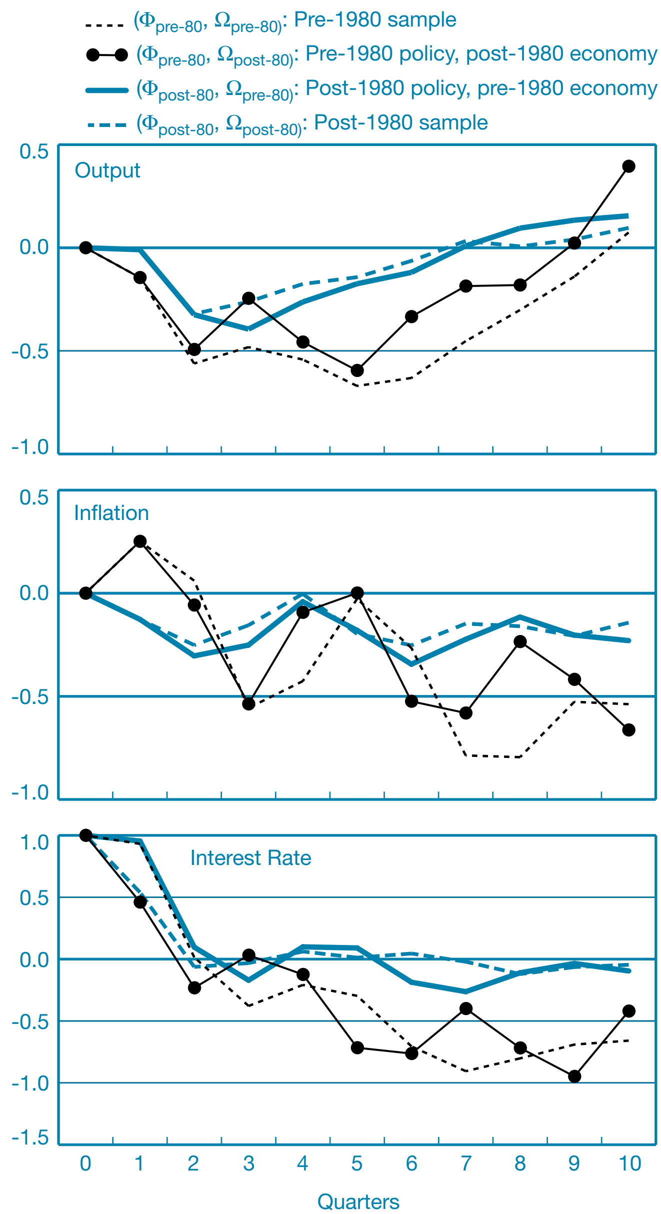
The previous section established that the economy's response to interest rate fluctuations has changed substantially over time, but the evidence does not identify the reasons why. In fact, while the tests of stability on the interest rate equation suggest that monetary policy is one potential source of this varying response of the economy, the evidence in Table 1 is also consistent with the presence of changes in the transmission mechanism.

We now investigate the source of change in the effect of monetary policy by performing a counterfactual analysis on the structural VAR. In particular, we use two counterfactual experiments to answer the following questions: 1) Are the observed changes in the policy rule sufficient by themselves to explain the evolution of the impulse response functions reported in Chart 1? 2) Alternatively, assuming that monetary policy did not change, can we reproduce the evolution of the impulse response functions through the equations of the VAR corresponding to the nonpolicy block?

To answer these questions, let Φ characterize monetary policy and Ω characterize the rest of the economy. More precisely, let Φ_s be the set of estimates of the parameters of the policy rule (equation 4) for sample *s*, and Ω_p be the set of estimates of the remaining VAR parameters, that is, the parameters of equation 3, for sample *p*. A combination (Φ_s, Ω_p) completely characterizes a set of impulse response functions. For instance, $(\Phi_{pre-80}, \Omega_{pre-80})$ corresponds to the impulse response functions obtained in the previous section for the pre-1980 sample. The two counterfactual experiments we undertake can then be expressed as $(\Phi_{post-80}, \Omega_{pre-80})$ and $(\Phi_{pre-80}, \Omega_{post-80})$. Chart 2 displays the resulting impulse response functions to an unexpected 1-percentage-point increase in the fed funds rate, together with the estimated impulse responses for the pre-1980 and post-1980 samples; Chart 3 displays the corresponding impulse response functions for the pre-1980 and post-1984 samples.

Charts 2 and 3 show that while both sets of parameters Φ and Ω sensibly affect the impulse response functions, most of

Chart 2
VAR-Based Counterfactual Analysis:
Pre-1980 Sample versus Post-1980 Sample

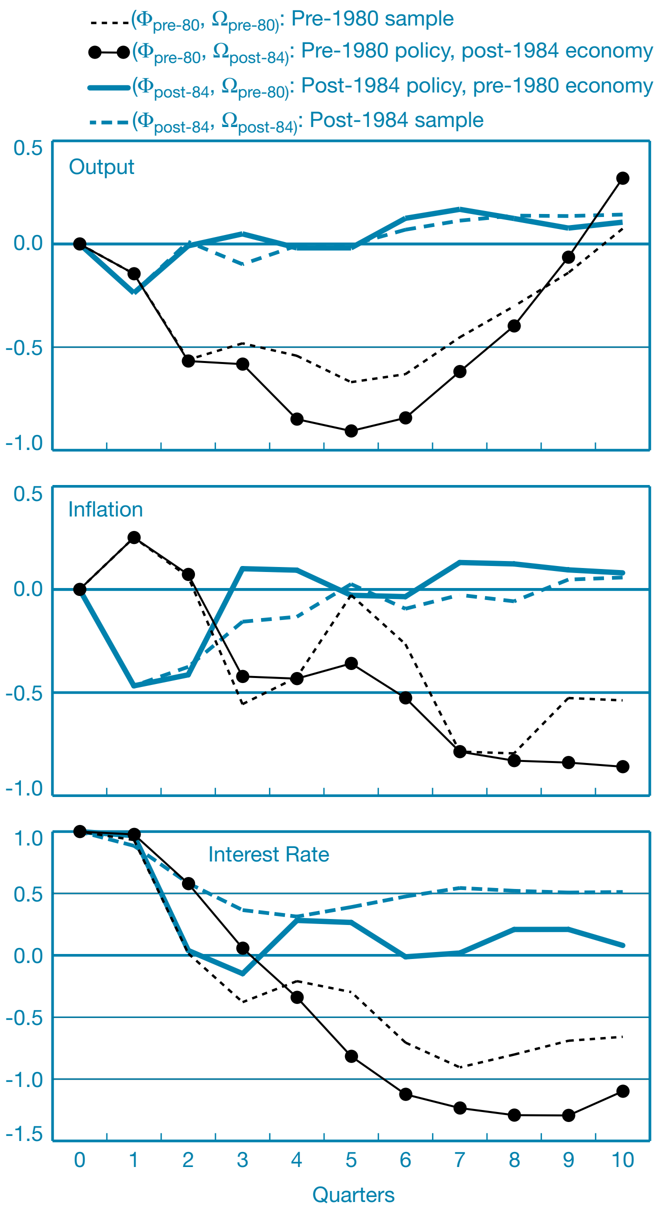


Source: Authors' calculations.

the reduced response of output and inflation in the post-1980 and post-1984 samples is accounted for by a change in the parameters characterizing systematic monetary policy. In fact, by changing monetary policy, Φ, and maintaining the parameters of the rest of the economy, Ω, fixed—that is, by comparing the lines $(\Phi_{pre-80}, \Omega_{pre-80})$ with $(\Phi_{post-80}, \Omega_{pre-80})$ and $(\Phi_{pre-80}, \Omega_{post-80})$ with $(\Phi_{post-80}, \Omega_{post-80})$—we note that the responses of output and inflation associated with the policy estimated for the post-1980 sample involve considerably less variation than those associated with the policy of the pre-1980 sample. In addition, by keeping the coefficients of the rest of the economy Ω_{pre-80} constant, we observe that a change in policy from Φ_{pre-80} to $\Phi_{post-80}$ explains an important part of the impulse responses $(\Phi_{post-80}, \Omega_{post-80})$ obtained in the second period. This is even clearer when one compares the pre-1980 and post-1984 samples (Chart 3).

Chart 3

VAR-Based Counterfactual Analysis: Pre-1980 Sample versus Post-1984 Sample



Source: Authors' calculations.

Moreover, keeping the monetary policy coefficients Φ fixed and letting the rest of the economy Ω vary, we observe that the impulse response functions are changed only little. Again, this supports the idea that most of the reduction in the response of output and inflation to monetary shocks is attributable to a change in the systematic response of monetary policy.

Our analysis suffers, however, from an important shortcoming: it does not address the famous Lucas (1976) critique. In fact, even though we have imposed some structure on the VAR, the description of the private sector behavior, as given by equation 3, corresponds to a reduced-form. For in general, firms and consumers typically care, at least in part, about their expectations of future states of the economy. Changes in the policy reaction function are thus likely to affect the way agents form their expectations of future variables, and therefore the coefficients of the equations in the system (equation 3). A more structural analysis necessary to address the Lucas critique by taking into account the effects of changes in the policy reaction function on a system of the form equation 3 is performed in Boivin and Giannoni (2002).

4. On the Potency of Monetary Policy: A Discussion

The empirical evidence that we have reported suggests that the response of output and inflation to monetary policy shocks has decreased since 1980. Does this imply, as is sometimes argued, that the Federal Reserve has partly lost its ability to affect the economy? Has the economy changed in such a way that it is now able to insulate itself better from monetary policy movements? Our analysis certainly does not imply that. For as we have argued, the change in the transmission mechanism is also at least partly—if not mainly—due to a change in the systematic behavior of monetary policy. In fact, if monetary policy was responding more systematically to economic conditions with the objective of minimizing the variability of inflation and output, we would observe precisely a reduction of the variability of target variables due to both monetary policy innovations and to the systematic part of monetary policy, hence, the transmission mechanism.

To clarify this point, we consider the following very stylized model. In this model, output, y_t, is determined by

$$y_t = E_t y_{t+1} - \sigma r_t + \delta_t, \tag{5}$$

where the parameter $\sigma > 0$. This equation, which is often called the intertemporal IS equation, lies at the core of many recent macroeconomic models.[20] It is similar to the traditional IS equation in the sense that it relates output negatively to the real interest rate, r_t.[21] However, output is also affected by expected future output (or income), as consumers want to smooth their consumption over time. The term δ_t represents unforecastable demand shocks, such as unexpected changes in government expenditures.[22] An equation of this form can be obtained as a log-linear approximation to an Euler equation for the optimal timing across periods in a fairly large variety of models. In this case, the parameter σ is associated with the elasticity of intertemporal substitution in consumption. For simplicity, we assume that the central bank conducts monetary policy by setting the short-term real interest rate. This is clearly a simplification. While central banks are usually seen as affecting short-term nominal interest rates, this assumption allows us to ignore the behavior of inflation, which is not relevant to our point. (For a more general model aimed at replicating the actual behavior of output, inflation, and short-term nominal interest rates, see Boivin and Giannoni [2002].) Iterating equation 5 forward, we obtain

$$y_t = \delta_t - \sigma r_t^L, \tag{6}$$

where

$$r_t^L = E_t\left[\sum_{j=0}^{\infty} r_{t+j}\right]$$

represents the long-run real interest rate.[23] As equation 6 makes clear, it is the long-run real interest rate that matters for the determination of output. In this framework, short-term interest rates affect output to the extent that their expected path determines the long-run rate. Thus, even though a central bank may have a direct influence only on short-term interest rates, it is also able to affect longer term rates through its effect on agents' expectations of future short-term rates. In fact, short-term rates and long-term rates must be related so as to prevent arbitrage opportunities from arising.

Following recent research on monetary policy rules (see, for example, Taylor [1999]), we assume that monetary policy is characterized by an interest rate rule. For simplicity again, we consider a rule of the form

$$r_t = \phi y_t + \varepsilon_t, \tag{7}$$

where $\phi > 0$. The monetary authority is assumed to change its instrument systematically in response to output fluctuations: the interest rate is raised as output is above trend, while it is lowered as output lies below trend. Changes in the instrument may also reflect monetary shocks ε_t of the kind discussed in Section 3 and that are supposed to be serially uncorrelated and uncorrelated with real demand shock δ_t. Combining equations 5 and 7, we obtain

$$y_t = \frac{\delta_t - \sigma\varepsilon_t}{1 + \sigma\phi}.$$

This last expression reveals that in equilibrium, output depends both on real demand shocks and on monetary shocks, as well as on the parameters σ and ϕ. In particular, an unexpected unit increase in the short-term interest rate $(\varepsilon_t = 1)$ reduces equilibrium output by $\sigma/(1 + \sigma\phi)$.

Does a reduced output response reflect a reduced potency of monetary policy? The answer really depends on the source of the change. If the reduced output response is due to a smaller value of σ, reflecting, for instance, a lower elasticity of intertemporal substitution in consumption, then monetary policy is less potent, as equation 6 indicates that output is less sensitive to changes in the interest rate. In contrast, if the reduced response of output stems from an increase in ϕ, then this is not related to the degree of potency of monetary policy. The reduced output response simply reflects an increased willingness by the monetary authority to stabilize output. In the limit, policymakers could almost entirely stabilize output by letting ϕ become very large, and hence by letting the interest rate respond very strongly to any fluctuation in output. Thus, a reduced output response to shocks is exactly what one would expect from a successful monetary policy that aims to stabilize output.

5. Conclusion

In this paper, we have investigated the extent to which the reduced variability in output, inflation, and interest rates is due to changes in the degree of variability of shocks, and the extent to which it is due to a change in the mechanism that propagates these shocks. We have argued that the change in the propagation mechanism has lowered the variability of macroeconomic variables to a large extent. This change has been associated further with a diminished effect of monetary policy shocks on output and inflation. This observation, however, does not imply that monetary policy has lost some of its potency in the past two decades, because the change in the transmission of monetary policy shocks could result from a change in the systematic behavior of the Federal Reserve.

We did not attempt to determine the origin of the change in the transmission mechanism—in particular, whether the change is due to parameters describing the functioning of the economy (such as σ above) or to a change in the conduct of monetary policy (represented by changes in ϕ above). In fact, it is not possible to disentangle these two types of changes using the VAR model considered in Section 3. To determine whether the reduced response of output and inflation to monetary shocks is due to a more stabilizing monetary policy or to a change in the functioning of the economy—the latter choice implying that monetary policy has lost some of its potency—one needs to construct a full-fledged structural model that can account for changes both in the behavior of private economic agents and in the policy rule chosen by the central bank. This issue is addressed in Boivin and Giannoni (2002) in a more sophisticated and arguably more realistic model of the economy. There, we conclude that the reduced effect of monetary policy shocks is due mainly to a more effective systematic behavior of monetary policy, and that there is little evidence that U.S. monetary policy has lost its potency in the past two decades.

Endnotes

1. See, for example, McConnell and Perez-Quiros (2000) and Blanchard and Simon (2000).

2. See, for example, Sims (1980), Watson (1994), and Stock and Watson (2001).

3. Bernanke and Boivin (2001) consider an empirical model that accounts for much more information.

4. To check the robustness of our results, we have replicated all exercises by replacing the output gap with quarterly output growth. While we report only the results obtained from the VAR with detrended output, the VAR with output growth yields very similar results.

5. All series are from the Standard and Poor's–DRI database. The mnemonics are GDPQ for real GDP, GDPD for the GDP deflator, and PSCCOM for the commodity price index.

6. When output growth is considered instead of detrended output, the analysis is performed on the 1960:2-2001:2 period.

7. Bernanke, Gertler, and Watson (1997) find evidence of instability in a monetary VAR, while Bernanke and Mihov (1998) and Christiano, Eichenbaum, and Evans (1999) reach the opposite conclusion.

8. For the VAR with output growth instead of detrended output, of the sixteen tests performed, eight—50 percent—reject the null hypothesis of stability at the 5 percent level.

9. To see this, suppose that we have a linear model, $y_t = x'_{1t}\beta_1 + x'_{2t}\beta_2 + \varepsilon_t$ for $t = 1, \ldots, T$, where the first column of x_{1t} contains only 1's, the β_i's are constant, and the distribution of x_{it} is time-invariant. If we omit x_{2t} from the regression, the OLS estimate of β_1 is given by $\left(\sum_{t=1}^{T} x_{1t}x'_{1t}\right)^{-1}\sum_{t=1}^{T} x_{1t}y_t$. The bias of $\hat{\beta}_1$ is given by $E\left[\left(\sum_{t=1}^{T} x_{1t}x'_{1t}\right)^{-1}\sum_{t=1}^{T} x_{1t}x'_{2t}\beta_2\right]$. So, we see that the bias is time-invariant, and thus misspecification *by itself* cannot generate instability.

10. We do not include 1979:4 in the second sample to be consistent with the one used by Rotemberg and Woodford (1997), Bernanke and Mihov (1998), and Clarida, Galí, and Gertler (2000).

11. The test used is a version of the Breush-Pagan LM-test adapted for the present split-sample context.

12. The same is true for the VAR that involves output growth instead of detrended output.

13. Note that given the interaction between the propagation mechanism and the variance of the errors, there is no unique way of performing this decomposition. For instance, in the fourth column of Table 3, the variance of the innovations, Σ_u, can be kept fixed at either sample estimate. We report the change in variance evaluated at the average of the sample estimates of Σ_u. The same approach is used in the last column of Table 3. More formally, we rewrite the VAR (equation 1) in companion form as $\tilde{Y}_t = \tilde{A}\tilde{Y}_{t-1} + \tilde{u}_t$, and express the vectorized variance-covariance matrix of $\tilde{Y}_t$ for sample *s* as $v_{Y,s} = \bar{A}_s v_{u,s}$, where $v_{Y,s} \equiv vec\ E(\tilde{Y}_t\tilde{Y}'_t)$, $v_{u,s} \equiv vec\ E(\tilde{u}_t\tilde{u}'_t)$, and $\bar{A}_s \equiv (I - \tilde{A}_s \otimes \tilde{A}_s)^{-1}$. We then decompose the change in variance between two samples as follows:

$$v_{Y,2} - v_{Y,1} = \frac{v_{u,1} + v_{u,2}}{2}(\bar{A}_2 - \bar{A}_1) + \frac{\bar{A}_1 + \bar{A}_2}{2}(v_{u,2} - v_{u,1}).$$

The figures in the fourth column of Table 3 correspond to the first term on the right-hand side, while the numbers reported in the last column correspond to the second term.

14. Arguably, the split between the systematic and shock components in a model of the form equation 2 is somewhat arbitrary. Indeed, if we had a full understanding of the functioning of the economy—and considered all variables that explain the evolution of output and inflation as well as all variables that determine those explanatory variables, and so on—most changes would in fact be accounted for by changes in the functioning of one or another part of the economy. Our understanding of the economy, however, is much more limited, so many changes are unexplained by the model and thus are represented by the disturbance vector ε_t. Since our simple estimated VAR indicates changes over time in the propagation mechanism, we account at least partly for changes in the economy.

15. See Bernanke (1986), Bernanke and Blinder (1992), Cochrane (1994), Leeper, Sims, and Zha (1996), Christiano, Eichenbaum, and Evans (1996, 1999), Bernanke and Mihov (1998), Evans and Kuttner (1998), and Stock and Watson (2001), among others.

16. The federal funds rate probably provides a less adequate measure of monetary policy stance for the 1979-82 period, as nonborrowed reserves were set to achieve a level of interest rates consistent with monetary growth targets. However, Cook (1989) argues that the fed funds rate may still provide a satisfactory indicator during this episode.

17. Note that while the identifying assumption here is not uniformly adopted, the effects of an unexpected monetary policy shock on output and inflation described below are in line with the effects commonly obtained. For alternative identifications of monetary policy, see, for instance, Bernanke (1986), Blanchard and Watson (1986), Sims (1986), Leeper, Sims, and Zha (1996), Bernanke and Mihov (1998), and Stock and Watson (2001).

18. The results reported in the table are obtained from the VAR with detrended output. Similar results are obtained from the VAR with output growth.

19. A similar result is obtained by Gertler and Lown (2000) for a different VAR and different subsamples in the post-1980 period.

20. See, for example, Woodford (1996, 1999), Goodfriend and King (1997), Rotemberg and Woodford (1997), Clarida, Galí, and Gertler (1999), and McCallum and Nelson (1999).

21. All variables are expressed here in terms of percent deviations from their long-run values.

22. Technically, we assume that δ_t satisfies $E_t\delta_{t+j} = 0$ for all $j > 0$.

23. This sum is converging, as r_t is expressed in terms of deviations from its long-run average.

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